LANDSCAPE RESEARCH RECORD

No. 8 | March 6-9, 2019

ENGAGED SCHOLARSHIP

A Peer-Reviewed Publication
Council of Educators in Landscape Architecture
www.thecela.org
LANDSCAPE RESEARCH RECORD is published annually and consist of papers focused on landscape architecture subject areas. Each issue is a collection of papers presented at the Council of Educators in Landscape Architecture annual conference of that year. Conference theme is expressed as the subtitle of Landscape Research Record. The views expressed in papers published in Landscape Research Record are those of the authors and do not necessarily reflect the views of the conference planning committee, or the Council of Educators in Landscape Architecture.

PEER REVIEW OF PAPERS: All papers published in Landscape Research Record have been reviewed and accepted for publication through the Council of Educators in Landscape Architecture’s peer review process established according to procedures approved by the Board of the Council of Educators in Landscape Architecture. Reviewers are recruited by track chairs from among conference attendees and other outside experts. The track chairs also serve as co-editors in the peer review process. The Council of Educators in Landscape Architecture requires a minimum of two reviews; a decision is based on reviewer comments and resultant author revision. For details about the peer review process and reviewers’ names, see REVIEWERS in Table of Contents.

IN THIS ISSUE: In 2019, the conference committee accepted 440 abstracts for presentation and rejected 43 abstracts. Authors of accepted abstracts were invited to submit a full paper. A total of 73 papers were received, 60 papers were selected for peer review. Finally, 36 papers were accepted for publication in this issue. The organization of this issue follows the standard conference tracks listed in the table of contents.
# TABLE OF CONTENTS

## FOREWORD

REVIEWERS ........................................................................................................................................................................ vi

## OUTSTANDING PAPER

THE ROLE OF SALIENT CANAL STRUCTURES IN ENVIRONMENTAL ADAPTATION
Hope Hui Rising. ................................................................................................................................................................. 302

## COMMUNICATION AND VISUALIZATION

REVISITING FILM PHOTOGRAPHY AS A TECHNIQUE TO REVEAL AND ARTICULATE LANDSCAPE PHENOMENA
César Torres Bustamante, Joseph. Ragsdale. ......................................................................................................................... 2

## DESIGN EDUCATION AND PEDAGOGY

REVISITING SCHOLARLY PRODUCTION AMONG RECENTLY TENURED LANDSCAPE ARCHITECTURE FACULTY
Keith M. Christensen, Sean E. Michael, Ole Sleipness. ........................................................................................................... 15

NATURE RX – IMPROVING HEALTH BY SPENDING TIME OUTSIDE
KIERS A. HAVEN. .......................................................................................................................................................... 25

THE NEXUS STUDIO: A SYNERGISTIC PEDAGOGICAL APPROACH FOR INTEGRATING RESEARCH AND EVALUATING LEARNING IN A LANDSCAPE ARCHITECTURE STUDIO
Daniel Cronan. .......................................................................................................................................................... 35

HOW VIRTUAL REALITY IMPACTS THE LANDSCAPE ARCHITECTURE DESIGN PROCESS AT THE SITE-SCALE DURING THE PHASES OF ANALYSIS AND CONCEPT DEVELOPMENT
Drew Hill, Benjamin George, David Evans ...................................................................................................................... 48

NOTES ON COMMUNITY DESIGN-LED COLLABORATION: WAIPAHU TRANSIT-ORIENTED DEVELOPMENT
Cathi Ho Schar. ........................................................................................................................................................ 62

THE LIVING GREEN INFRASTRUCTURE LAB: ADVANCING INTERDISCIPLINARY TEACHING AND EXPERIENTIAL LEARNING IN LANDSCAPE ARCHITECTURE PEDAGOGY
Zhihan Tao, Galen Newman, Michael Arnold, Ming-Han Li, Jun-Hyun Kim........................................................................ 75

## HISTORY, THEORY AND CULTURE

IAN McHARG’S OPERATIONAL AESTHETICS
Bo Zhang................................................................................................................................................................. 88

TRANSITION FROM PRIVATE GARDENS TO PUBLIC SPACE APPLYING WATER MANAGEMENT METHODS OF PERSIAN GARDENS TO URBAN AREAS
Behnaz Avazpour, Paul Osmond, Linda Corkery. .......................................................................................................... 103

GREENING WASTELANDS: HISTORICAL LINEAGE AND FUTURE PROSPECTS
Catherine De Almeida, Caitlin Smith. ......................................................................................................................... 116
TRENDS IN TECHNOLOGY AND MATERIALS COLUMNS IN LANDSCAPE ARCHITECTURE MAGAZINE: 1978-2017  
Kris Fox .................................................................................................................................................................. 132

THE CHANGING ROLE OF BOTANIC GARDENS IN THE CONSTRUCTION OF THE NATURAL ORDER  
Pablo Pérez-Ramos............................................................................................................................................... 146

THE GAMBACORTA OR TOWN MARSH IN NEW CASTLE, DELAWARE: AN INVESTIGATION INTO ITS TRANSFORMATION OVER TIME  
Anna Wik............................................................................................................................................................ 157

LANDSCAPE PERFORMANCE........................................................................................................................................... 170

BEYOND QUANTITY: ASSESSING TREE HEALTH FOR HIGHER PERFORMANCE IN DESERT PARKING LOTS  
Phillip Zawarus................................................................................................................................................ 171

BASELINERS: COLLECTING BASELINE DATA TO MEASURE SOCIAL BENEFITS IN TRANSFORMED LANDSCAPES  
Catherine De Almeida, Hannah Lopresto .............................................................................................................. 186

LANDSCAPE PLANNING AND ECOTOLOGY........................................................................................................... 198

FEASIBILITY OF A CONSTRUCTED WETLAND FOR WASTEWATER TREATMENT IN JULIAETTA, IDAHO  
Alison Tompkins, Gary Austin................................................................................................................................ 199

NEW TOOLS FOR LANDSCAPE CONSERVATION PLANNING: LOCAL CONSERVATION PLANNING THAT COMPLEMENTS STATE AND FEDERAL CONSERVATION PLANS  
Steven E. Greco..................................................................................................................................................... 213

IDENTIFYING OIL SPILL HAZARDS IN NORTH DAKOTA, THROUGH HYDRAULIC MODELING AND CONSERVATION PLANNING  
Yang Song, Morgan Davis-Kollman ...................................................................................................................... 224

PEOPLE-ENVIRONMENT RELATIONSHIPS........................................................................................................... 236

BUILDING THE OUTSIDE-IN CLASSROOM  
Michael McCullough, Michael Martin, Mollika Sajady ........................................................................................... 237

ASSESSING THE VALUE OF OUTDOOR SPACE IN NURSING HOMES: A CASE STUDY FOR ATHENS GERIATRIC HOME (GREECE)  
Anna-Maria Vissilia, Theodora Porfyraki, George Papadopoulos ......................................................................... 249

PARK PERCEPTION IN BROOKINGS, SOUTH DAKOTA: INVESTIGATING THE ROLE OF LANDSCAPE ARCHITECTURE IN COGNITIVE MAPPING  
Joshua Goeden, Don Burger .................................................................................................................................. 261

HOW VARIABLES OF SOCIAL CAPITAL IN THREE HISPANIC NEIGHBORHOODS RELATE TO AN INDIVIDUAL’S ACTIVITY SPACE  
Nikolas Smilovsky, Chris Lukinbeal ..................................................................................................................... 271

SUSTAINABLE SOLUTIONS FOR VISITOR ACCESS AT YELLOWSTONE NATIONAL PARK: EXPLORING TRANSIT OPTIONS FOR THE PARK’S MOST POPULAR DESTINATIONS  
Mandi Roberts, Elizabeth Scott ............................................................................................................................. 284

REDEFINING INDIGENOUS LANDSCAPES FOR AUTHENTIC REPRESENTATION  
Olivia Shoty, Peter Aeschbacher ........................................................................................................................ 295
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>THE ROLE OF SALIENT CANAL STRUCTURES IN ENVIRONMENTAL ADAPTATION</td>
<td>302</td>
</tr>
<tr>
<td>QUANTITATIVE STUDY ON THE VEGETATION LANDSCAPE CHARACTERS OF</td>
<td>313</td>
</tr>
<tr>
<td>CHINESE BUDDHIST MOUNTAIN ENVIRONMENTS BASED ON ECognition IMAGE</td>
<td></td>
</tr>
<tr>
<td>INTERPRETATION TECHNOLOGY: A CASE STUDY OF JIZU MOUNTAIN, YUNNAN</td>
<td></td>
</tr>
<tr>
<td>PROVINCE</td>
<td></td>
</tr>
<tr>
<td>RESEARCH AND METHODS.</td>
<td>325</td>
</tr>
<tr>
<td>THE INTEGRATION OF BEHAVIORS MAPPING AND CONNECTIVITY MEASURES: A</td>
<td>326</td>
</tr>
<tr>
<td>NEW METHOD FOR INTERPRETING HEALTHCARE ENVIRONMENTS</td>
<td></td>
</tr>
<tr>
<td>Pai Liu, Yang Song, Matthew Powers</td>
<td></td>
</tr>
<tr>
<td>ADVANCING DESIGN RESEARCH: CREATING A NEW FRAMEWORK FROM THREE</td>
<td>333</td>
</tr>
<tr>
<td>APPROACHES TO CASE STUDY RESEARCH</td>
<td></td>
</tr>
<tr>
<td>Sarah Little, Adina Cox</td>
<td></td>
</tr>
<tr>
<td>ENGAGED SCHOLARSHIP</td>
<td>343</td>
</tr>
<tr>
<td>TEACHING LANDSCAPE 'TRIAGE' THROUGH FIELDWORK: SITE ANALYSIS AT</td>
<td>344</td>
</tr>
<tr>
<td>WHITE PARK, MORGANTOWN, WEST VIRGINIA</td>
<td></td>
</tr>
<tr>
<td>Vaike Haas</td>
<td></td>
</tr>
<tr>
<td>ENGAGED LEARNING IN THE LANDSCAPE: CAMPUS AS LIVING LAB DVANCING</td>
<td>359</td>
</tr>
<tr>
<td>DESIGN RESEARCH: CREATING A NEW FRAMEWORK FROM THREE APPROACHES TO</td>
<td></td>
</tr>
<tr>
<td>CASE STUDY RESEARCH</td>
<td></td>
</tr>
<tr>
<td>Holly Grace Nelson, Christina Kaunzinger, Jeanmarie Hartman, Edwin</td>
<td></td>
</tr>
<tr>
<td>Gano, Lena Struwe, Laura Lawson</td>
<td></td>
</tr>
<tr>
<td>SUSTAINABILITY</td>
<td>373</td>
</tr>
<tr>
<td>AN URBAN CLIMATE DESIGN FRAMEWORK FOR MORE THERMALLY-COMFORTABLE</td>
<td>374</td>
</tr>
<tr>
<td>AND EQUITABLE COMMUNITIES</td>
<td></td>
</tr>
<tr>
<td>Paul Coseo</td>
<td></td>
</tr>
<tr>
<td>RESEARCH BY DESIGN</td>
<td>388</td>
</tr>
<tr>
<td>THE ETHICS OF FORM: DESIGNING NEW LANDSCAPE HISTORIES THROUGH AN</td>
<td>389</td>
</tr>
<tr>
<td>ALTERNATIVE PEDAGOGY</td>
<td></td>
</tr>
<tr>
<td>Fionn Byrne</td>
<td></td>
</tr>
<tr>
<td>DESIGN RESEARCH BASED DEVELOPMENT OF CAMOUFLAGE LANDSCAPE FEATURES</td>
<td>402</td>
</tr>
<tr>
<td>TO PREVENT CRIMINAL UAV ACTIVITY</td>
<td></td>
</tr>
<tr>
<td>Robert Hewitt, Hala Nassar</td>
<td></td>
</tr>
<tr>
<td>CREATURE DISCOMFORTS</td>
<td>411</td>
</tr>
<tr>
<td>Forbes Lipschitz</td>
<td></td>
</tr>
<tr>
<td>USING DESIGN-RESEARCH TO ADVANCE COASTAL ADAPTATION IN THE FRASER</td>
<td>421</td>
</tr>
<tr>
<td>RIVER DELTA</td>
<td></td>
</tr>
<tr>
<td>Kees Lokman</td>
<td></td>
</tr>
<tr>
<td>SURPASSING RESEARCH: INFORMED PRACTICE</td>
<td>434</td>
</tr>
<tr>
<td>Marc Treib</td>
<td></td>
</tr>
<tr>
<td>APPENDIX</td>
<td>444</td>
</tr>
<tr>
<td>LANDSCAPE RESEARCH RECORD PEER REVIEW PROCESS</td>
<td>445</td>
</tr>
</tbody>
</table>
Welcome to the eight issue of Landscape Research Record, published by the Council of Educators in Landscape Architecture (CELA). In 2013, the CELA Board approved and adopted a procedure to become fully responsible for publishing peer-reviewed conference papers annually and named the publication Landscape Research Record (LRR). LRR is a post-conference publication and published online only.

This eighth issue of LRR is a collection of peer-reviewed papers presented at CELA 2019 hosted by The University of California, Davis (UC Davis). The 2019 annual conference focused on research, scholarship and creative activity that highlighted the theme of “Engaged Scholarship” which created an opportunity to examine our collective past and future contributions to community-based education and real-world problem solving.

This issue contains 36 quality peer-reviewed papers resulting from the conference. We hope you find them to be a collection of provocative and insightful research that enriches CELA’s dialog of research and creative inquiry on the processes of debate and discussion.

Galen Newman, PhD, ASLA, APA
Texas A&M University
Editor-in-Chief, Landscape Research Record No. 8
CELA Vice President for Research & Creative Scholarship 2018-2020
REVIEWERS

Catherine De Almeida  Kimberlee Douglas  Jun-Hyun Kim
Richard Alomar  Christopher D. Ellis  Mintai Kim
Hamad Alsaaiari  Jessica Ernandez  Maren King
Sadik Artunc  Dominic Fisher  Travis Klondike
David Barbarash  Travis Flohr  Yekang Ko
Anne Beamish  Taz Fulford  Marty Koelsch
Noah Billig  Benjamin George  Byoung-Suk Kweon
Mallika Bose  Maria Goula  Zachary Lamb
Jennifer Britton  Steven Greco  Charlene
Kenneth Brooks  Yexuan Gu  Sungkyung Lee
Robert Brzuszek  Maggie Hanson  Barry Lehrman
Juan Antonio Bueno  Sara Harrell  Chuo Li Dongying
Jessica Canfield  Nathan Heavers  Li Weimin Li
Sara Carr  Robert Hewitt  Phoebe Likwar Lisa
Liska Chan  Martin Holland  D. Lulo
Chingwen Cheng  Rob Holmes  Yi Luo
Keith Christensen  David Hopman  Marc L. Miller
Paul Coseo  Jon D. Hunt  Brett Milligan
Adina Cox  Bin Jiang  Patrick Mooney
Carter Crawford  Shan Jiang  Holly Nelson
M. Elen Deming  Kathleen Kambic  Lisa Orr
Kirk Dimond  Haven Kiers  Taner R. Ozdil
REVIEWERS

Sohyun Park          Archana Sharma          Sarah Toth
Justin Parscher     Alan Shearer            Jamie Vanucchi
David la Pena        Ole Sleipness           Emily Vogler
Nicholas Pevzner     Samantha Solano        Judith Wasserman
Jake Powell          Alec Spangler           Heather Whitlow
Matthew Powers       Benjamin Spencer        Karen Wilson
Joseph J. Ragsdale   Stefania Staniscia     Jane Winslow
Rob Ribe             Ashley Steffens         Bo Yang
Hope Rising           Roxi Thoren             Yalcin Yildirim
Michael Ross         Anna Thurmaryr          Bambi L. Yost
Deni Ruggeri         Alison Tompkins          Phillip Zawarus
Micheal Seymour
COMMUNICATION AND VISUALIZATION

Edited by Bambi L. Yost & Jon D. Hunt
REVISITING FILM PHOTOGRAPHY AS A TECHNIQUE TO REVEAL AND ARTICULATE LANDSCAPE PHENOMENA

Torres Bustamante, César
California Polytechnic State University, San Luis Obispo, CA, cторresb@calpoly.edu

Ragsdale, Joseph
California Polytechnic State University, San Luis Obispo, CA, jragsdal@calpoly.edu

1 ABSTRACT
This paper presents work from a paired, undergraduate design studio and digital representation class in landscape architecture conducted in fall 2018 at Cal Poly San Luis Obispo, in which students experimented with a film camera to explore representation and visualization techniques as part of the early stages of the design process. Film photography was used to capture landscape qualities, and to contrast and highlight traditional photographic methods with the current, widespread use of the smartphone, for photographic documentation. This paper interprets student work and identifies successes and challenges of using the film method, both for students and for studio instructors. Results make the case for the relevance of film photography during the site analysis phase and identify ways of seeing and framing the landscape that have been replaced and substituted by the prevalence of digital photography, in particular smartphone photography. The authors also found that while photography is a valuable observation and recording tool, its use as a strategy has radically changed smartphone photography. Photos are no longer solely associated with the purely visual or fine arts, and the camera and the image become extensions of the memory and thinking processes, as we rely more on captured images to recall key information, details, data and moments. Future discussion points include: what are future opportunities for photography in landscape architecture then? what are the opportunities for photography in landscape architecture education? how should smartphone photography be used in design studios?

1.1 Keywords
Photography, film photography, smartphone, smartphone photography, site analysis.

The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the Council of Educators in Landscape Architecture (CELA), and its printing and distribution does not constitute an endorsement of views which may be expressed. Citation of this work should state that it is from a CELA conference paper. EXAMPLE: Author’s Last Name, Initials. 2018. Title of Paper. Blacksburg, Virginia: CELA. For information about securing permission to reprint or reproduce this paper, please contact CELA at staff@thecela.org
INTRODUCTION

This paper presents work from a paired, undergraduate design studio and digital representation class in landscape architecture conducted in fall 2018 at California Polytechnic State University (Cal Poly) in San Luis Obispo. Through repeated site visits, photography and discussion, students explored representation and visualization techniques as part of the early stages of the design process in order to develop a deeper understanding of the landscape and to discover design opportunities. Student exploration included film-based photography, digital photography and post-production/post-site visit techniques across multiple assignments. This paper focuses on a film-based technique meant to help students develop a deeper understanding of the landscape during a site visit, and to contrast and highlight traditional photographic methods with the current, widespread use of smartphones for photographic documentation. Methods, results and interpretation using film photography in order to capture landscape qualities are presented in this paper. It also interprets the results of student work, identifies successes and challenges in using the film photography method, and compares it with the current use of the smartphone camera for documentation. The results make the case for rethinking the use of smartphone photography during the site analysis phase, and consider new ways of seeing and framing the landscape that have been replaced and substituted by digital photography.

2.1 The Prevalence of Digital Photography and the Smartphone

As a tool to understand the landscape, photography, along with sketching, is used frequently to convey key understandings of a site; it provides a useful aide-memoire of a visit to build up a useful first impression (Entwistle & Knighton, 2013). The art and craft of color picture-taking started becoming widely and affordably available in the 1930s, when Kodak and Afga began producing mass-market, consumer ready color film. Film-photography remained the dominant form of photography until the early 21st century with the appearance of digital formats.

The number of digital photographs taken annually has grown at a compound annual rate of 9% with an estimated 1.2 trillion digital photos taken in 2017; of these, 85% were estimated to be captured with a smartphone (Perret, 2017). Smartphone photography has become the dominant device for the production and sharing of photographic images. The smartphone camera has not only replaced the digital camera (sales of digital cameras declined from 121.5 million in 2010, to 24 million 2016), but it has reconfigured our relationship with photography by setting up new processes for image making, for the perception and use of photography, and for establishing new ways of seeing and telling. Their ease of use, connectivity, and accessibility make them ideal for capturing, editing, storing and sharing visual representations of personal or collective experiences.

While the photograph is an essential tool for documentation in design courses, the current scholarship of digital photography in academic studios focuses on the product itself (the photograph) and its potential to reveal the existing and to imagine also what could be; photographs hold a “constitutive power in the shaping of reality and the perceiving of place and time” (Corner, 1996, p. xvi). The importance of non-picturesque photographic representation in design practices has been exemplified in contemporary practice by James Corner (aerial photography), Charles Waldheim and Andrea Hansen (photomontage), and Nadia Amoroso (photography in representation) among others. However, there is little scholarship that focuses on the process and devices used to take the photograph, apart from anecdotal examples. This paper does not aim to fill in that gap, but to reveal the importance of addressing the smartphone as a device to record and...
represent landscape imagery, and as a tool that frames (literally and metaphorically) the landscape in different ways that its film predecessor.

Continuous with the development and adoption of the smartphone, research has considered and advanced the use of this device in education (Patten, 2005; Herrington, 2009; Anshari, 2017). Prevalent uses of the smartphone in education include administrative tasks such as calendaring and emailing, reference tasks like information searches and lecture review, and interactive functions such as quiz taking, response software or discussion boards (Herrington, 2009). Within the studio and classroom, both authors have observed the rise in use of the smartphone by landscape architecture students. The authors regularly observe students taking notes, verifying information, searching references, collaborating via cloud-computing and capturing images of presentation slides and chalkboards with notes via their smartphones. During site visits, the authors have noticed students seeking directions, exploring site context via a satellite imagery, tracking routes, making notes, researching background information and documenting conditions with photography. Little research, however, explores the use of the smartphone photograph in design education. Although students have the opportunity to share, edit and arrange site photos as part of the design process, the authors observed that most photos remained connected and organized within the device. Site conditions and key moments informing the design process were often reviewed with students and faculty solely through the interface of the smartphone. Students scroll, locate and open a photo using the touchscreen interface, and move to the next image. Within the structure of the application and interface, students would chronologically retrace their site visit and provide narration and interpretation to the images.

2.2 Understanding the Landscape through Recording Techniques

Inventory and site analysis methods are utilized by students and professionals during the early stages of the design process. Understanding site is central to the design process for landscape architecture students and professionals. In the influential essay, *Four Trace Concepts in Landscape Architecture*, Christopher Girot advocates, “Each time a landscape project begins there should follow an extended period in which one may simply discover what already exists, most of which will not be obvious or quickly ascertained. The introduction to a site project has all too often been reduced to systematic and quantitative formulas for analyzing the site from a distance.” (Girot, 1999, p. 65). While Girot asks designers to tap into personal intuition and perception, techniques of recording observations and perceptions are left to the designer and other authors. Laurie Olin connects learning about the world and drawing because it “makes you look at it, sit still... think about what’s in front of you and what makes it tick.” (TCLF, 2013, 0:25) and Caroline Lavoie notes that drawing “creates an awareness of place that is a distinct form of information gathering and of understanding the landscape.” (Lavoie, 2005, p.13).

Photography also holds potential to deepen the connection and understanding of site. Photographs embody a finding that is unrepeatable; they hold an otherwise imperceptible time still for eternity (Corner, 1996). Although, the Journal of Landscape Architecture, *Thinking Eye* contribution guidelines explore “critical investigations into visual concepts, methodologies and media” and utilize “original ways of visually documenting, conceiving, evaluating, or changing perceptions of landscape” (JOLA, 2017), the use of photography techniques for landscape architecture focuses on the product, while the process remains elusive in the literature. The photograph can instead be found in association with design representation, post-processing and photomontage techniques (Cantrell, 2015; Amoroso, 2015; Belanger, 2014).
2.3 Purpose

Given the rise in both digital photography and smartphone use, landscape architecture might better examine the role of photography and smartphones in the design process. In order to examine and assess student’s use of the technique of photography and the technology of the smartphone, a larger study was guided by several inquiries, including: what is the role of photography in understanding a landscape? what are the opportunities and limitations for smartphone technology in recording and revealing the landscape? and what new techniques can help students understand traditional site inventory and analysis methods? Assignments and outcomes provided instruction and direction for using specific techniques to both understand and reveal a landscape site: this paper focuses on a film-based photography technique. This technique helped students utilize, consider and evaluate the use of photography in understanding the landscape, specifically in the early stages of the site inventory and analysis phase of the design process. The outcomes confirm that students did see, perceive and record the landscape differently, and also revealed unexpected observations regarding smartphone use and prevalence in design studios, and how it may affect memory and thinking processes.

3 METHODS

Sixteen students enrolled in the paired design studio and digital representation courses during a 10-week academic quarter. Both courses shared an emphasis on site exploration, recording and representation techniques and common goals for having students develop deeper understandings of place during the early stages of the design process. A study site of approximately 350 acres was selected from the larger 8,000-acre landscape at Montaña de Oro State Park in California. The study site provided students with a diversity of cultural remnants from the 100+ years of agricultural use and a transect of natural features ranging from tidepools to distinct geologic outcroppings to coastal bluff ecological communities. The study site was easily accessible and manageable for students to review over the course of a site visit and throughout the quarter. The study site also contained the main attractions and visitor infrastructural elements such as trails, information signs and parking.

A series of photography-based exercises guided students recording and representation techniques over the course of four weeks. Assignment learning outcomes emphasized site visualization, explored recording techniques and tested representation methods. For the film photography technique, the process of both understanding and recording the study site began using a limited number of photos during the first site visit. Although most students had not used film photography before, the media and associated techniques were not entirely new. Some students either owned or had worked with a film camera as a hobby or part of art-related courses. They were confronted to rethink the accessibility, ease and reliance on the digital photo, particularly those taken with the use of a smartphone. Students were grouped in pairs, and each group was given a Fujifilm QuickSnap disposable 35mm camera. These devices used Superia X-TRA 400 film with 27 exposures, so thirteen images were allocated to each individual. Instructions directed students to capture observations and impressions through the careful and purposeful use of the film-based camera. Observations could range from sensory qualities, views, materials, uses or unique experiences. Students were required to carefully consider both the topic and how the topic was captured with the viewfinder. Before clicking the shutter, critical thinking was required and students were coached to not worry about ‘being a photographer.’ An additional selfie image was a requisite to place the student into the study landscape and to help identify student photos once the film was developed. Cameras were collected by the instructors, and films were developed outside of class. Each student
received thirteen, 4”x6” glossy print photos and access to digital files approximately one week after the initial site visit. Upon returning the physical and digital photos, students were required to review the images and format a display that represented an understanding of the landscape conditions. They were required to utilize the images, either digital or physical, for subsequent presentations with the overall layout, size and order determined individually. Film photography images and formatted displays were used throughout the quarter in order to portray student understanding of the landscape.

Student work was evaluated several times throughout the quarter by both authors during project reviews. In addition, students were asked to complete two self-reflection exercises. During student reviews, the authors recorded the use of the film photography exercise in both the visual presentation of imagery pinned on the wall and in verbal presentations. Within self-reflection exercises, students indicated how they used various techniques and technology to record and reveal the site as well as how their perceptions of the techniques and technology changed during the assignment timeframe. Author notes and self-reflections were examined for repeated concepts, unique observations and novel insights in order to establish project results and discussion points.

4 FINDINGS

The students that participated in this project belong to Generation Z, a generation that is digital native as it did not experience life before the internet; it is also the first generation to have technology so readily accessible at such a young age (Turner, 2015). These individuals see and perceive things differently than previous generations. During our site visit exercise, students were observed gazing at a view while walking or scouting the site, and then framing it through the viewfinder. Many times, after framing the views, students decided not to take the photo, something that they may have done if they had a smartphone. Probably seeing through the viewfinder showed a different view, or maybe they were searching for a scene worth photographing, as they were restricted by the limited number of exposures they could take. In general, we noticed that the influence from smartphone photography asked students to define a new image making process and to reconfigure their engagement with photography and seeing and perceiving the landscape.

Modern visual technologies have transformed the way that we see. The world we live in now is not the same as it was twenty years ago, when film and film cameras dominated the market, or just five years ago, when an estimated 1 trillion digital photos were taken worldwide. Changes in technology are happening more rapidly, and these changes shape how we see and perceive the world. This process is accelerated by modern visual technology, and the vastly expanded quantities of imagery and dynamic changes that we are exposed to in everyday life.

4.1 Recording the Landscape

Students felt that limiting the number of photographs required substantially more time on-site and more thought during site exploration. In fact, restricting the number of photographs encouraged not only exploration, but also required students to see the landscape differently. Students engaged in photography as a discovery of conditions for what could be, not merely a simple documentation of what exists on site. During a regular site visit, the virtually unlimited number of photographs that can be taken with a smartphone or digital camera asks for post-review and assessment at a later time, usually after leaving the study site. When students use a digital device, they are more interested in collecting an overabundance of snapshots than on capturing only essential elements or conditions of the site. Smartphone photography is less preoccupied with the creative potential of the site, and more with the production of redundancies: a collection in which
something of interest may be found at a later time (it is not uncommon that students end up with several hundreds of photographs after a site visit). In our site documentation exercise, limiting the number of photographs to thirteen asked students to not only make informed decisions about the photographs that they would be taking, but also to reflect about the images that they already took:

> Each time I took a photo, I reflected on the previous ones I had taken and made sure that I avoided taking more than one photo of the same object or view. I think that it is interesting that all the photos can somewhat be merged together because similar colors and textures overlap amongst them.

> Student Isabelle Bertolas

> Only having 12 opportunities to capture the essence of the place, I became hyper-aware of what moments, views, and spaces captivated me. Not knowing how the pictures would turn out, it forced me to put all my trust my existing artistic and photographic ability.

> Student Elizabeth Walinder

Students had to remember the scenes that they have photographed, and create a mental map of these images. In total, they took 192 photos, all of them with different subjects, objects, textures and spaces, except for 4: two individuals decided to take the photo subject again, but shifting the photo orientation from landscape to portrait in both cases. It appears that, apart from these instances, students were satisfied by the framing offered by the viewfinder -they had to speculate how images would turn out when developed. This suggests that students were more concerned on capturing a diversity of features and scenes rather than on achieving a 'perfect' photograph.

> Traditional media puts the photographer under grave attention to take the best shot, as perceived through the lens only, while feeling a certain uncertainty of what the images will actually render.

> Student Ioanna Bruno

The redundancy of images enabled by the smartphone camera allows for experimentation and error: if something of interest is seen, there is little or no impediment to take the phone out and film -or photograph- it (Berkeley, 2014). The smartphone eliminates the time lapse between wanting to take a photo and actually taking it. However, it also promotes redundancy, as something of interest may be found in the digital pictures when analyzed at a later time. This delayed visualization is done via a smartphone or a computer: these views are not experienced directly, but on screens that “appear to offer unlimited freedom but [that] are carefully controlled and filtered views of the world” (Mirzoeff, 2016, p. 14). Screens may limit the appreciation and understanding of the site and its phenomena: the images that are used for documentation are often inspected in a different context (usually the design studio) and more importantly, the review process is altered based on the sequence in which the images are stored in the device. Unless images are organized by the user in albums, folders or galleries, smartphone stores them in the order in which they were taken: this chronologic recreation of the site visit constructs an accurate linear organization based on the order in which the images were taken. Although smartphones have advanced searching methods that help finding photos by suggesting matches to specific moments, locations, categories, persons and pets, it is
common to see students looking for a particular image by swiping or flicking rapidly across the touchscreen, scrolling and zooming through hundreds or maybe thousands of images. Each time a search is performed, the narrative of the site visit is re-created chronologically (complete or in segments), as are all other events and scenes (often personal) stored in the device since the site visit. (Figure 1)

![Figure 1. Student using the Photos app to find a specific image, after scrolling and swiping through a chronological sequencing of the site visit imagery (2018). Photos by Joseph Ragsdale.](image)

4.2 Engagement with photography

The established conventions associated with photography, such as a desire to document or preserve our memories of people, places and events (Barthes 1981; Benjamin 1936), were seen in the way students engaged with the printed photographs, with unexpected findings when images were seen together:

> Upon receiving the printed images, I was able to organize the photos by how I framed certain views. I found the similarities striking…. Upon completing this extensive, unorthodox site analysis, I found that I learned many things about not only the site, but about myself as a designer. Beginning with site exploration with a disposable camera and sketch paper, I would say that was the most comfortable part of our site analysis.

> Student Elizabeth Walinder

Students had an opportunity to organize the photos to create new narratives of the site, and the images were arranged based on physical conditions, materiality, textures, phenomena, colors, vegetation, etc., effectively eliminating the chronological narrative (Figure 2). The sequential organization that the images originally had in the film was no longer present, and new relationships and narratives emerged.
4.3 Engagement through photography

Smartphone photography defines new ways of thinking about the way we use photography in our daily lives as photography is no longer a static medium to be hung on a wall (Keep, 2014). Cultural baggage for traditional photography was evident in the way students perceived and organized the printed images: there was care in the way these images were displayed on their desks and during reviews. Along with the printed copy, students were provided with digital files, and instructors expected that these images would be edited in Photoshop. The disposable cameras used X-TRA 400 film (good for action shots and suitable to medium and low lighting conditions) and had fixed-focus lens with no other camera adjustments, except for a flash switch. Therefore, instructors speculated that students would digitally adjust their digital copies to improve light and contrast, temperature, white balance, frame and composition, etc., to remove errors like fingers obscuring photos (which happened in 10 images) or reduce blurriness (Figure 3). However, this editing was not a requirement, and instructors believe this may have been the reason why none of the students engaged in post-editing.

The first exercise was typical in that it utilized photography, but unique in the fact that the number of photos taken was restricted, and because there was no post-production work required.

Student Zoe Kulli

Instructors would also like to think that students may also have been more satisfied with the outcome, just like “film photographers are often much happier with the results of their photography [than digital photographers]” (Marquardt, 2016).
Figure 3. There were unexpected results when photographs were developed, such as fingers visible in the photo (top row) and poor focus for close-ups (bottom row). However, students seemed satisfied with the results and did not edit original files (2018). From top left, in clockwise order, photos by Carter Terranova, Daniel Wilson, Laure Goode, Nicholas Clark and Isabelle Bertolas (last two images)

Students were asked to take a selfie with their last exposure: this would help identify student’s photos once the films were developed, served as a way of placing the student into the study landscape, and seemed appropriate for students who belong to a generation who has used self-portraiture as a genre unto itself, with its own visual conventions and clichés. (Marwick, 2015). The selfie shows to others the status of the person depicted, and is a fusion of the self-image, the self-portrait of the artist as a hero, and the machine image of modern art that works as a digital performance. A selfie is a performance of a person as they hope to be seen by others. It has defined a visual vocabulary for itself (for example, a selfie looks better when taken from above and with the subject looking at the camera, and the picture usually concentrates on the face) (Mirzoeff, 2016). The portrayal of oneself asks people to pose themselves in the most flattering way they can: multiple snapshots and careful review of the images on a digital device ensures that only the perfect shot is made public.

Out of the sixteen students enrolled in the studio, three chose not to take selfies (figure 4), and preferred regular portraits taken by someone else. The reasons for not taking selfies are unclear to instructors: perhaps the students that chose portraits did so as an expression of their personal identity. At least one of these individuals has social media presence with regular updates, and instructors speculate that the film-photograph lacked the well-rehearsed pose of digital self-portraits, and that these students may not feel comfortable sharing photos that make them look less than perfect.
Figure 4. Selfies taken by students run the risk of not fitting with the set visual vocabulary for a standard selfie (top row). Some students preferred to take a portrait instead of a selfie, probably aware that they would not know how the image would turn out (2018). From top left, in clockwise order, photos by Sarah Maloney, Isabelle Bertolas, Eliana Parkerton, Jacob Scally, Daniel Wilson and Elizabeth Walinder.

5 DISCUSSION AND OPPORTUNITIES

The invention of the photograph, announced to the public in 1839, offered a new form of representation to practitioners of visual imagery (Waldheim & Hansen, 2014). At that time, it was not immediately clear how the new technique may be used: some speculated about its utility in documentation of architecture and scientific and technological subjects, and others suggested that it may become a new form of fine art. This debate lasted well into the twentieth century, with the photographers of the Picturesque legitimizing photography’s claim to be accepted as an art form by placing it in the established tradition of landscape painting and prints.

The current widespread use of the smartphone camera sets up a similar scenario for how the smartphone photograph should be used. Are instructors applying conventional film photography approaches and techniques to students’ smartphone photographs? Are students relying too much on smartphone photography for seeing and framing the landscape? Smartphone photography is so closely attached to the device that often only exists inside it; the device is no longer an optical instrument to capture still or moving images, but an apparatus for complex and previously unanticipated operations like scanning documents, depositing checks or translating text. Smartphone photography has diverged from established aesthetic conventions of traditional photography and defined a complex visual language system of our networked lives. The current use of photography in social media transforms the photograph into a device that requires feedback and becomes alive in virtual communities and networks: our bodies have become extensions of data networks, clicking, linking, and taking selfies (Mirzooff, 2016). How should then photography as documentation be framed in a design studio, and during site visits? How is a site seen, perceived and recorded through a smartphone?

This paper interprets the results of student work and identifies successes and challenges of using this singular photographic method. Results make the case for the
relevance of film photography during site review, but the conscious and deliberate use of photography can be extended to digital media as well. Carefully framing an observation with photography can help students see and understand the landscape in ways that have been replaced and substituted by digital photography. Through multiple traditional and digital photographic techniques students engaged with the landscape, developed a deeper understanding of place and experimented with representation techniques. Film photography helped students connect with place but more importantly helped connect them with the methods and practices of capturing and recording place. It also made instructors aware of the possibilities of using smartphone cameras during site visits, and of the little explored field of smartphone photography uses, approaches and meanings in the design studio. The use of a film camera became a creative activity, instrumental for both the engagement and appreciation of the landscape. While students uncovered and projected an understanding of the landscape, they also contemplated opportunities and constraints associated with using a finite versus infinite number of images. Reflections point to students valuing being forced to slow down, carefully consider and purposefully capture what they are seeing on site. This deliberate action of thinking, framing a subject and attentively observing helped students understand site conditions and uncover design possibilities for a future design intervention. As Caroline Lavoie notes of drawing, this exercise revealed similar possibilities for photography in the landscape to “create an awareness of place that is a distinct form of information gathering and of understanding the landscape setting.” (Lavoie, 2005, p.13).

Photography is a valuable observation and documentation tool, and as (digital) photographs are more prevalent than ever, captured photos are no longer solely associated with the purely visual or fine arts. The camera and image become extensions of our memory and thinking as we rely on captured images to recall key information, data and moments. What are future opportunities for photography in landscape architecture then? What are the opportunities for photography in landscape architecture education? If smartphone photography focuses more on the outcome (photograph) than the process (taking the photo), how should educators take advantage of this device as a recording and documenting tool? A gap in literature connecting photography to the landscape architecture design process is apparent. This paper reports on efforts to include photography in the landscape architecture education not for the sake of making images, rather as a tool for seeing and understanding the landscape. As students rely more on photography to take notes during class, document observations and position themselves in the landscape through selfies and social media posts, will the profession adapt to these transformations?

6 REFERENCES


DESIGN EDUCATION AND PEDAGOGY

Edited by Matthew Powers & Ashley Steffens
REVISITING SCHOLARLY PRODUCTION AMONG RECENTLY TENURED LANDSCAPE ARCHITECTURE FACULTY

CHRISTENSEN, KEITH M
Landscape Architecture and Environmental Planning, Utah State University, keith.christensen@usu.edu

MICHAEL, SEAN E.
Landscape Architecture and Environmental Planning, Utah State University, sean.michael@usu.edu

SLEIPNESS, OLE
Landscape Architecture and Environmental Planning, Utah State University, ole.sleipness@usu.edu

1. ABSTRACT
The career development and success of landscape architecture faculty hinges increasingly on their scholarship. Landscape architecture education, often emphasizing the preparation of practitioners, does not easily fit the traditional academic department model. As a result, it becomes necessary for landscape architecture faculty to describe the academic context in which they engage in scholarship and may place them at a disadvantage when evaluated. The purpose of this study was to revisit a study of landscape architecture faculty scholarly productivity by replicating a study conducted over the 2008 to 2012 academic years, assessing findings for faculty tenured since 2013 to establish a more longitudinal understanding of the trajectory of faculty scholarly productivity.

The study employed direct content analysis of the curriculum vitas of landscape architecture faculty members who were awarded tenure at public universities in the 2013-14 academic year or thereafter. Common scholarly outputs, such as refereed journal articles, juried competition participation, reports, etc., were operationalized by the research team. Two researchers independently analyzed each vita, thereafter comparing the individual results, and negotiating any discrepancies with a third researcher.

The results describe the mean scholarly productivity of landscape architecture faculty during the tenure evaluation period and after the awarding of tenure. The findings suggest landscape architecture faculty members’ scholarly productivity continues to be relatively low in comparison with other academic disciplines. An evolving, or new standard of scholarship, among landscape architecture faculty increasingly emphasizes traditional academic refereed products. Landscape architecture as an academic field is in need of greater training in conceptualizing, acquiring support for, conducting, and reporting research to be successful in an academic environment and provide a much needed foundation for current practice.

1.1 Keywords
Scholarship, Faculty, Tenure, Academia, Productivity
BACKGROUND
The career development and success of landscape architecture faculty continues to be based increasingly on their scholarship (Deming & Swaffield, 2011). Academic institutions often emphasize research performance, whose assessments of faculty productivity tend to be based on quantifiable research behaviors (Milburn & Brown, 2003). Faculty in the process of demonstrating their scholarly productivity and its value to secure academic promotion and tenure must often balance the demands of scholarship and the preparation of future practitioners. Landscape architecture does not easily fit the traditional academic department model (Milburn et al., 2003). Prior studies of landscape architecture scholarship indicate that faculty productivity is hindered by relatively high instructional loads and student contact time (Milburn, Brown, & Paine 2001; Chen et al., 2011; Christensen & Michael, 2014). As a result, it often becomes necessary for landscape architecture faculty to describe the academic context in which they engage in scholarship (Gobster, Nassauer & Nadenicek, 2010), and may place them at a disadvantage when evaluated with other faculty across their institutions.

There has been some recent investigation of the type, quality, and quantity of scholarship on which faculty may be appropriately evaluated in the diverse context of landscape architecture (Chenoweth, 1992; LaGro 1999; Milburn, Brown & Paine, 2001; Milburn & Brown, 2003; Milburn & Brown, 2016). In particular, Milburn and Brown (2016) followed up on their earlier study (2003) to identify whether research productivity of landscape architecture faculty in North America had changed over the past 15 years, providing a rare and valuable longitudinal assessment. The findings, which will be discussed further subsequently, indicate that both the research attitudes and behaviors of faculty have improved, with faculty producing research at a rate higher than ever before (Milburn & Brown, 2016). In 2014, Christensen and Michael published a study examining a smaller cohort of similar landscape architecture programs’ faculty research productivity. This study’s purpose was to revisit that study conducted for the 2008 to 2012 academic years (Christensen & Michael, 2014) and assess findings for faculty tenured from 2013 to 2016 to add to a more longitudinal understanding of faculty scholarly productivity.

METHODS
This study replicates Christensen and Michael’s (2014) earlier study employing direct content analysis, specifically systematic intuitive interpretive analyses to classify and quantify the curriculum vitae of landscape architecture faculty members who were awarded tenure in the 2013-14 academic year or thereafter. Participant selection was framed by the specific need to communicate expectations for landscape architecture faculty productivity within Utah State University. As a result, participant selection involved first identifying similar public land-grant university programs with accredited bachelors and masters degrees in landscape architecture. Twenty one of 66 accredited academic programs, all within the United States, were identified as peer institutions to Utah State University. These institutions are the same as those from Christensen and Michael’s 2014 study.

During September of 2016, the administrators for each of these 21 academic programs and Utah State University were contacted and asked to identify their faculty who had been awarded tenure in the 2013-14 academic year or thereafter. One program administrator was unresponsive after repeated requests and was excluded from the study. The remaining 21 administrators identified 19 faculty who were awarded tenure during the defined period. However, one of these faculty members was included in the prior study (Christensen & Michael, 2014) and were excluded from this study. According to the purpose of the study, faculty members who were not successful in garnering tenure were excluded from the study. Eight academic programs reported no faculty awarded tenure since the 2013-14 academic year. No indication of overall tenure success rates among landscape architecture faculty could be identified in the published literature.

Participation of the 18 identified individuals was solicited by an email request wherein they were asked to provide their current full curriculum vita. Participants were assured anonymity in the reported results. One faculty member was unresponsive after repeated requests. In total, 17 faculty members representing thirteen academic programs participated in the study, a 94% response rate.

3.1 Measures
Scholarship in landscape architecture may be defined as creative intellectual work that is validated by peers and communicated. Accordingly, scholarly productivity is primarily assessed by peer
review as a measure of the quality of a faculty member’s contribution, and the number of publications, presentations, and secured external funding as measures of communication productivity or quantity (Rudd, 1988 in Milburn et al., 2003). Although these generalities cannot fully elucidate the complexity of scholarship in landscape architecture, an important step toward a more coherent academy is the acceptance of increasingly precise terminology regarding scholarly outputs (LaGro, 1999). This is still the case. Accordingly, to establish a coherent metric for this study the authors identified categories of scholarly output felt to be generally recognized, as shown in Table 1, the definitions for which were taken from established definitions/specifications such as the 2012 Higher Education Research Data Collection (HERDC) specifications and Australia Research Council (HERDC, 2012; ERA, 2012; Deakin, 2012) and were those use in Christensen and Michael’s prior study (2014).

3.2 Procedures

Content analysis of the curriculum vita was conducted during January 2017. The textual content was individually coded and quantified for the year tenure was awarded and the prior five years. Post-tenure was the year following through the fall semester of the 2016-17 academic year. In consideration of publication lags, all works reported as accepted or in-press were counted as published in the year indicated. Single and multi-authored publications or creative works were not assessed differently.

Two researchers independently coded the textual content of each vita according to the pre-defined operational terms/categories and their subjective perspective, for both pre- and post-tenure. The categories under which individual faculty presented their scholarly output were not strictly adhered to, but rather the textual information was coded according to the previously agreed upon operational definitions for this study. The individual results were then compared to identify any discrepancies, whereupon consensus agreement concerning alternative interpretations was reached through dialogue with a third researcher (Graneheim & Lundman, 2004). The agreed upon findings were then interpreted to address the purpose of the study. For the 40 pre- and post-tenure categories assessed, initial agreement was over 80% with the exception of five categories where a consensus agreement had to be reached.

4 RESULTS

The study results are reported descriptively as the total mean productivity by category during the tenure evaluation period and after the awarding of tenure in Table 2. The information in Table 2 is not presented for comparison between the pre- and post-tenure award periods as the post-tenure period varies in length between participants. However, the total mean productivity from the prior study (Christensen & Michael, 2014) is included for comparison, with an asterisk where there appears to be a substantial increase. Three participants are outliers with significantly higher scholarly productivity in numerous categories, being at least one standard deviation greater than the mean. For example, of the 89 total pre-tenure peer reviewed journal articles published by the cohort, 40 were published by the three outliers. The total mean productivity is also reported with these three participants excluded from the sample for clarity.

Participants’ curriculum vita were very unclear regarding the distinction between grants and contracts. As the researchers were unable to code the information appropriately, it was necessary to aggregate all funding as external funding, although this category does include internal academic institution awards as well. The consensus agreement value is used for the remaining categories where initial agreement was below 80%; pre-tenure peer reviewed journal articles (65% initial agreement), peer reviewed conference proceedings (53% initial agreement), presentations (76% initial agreement). Across the participants it was difficult to assess the accuracy of journal articles and conference proceedings designated as peer-reviewed. These category required substantial careful investigation of the referenced journals and proceedings by the researchers to determine the review process and establish consensus agreement. While presentations and awards were rarely presented in a consistent or straightforward manner.

The mean yearly scholarly productivity is reported in Table 3. To calculate the yearly productivity for participants after the awarding of tenure, the overall scholarly productivity was divided by the mean post tenure period for participants. The data is presented with the total mean productivity from the prior study (Christensen & Michael, 2014) included for comparison, with an asterisk where there appears to be a substantial increase.
Table 1. Scholarly output categories and definitions (Christensen & Michael, 2014).

<table>
<thead>
<tr>
<th>Category</th>
<th>Review</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal Article</td>
<td>Peer</td>
<td>A written work published in an academic/professional journal. The journal is published by a recognized publisher and possesses an ISBN.</td>
</tr>
<tr>
<td>Conference Proceedings</td>
<td>Peer</td>
<td>A fully written work published in the collection of papers of an academic/professional conference.</td>
</tr>
<tr>
<td>Abstract</td>
<td>Peer</td>
<td>A written abstract, extract, extended abstract, or synopsis published in an academic/professional journal or conference proceedings.</td>
</tr>
<tr>
<td>Presentation – Invited</td>
<td>-</td>
<td>Presentation at an academic/professional conference where the organizers independently approach the author.</td>
</tr>
<tr>
<td>Presentation – Contributed</td>
<td>-</td>
<td>Presentation at an academic/professional conference where the author approaches the organizers.</td>
</tr>
<tr>
<td>Presentation – Poster</td>
<td>-</td>
<td>Presentation of a display at an academic/professional conference.</td>
</tr>
<tr>
<td>Book</td>
<td>-</td>
<td>A major written work bound and published. Preferably by a recognized commercial press or publisher, and possessing an ISBN.</td>
</tr>
<tr>
<td>Book Chapter</td>
<td>-</td>
<td>A written work contributing to a compilation subject to editorial scrutiny.</td>
</tr>
<tr>
<td>Article – Working Paper</td>
<td>-</td>
<td>A written work distributed independently or in an unrecognized journal.</td>
</tr>
<tr>
<td>Article – Popular Press</td>
<td>-</td>
<td>Newspaper or magazine articles, media interviews, internal newsletters and the like.</td>
</tr>
<tr>
<td>Report</td>
<td>-</td>
<td>A written work completed in behalf of an independent entity.</td>
</tr>
<tr>
<td>Website</td>
<td>-</td>
<td>An online work.</td>
</tr>
<tr>
<td>Illustration</td>
<td>-</td>
<td>A graphic work distributed independently or in a recognized outlet.</td>
</tr>
<tr>
<td>Exhibit</td>
<td>Refereed</td>
<td>Curated exhibition of original creative work in an independent public venue.</td>
</tr>
<tr>
<td>Design Competition</td>
<td>Refereed</td>
<td>A competition sponsored by an independent organization inviting the submission of proposals.</td>
</tr>
<tr>
<td>Creative Work,</td>
<td>-</td>
<td>Original work for which copyright law could conceivably apply.</td>
</tr>
<tr>
<td>Design/Planning Project</td>
<td>-</td>
<td>The manifestation of original work/design common to landscape architecture and its allied disciplines.</td>
</tr>
<tr>
<td>Built Work</td>
<td>-</td>
<td>An award offered by an independent organization according to a publicly understood process. The independent organization is at least an academic institution or equivalent.</td>
</tr>
<tr>
<td>Award</td>
<td>-</td>
<td>Funding allocated through competitive granting schemes.</td>
</tr>
<tr>
<td>Grant Award</td>
<td>Refereed</td>
<td>Funding allocated in response to an independent organization’s request.</td>
</tr>
<tr>
<td>Contract Award</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Peer – Peer reviewed work involved a formal, impartial, and independent assessment or review of the work in its entirety before publication/presentation, conducted by qualified experts independent of the author.

Refereed – Refereed exhibits involved a publicly understood refereeing process conducted by an independent review panel formed from qualified peers.

Table 2. Total mean productivity by scholarly output category (not for pre-post comparison).

<table>
<thead>
<tr>
<th>Category</th>
<th>Tenure Timing</th>
<th>2013 Mean Productivity</th>
<th>2016 Mean Productivity</th>
<th>2013 Mean Productivity excluding Outliers</th>
<th>2016 Mean Productivity excluding Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal Article</td>
<td>Pre</td>
<td>3.6</td>
<td>5.2*</td>
<td>2.4</td>
<td>3.5*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.7</td>
<td>1.5</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Journal Article</td>
<td>Pre</td>
<td>1.7</td>
<td>2.0</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.5</td>
<td>0.3</td>
<td>1.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Conference Papers</td>
<td>Pre</td>
<td>3.0</td>
<td>2.6</td>
<td>1.8</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>2.2</td>
<td>0.4</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Conference Papers</td>
<td>Pre</td>
<td>1.2</td>
<td>2.4*</td>
<td>0.9</td>
<td>2.1*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.2</td>
<td>0</td>
<td>0.6</td>
<td>0</td>
</tr>
<tr>
<td>Abstract</td>
<td>Pre</td>
<td>2.6</td>
<td>2.8</td>
<td>0.4</td>
<td>1.2*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.9</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Abstract</td>
<td>Pre</td>
<td>0.1</td>
<td>0.8*</td>
<td>0.1</td>
<td>0.7*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Presentation – Invited</td>
<td>Pre</td>
<td>7.9</td>
<td>5.9</td>
<td>6.6</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>6.4</td>
<td>0.9</td>
<td>6.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Presentation – Contributed</td>
<td>Pre</td>
<td>16.1</td>
<td>12.1</td>
<td>5.2</td>
<td>10.4*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>4.9</td>
<td>1.5</td>
<td>4.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Presentation – Poster</td>
<td>Pre</td>
<td>0.8</td>
<td>1.1*</td>
<td>0.3</td>
<td>1.3*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.0</td>
<td>0.1</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Book</td>
<td>Pre</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3*</td>
</tr>
<tr>
<td>Book Chapter</td>
<td>Pre</td>
<td>0.5</td>
<td>0.6</td>
<td>0.4</td>
<td>0.8*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.0</td>
<td>0.1</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Article – Working Paper</td>
<td>Pre</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Article – Popular Press</td>
<td>Pre</td>
<td>8.3</td>
<td>1.5</td>
<td>9.4</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>4.6</td>
<td>0.1</td>
<td>5.7</td>
<td>0</td>
</tr>
<tr>
<td>Report</td>
<td>Pre</td>
<td>3.4</td>
<td>1.4</td>
<td>2.9</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.6</td>
<td>0.1</td>
<td>0.6</td>
<td>0.1</td>
</tr>
<tr>
<td>Website</td>
<td>Pre</td>
<td>0.2</td>
<td>0</td>
<td>0.3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.1</td>
<td>0</td>
<td>1.3</td>
<td>0</td>
</tr>
<tr>
<td>Illustration</td>
<td>Pre</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exhibit</td>
<td>Pre</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exhibit, Refereed</td>
<td>Pre</td>
<td>0.9</td>
<td>1.1</td>
<td>1.0</td>
<td>1.4*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.5</td>
<td>0.4</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Design Competition</td>
<td>Pre</td>
<td>0.3</td>
<td>0.6*</td>
<td>0.3</td>
<td>0.7*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Creative Work, Design/Planning Project</td>
<td>Pre</td>
<td>1.3</td>
<td>3.5*</td>
<td>1.2</td>
<td>3.0*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.5</td>
<td>0.4</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Built Work</td>
<td>Pre</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Award</td>
<td>Pre</td>
<td>2.9</td>
<td>9.3*</td>
<td>3.0</td>
<td>9.1*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>2.4</td>
<td>2.0</td>
<td>2.1</td>
<td>2.4</td>
</tr>
<tr>
<td>External Funding</td>
<td>Pre</td>
<td>$610,024</td>
<td>$175,616</td>
<td>$344,915</td>
<td>$120,509</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>$266,665</td>
<td>$47,353</td>
<td>$81,146</td>
<td>$28,843</td>
</tr>
</tbody>
</table>

* Denotes at least a 25% increase.
Table 3. Mean yearly productivity by scholarly output category.

<table>
<thead>
<tr>
<th>Category</th>
<th>Tenure Timing</th>
<th>2013 Mean Yearly Productivity</th>
<th>2016 Mean Yearly Productivity</th>
<th>2013 Mean Yearly Productivity excluding Outliers</th>
<th>2016 Mean Yearly Productivity excluding Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal Article</td>
<td>Pre</td>
<td>0.6</td>
<td>0.87*</td>
<td>0.4</td>
<td>0.58*</td>
</tr>
<tr>
<td>Peer Reviewed</td>
<td>Post</td>
<td>1.19</td>
<td>0.81</td>
<td>0.35</td>
<td>0.50*</td>
</tr>
<tr>
<td>Journal Article</td>
<td>Pre</td>
<td>0.28</td>
<td>0.33</td>
<td>0.31</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.48</td>
<td>0.17</td>
<td>0.58</td>
<td>0.17</td>
</tr>
<tr>
<td>Conference Proceedings</td>
<td>Pre</td>
<td>0.5</td>
<td>0.43</td>
<td>0.3</td>
<td>0.37</td>
</tr>
<tr>
<td>Peer Reviewed</td>
<td>Post</td>
<td>0.71</td>
<td>0.21</td>
<td>0.29</td>
<td>0.17</td>
</tr>
<tr>
<td>Conference Proceedings</td>
<td>Pre</td>
<td>0.2</td>
<td>0.4*</td>
<td>0.15</td>
<td>0.36*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.38</td>
<td>0</td>
<td>0.19</td>
<td>0</td>
</tr>
<tr>
<td>Abstract</td>
<td>Pre</td>
<td>0.43</td>
<td>0.47</td>
<td>0.06</td>
<td>0.20*</td>
</tr>
<tr>
<td>Peer Reviewed</td>
<td>Post</td>
<td>1.26</td>
<td>0.31</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Abstract</td>
<td>Pre</td>
<td>0.01</td>
<td>0.14*</td>
<td>0.01</td>
<td>0.12*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0.03</td>
<td>0</td>
<td>0.04</td>
</tr>
<tr>
<td>Presentation – Invited</td>
<td>Pre</td>
<td>1.31</td>
<td>0.99</td>
<td>1.1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>2.07</td>
<td>0.52</td>
<td>1.97</td>
<td>0.63</td>
</tr>
<tr>
<td>Presentation – Contributed</td>
<td>Pre</td>
<td>2.68</td>
<td>2.02</td>
<td>0.86</td>
<td>1.73*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.58</td>
<td>0.90</td>
<td>1.52</td>
<td>0.71</td>
</tr>
<tr>
<td>Presentation – Poster</td>
<td>Pre</td>
<td>0.13</td>
<td>0.18*</td>
<td>0.05</td>
<td>0.21*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.32</td>
<td>0.03</td>
<td>0.09</td>
<td>0.04*</td>
</tr>
<tr>
<td>Book</td>
<td>Pre</td>
<td>0.06</td>
<td>0.06</td>
<td>0.08</td>
<td>0.06*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.06</td>
<td>0.14*</td>
<td>0.06</td>
<td>0.17*</td>
</tr>
<tr>
<td>Book Chapter</td>
<td>Pre</td>
<td>0.08</td>
<td>0.11*</td>
<td>0.06</td>
<td>0.13*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.32</td>
<td>0.07</td>
<td>0.25</td>
<td>0.08</td>
</tr>
<tr>
<td>Article – Working Paper</td>
<td>Pre</td>
<td>0</td>
<td>0.02</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0.02</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td>Article – Popular Press</td>
<td>Pre</td>
<td>1.38</td>
<td>0.25</td>
<td>1.56</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>1.48</td>
<td>0.07</td>
<td>1.84</td>
<td>0</td>
</tr>
<tr>
<td>Report</td>
<td>Pre</td>
<td>0.56</td>
<td>0.24</td>
<td>0.48</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.51</td>
<td>0.03</td>
<td>0.19</td>
<td>0.04</td>
</tr>
<tr>
<td>Website</td>
<td>Pre</td>
<td>0.03</td>
<td>0</td>
<td>0.05</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.35</td>
<td>0</td>
<td>0.42</td>
<td>0</td>
</tr>
<tr>
<td>Illustration</td>
<td>Pre</td>
<td>0</td>
<td>0.02</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0.02</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td>Exhibit</td>
<td>Pre</td>
<td>0.15</td>
<td>0.19*</td>
<td>0.16</td>
<td>0.23*</td>
</tr>
<tr>
<td>Refereed</td>
<td>Post</td>
<td>0.16</td>
<td>0.21*</td>
<td>0.16</td>
<td>0.22</td>
</tr>
<tr>
<td>Design Competition</td>
<td>Pre</td>
<td>0.05</td>
<td>0.10*</td>
<td>0.05</td>
<td>0.12*</td>
</tr>
<tr>
<td>Refereed</td>
<td>Post</td>
<td>0.03</td>
<td>0.07*</td>
<td>0.03</td>
<td>0.08*</td>
</tr>
<tr>
<td>Creative Work, Design/Planning Project</td>
<td>Pre</td>
<td>0.21</td>
<td>0.59*</td>
<td>0.2</td>
<td>0.50*</td>
</tr>
<tr>
<td>Built Work</td>
<td>Pre</td>
<td>0.01</td>
<td>0.02*</td>
<td>0.01</td>
<td>0.02*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0</td>
<td>0.02</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td>Award</td>
<td>Pre</td>
<td>0.48</td>
<td>1.55*</td>
<td>0.5</td>
<td>1.51*</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>0.77</td>
<td>1.18*</td>
<td>0.67</td>
<td>1.39*</td>
</tr>
<tr>
<td>External Funding</td>
<td>Pre</td>
<td>$101,670</td>
<td>$29,269</td>
<td>$57,485</td>
<td>$20,085</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>$86,299</td>
<td>$27,855</td>
<td>$26,260</td>
<td>$16,966</td>
</tr>
</tbody>
</table>

* Denotes at least a 25% increase.
5 DISCUSSION

A major criticism of the academic field in supporting the profession (Milburn, Brown & Paine, 2001), scholarly productivity in landscape architecture is low relative to that of collegiate scholars, where yearly publication rates range between 0.74 in the fine arts, 1.46 in the physical sciences, 2.54 in health sciences, and 3.38 in engineering for example (Pripp, 2009; Fox, 2005; Fairweather, 2002; Dundar & Lewis, 1998). Prior study indicates landscape architecture faculty publish 0.93 refereed articles per year (Milburn & Brown, 2016) and give 2.25 conference presentations per year (Milburn & Brown, 2016). Further, Milburn and Brown (2016) suggest that 54% of refereed journal articles are produced by 20% of the landscape architecture faculty.

This study supports this finding, with 18% of the faculty participants having produced 45% of the total refereed journal articles pre-tenure and 50% post-tenure. With such a disparity it is difficult to know how to best represent the scholarly productivity of landscape architecture faculty, hence this study presents the findings with these ‘outliers’ included and excluded. Given this, the study findings indicate that during the evaluation period for tenure landscape architecture faculty publish between 0.6 and 0.9 peer reviewed journal articles per year, 0.4 peer reviewed articles in conference proceedings per year, give 1 invited conference presentation, and delivered between 1.7 and 2 contributed conference presentations per year. The findings represent an increase in peer reviewed journal articles since that reported in 2014 of about a quarter of an article per year. Presentations and peer-reviewed conference proceeding rates are more similar to those reported in 2014 (Christensen and Michael, 2014) and by Milburn and Brown (2016), perhaps suggesting an increasing focus on peer reviewed journal articles as a recognized academic product in the tenure assessment process.

It is important to recognize that measuring publication rates is likely not a reliable indicator of article quality, nor does it account for the effect of co-authorship, journal quality, etc. The use of citation rates as a proxy for article quality and impact is common in promotion and tenure decision processes. However, citation analysis, such as the $h$-index, are criticized for being discipline-dependent; skewed toward science and technology, while design fields are disadvantaged and deficient in their scholarly representation (Gervits & Orcutt, 2016). It is likely that citation rates among landscape architecture faculty are low in comparison with other fields. Of the 17 participants in this study, a Google Scholar $h$-index was only found for 5 which ranged from 3 to 6, with one outlier whose $h$-index was 15. This study did not formally examine citation rates among the participants and their publications.

With regard to external funding, landscape architecture faculty secured between $29,269 and $20,085 per year of their pre-tenure evaluation period. This is a significant reduction, an over 65% decrease, than the external funding secured pre-tenure reported in 2014. It is unclear from the data available what may be contributing to this reduction in external funding.

After being awarded tenure, landscape architecture faculty publish between 0.50 and 0.81 peer reviewed journal articles per year, 0.17 to 0.21 articles in peer reviewed conference proceedings per year, give one invited presentation, and delivered 0.71 to 0.90 contributed conference presentations per year. Post tenure, landscape architecture faculty secure between $16,966 and $27,855 in external funding each year. These results suggest that publication rates do not appear to significantly decline post-tenure, although conference presentation rates appear to decline. At the same time, these rates appear to be substantially lower than those reported in 2014 and by Milburn and Brown (2016), particularly for presentations. However, Milburn and Brown (2016) did not differentiate between pre- and post-tenure faculty in reporting these results, and it may be that pre-tenure faculty in landscape architecture are contributing the majority of the peer reviewed scholarly outputs in the field.

While low overall, the results suggest that landscape architecture faculty are emphasizing traditional academic refereed products. Further, scholarly products historically associated with landscape architecture, but less so with other academic disciplines, such as exhibits, design competitions, and creative work, are being largely ignored likely in favor of the more institutionally accepted outlets needed to garner support in the academic environment. This emphasis is reflected in the way faculty scholarship is presented in vita, which can appear highly variable without widely understood and adhered to definitions of scholarly products. In lieu of establishing specifications for scholarly products in the field of landscape architecture, it would be beneficial if landscape architecture faculty adhered more closely to commonly accepted definitions of scholarly products, as suggested previously (Christensen & Michael, 2014). Although doing so deserves a great deal more discussion.

Publication of faculty research is currently occurring primarily in recognized scholarly outlets, with no participants reported the independent distribution of working papers and very few articles in the
popular press, a decline from 2014. This may portend a negative impact on the translation of research to practice, which is a major criticism of academia. The vast majority of the peer reviewed abstracts are associated with the annual conference of the Council of Educators in Landscape Architecture (CELA). There are very few other outlets which employ a similar dissemination strategy of peer reviewed abstracts. Landscape architecture faculty members are endeavoring to maximize this outlet during the tenure review period, and much less so post-tenure.

The results of this study are similar to those reported by Milburn and Brown (2016) in suggesting that a minority of landscape architecture faculty are responsible for a majority of the scholarly productivity. A comparison of scholarly productivity between the three outlying participants and the remainder of the sample indicates that the three outlying participants are responsible for over 24% of the scholarly productivity during the tenure evaluation period and 23% post-tenure. When considering all of the participants and all of the identified scholarly products, the results suggest that faculty productivity decreases significantly (45%) post tenure. Most interestingly, external funding awards do not appear to change pre- to post-tenure (5% decrease), unless the three outlying participants are excluded and then external funding falls 16% post-tenure. It appears that in part, an experienced faculty member is better positioned to garner funding and will continue to do so, but this experience needs to be gained during tenure process. Otherwise, the trend in securing external funding does not continue. The findings thus suggest that faculty productivity decreases immediately post tenure, quite significantly, as well as reiterating that a minority of landscape architecture faculty members are responsible for a majority of the scholarly productivity, results similar to those found recently by Milburn and Brown (2016).

The reasons behind these findings should be examined in the future, but are likely due to a minority of landscape architecture faculty being academically trained for the scholarly demands of the academic environment. The proportion of faculty who hold doctoral degrees in this sample (9 of 17) is very similar to that reported in 2014 (8/18) (Christensen & Michael, 2014). A careful examination of the results supports this assertion in that productivity measured for scholarly categories that are often less valued in the academic environment, such as exhibits, popular press articles, and contributed presentations, actually rises when those faculty who do not possess doctoral degrees are excluded. While the scholarly categories typically most valued in the academic environment, such as peer reviewed publication, are lower.

However, some caution should be exercised as the data are reported for the six years of the tenure period, while productivity post tenure is reported for individual periods that together averaged just 1.7 years. Further, sabbatical leave awarded post tenure is not accounted for in this study. While an argument can be made that scholarly activities continue during a sabbatical period, the opposite may be true in that faculty on sabbatical leave may not be engaged in scholarly activities. Interestingly, very few participants (n=2) were awarded tenure in the last two years.

5.1 Limitations

This study has a number of limitations. We were unable to evaluate the level of responsibility individual participants had for externally funded research as few faculty members reported whether they were the principal or co-principal investigator. We were unable to assess the level of responsibility for multiple author publications as few respondents reported their role in the publication. Nor were we able to assess the role played in individual faculty member’s professional practice experience or whether their experience was academic or professional practice experience. Guest or invited jury participation was not measured in this study given the variability of reporting.

Most unfortunately, there are a host of well-studied factors which influence scholarly productivity, such as age, gender, subfield specialization, collaboration, etc., which the authors did not assess (see Helsi & Lee, 2011 for a more complete presentation of these factors), although Milburn and Brown (2016) suggest that age, gender do not influence scholarly productivity. It is very likely that instructional loads have a great deal of impact on scholarly productivity. Teaching in landscape architecture is time intensive. With studio-based curricula and faculty/student ratios being accreditation requirements, landscape architecture faculty typically have high student contact time overall as well as per credit hour, and labor intensive teaching loads (Milburn, Brown & Paine, 2001). The high instructional load is often offered as justification for the low scholarly productivity among landscape architecture faculty. However, we were unable to accurately assess instructional load as very few respondent’s curriculum vita indicated the number of credits or contact time for the listings of courses taught. In addition, the difference between academic institutions’ credit equivalents was not known.
6 IMPLICATIONS

The purpose of this study was to establish a current understanding of landscape architecture faculty scholarship. The findings indicate that scholarly productivity in landscape architecture is low overall and falls significantly after the awarding of tenure. The role of instructional loads needs to be examined. During the evaluation period for tenure faculty members focus on more commonly valued categories of academic scholarship. In addition to establishing the scholarly productivity rates of landscape architecture faculty, the most significant finding of this study suggests that a minority of landscape architecture faculty are responsible for a majority of the scholarly productivity. Considered together, the overall low scholarly productivity and a minority of faculty accounting for the majority of the scholarly productivity points toward a critical need for greater preparation of the landscape architecture academy in conceptualizing, acquiring support for, conducting, and reporting meaningful scholarship. Doing so will lead to greater success in the academic environment, support for evidence-based professional practice, and provide a much needed theoretical foundation for the future of landscape architecture. At the same time, instruction in the field needs to be examined. The low overall scholarly productivity of faculty may be hindered by high instructional loads, which is likely. Evidence for this assumption should be sought to provide an evidence base for faculty’s case for promotion and tenure in the academic environment.

Despite national discussions regarding the future of the tenure model in higher education, the majority of new and emerging landscape architecture faculty positions employ this system. Consequently, success for the emerging faculty nationally will rely upon effective performance within the tenure track system. In a climate of increasing demands for transparency and accountability by the public and legislators, emerging academics can expect to face calls for performance at or above national standards. Doing so within the realm of scholarship requires clarity in benchmarks among peers at peer institutions. This study contributes to continuing efforts to establish an understanding of these benchmarks and their longitudinal trends. The current findings offer a foundation for understanding productivity among successful early career scholars in the discipline.

7 REFERENCES


NATURE RX – IMPROVING HEALTH BY SPENDING TIME OUTSIDE

KIERS, A. HAVEN
University of California at Davis, ahkiers@ucdavis.edu

1 ABSTRACT

Ever accelerating technological changes had the unfortunate effect of disconnecting us from the outdoors. In multiple studies, researchers have shown that people spend more time indoors looking at screens than they do outside and that our mental and physical health is suffering as a result (Louv, 2011; Williams, 2018). UC Davis is one of a number of universities attempting to address this nature deficit disorder through programs that fall under the umbrella of “Nature Rx.”

This paper seeks to evaluate these programs and their attempts to embolden participants to push competing priorities aside and head outdoors. Goals included: 1) exposing students, staff, and faculty to the gardens, green spaces, and natural areas of UC Davis; 2) introducing them to community members that interact with nature through research or vocation; 3) identifying organizations that connect people to nature at UC Davis; and 4) providing information about the therapeutic benefits associated with spending time in nature.

A mixture of quantitative and qualitative methods was used to determine the programs’ effectiveness. Data were compiled through pre and post class survey instruments, final evaluations, and written personal reflections. Survey data taken from a similar Nature Rx class at Cornell University were also integrated into the findings. Results indicate participants gained greater levels of comfort and familiarity with the campus and its community and developed a deeper awareness of the value of time spent in nature. These findings suggest that directed classes in nature therapy can positively impact the health of university communities.

1.1 Keywords
Nature Rx, Nature Deficit Disorder, Nature Prescription, Biophilia, Landscape Architecture Pedagogy
2 INTRODUCTION

In March of 1994, the Departments of Environmental Design and Environmental Horticulture at the University of California, Davis, along with the San Francisco Sheriff's Department, organized a research symposium to explore the relationship between plants and human well-being. The symposium, entitled Healing Dimensions of People-Plant Relations, attracted researchers from disciplines spanning landscape architecture, horticulture, psychology, and sociology. Through presentations focusing on community gardens, urban forests, horticultural therapy, environmental education, healing gardens, and more, researchers outlined the health and well-being case for encouraging people to interact more deliberately with nature. In his keynote address to the symposium, founding member of the People-Plant Council Charles Lewis applauded research accomplishments within the nascent cross-disciplinary field and speculated on the future of people-plant relations. He predicted that a) technological innovations would help further refine research results on the psycho-physiological benefits of nature interaction, b) the health benefits of people-plant relationships would be recognized as necessary for the nation’s well-being, c) plants and plant-centered activities would be more integrated into our culture, and d) a priority for healthy humanity would be the reestablishment of the people-plant connection (Lewis, 1994).

Strikingly, twenty-five years later, attitudes have changed very little, and society places even less emphasis on human health and nature contact. While Lewis was correct in forecasting the rise of evidence-based research to scientifically support the positive health effects of nature interaction (e.g. Frumkin et al., 2017), he was unable to account for the deleterious effect increased technology use would have on society and our resulting inability to embrace the healing value of people-plant relationships. Technology now dominates our daily lives, with recent studies highlighting alarming trends of American teens spending close to eight hours a day using entertainment media and adults checking email obsessively while on vacation and insisting on sleeping with their smart phones within reach (Rideout, 2010; Perlow, 2012). A 2017 study reported that of 12,000 adults interviewed, more than half reported spending five hours or less in nature per week and that their children spend three times as many hours indoors on computers and telephones as they do playing outside (Kellert, 2017).

This is not to say that social and cultural progress hasn’t been made in the interim towards the integration of plant contact into our daily lives, as evidenced by the popularity of nature programming such as biophilic design, the rise of physicians writing park prescriptions requiring patients to spend time outside, and the creation of forest therapy trails to promote the practice of shinrin-yoku (forest bathing), among others. The terms may have evolved and our scientific knowledge base may have expanded, but, unfortunately, our methods for disseminating the benefits of nature interaction have remained static. Charles Lewis charged symposium attendees in 1994 to “shout from the rooftops of the miracles we have witnessed” and encouraged them to “mount campaigns to spread the word that plants play an essential role in human well-being.” In the current age of information inundation through internet, social media, and smart phones, Lewis’s traditional methods of sharing information have failed to bring about the large-scale cultural changes he predicted, largely because messages about well-being are crowded out by competing priorities and technologies.

A growing body of research indicates that the most effective and durable way to create meaningful learning experiences is through experiential education. As posited by David Kolb in his theory of experiential learning, knowledge is gained through concrete experience (hands-on learning) and abstract conceptualization, and then solidified through reflective observation and active experimentation (Kolb, 1984). The UC Davis Nature Rx Program was founded on the belief that while people are engaged in immersive outdoor activities, they are also reaping the health and wellness benefits of being in nature and experiencing the value of people-plant interactions. Cultural attitudes change not from lectures, social media posts, or scientific articles, but from ongoing direct experiences and the reflections that come from participating in them. Nature Rx is now one of the foundational elements of a broader, campus-wide effort to create programs and landscapes that support a more holistic vision of sustainability that encompasses human health and well-being at its core.

3 BACKGROUND

Although the beneficial relationship between nature connectedness and human health and well-being has been well defined in the literature (for reviews see Richardson, 2017, Pritchard, 2019, Hartig, 2018).
2014), it is only relatively recently, with rising crises in both human mental health (Frankish, 2018) and planetary health (Camilo, 2018), that there has been a resurgence in research on this topic. Policy makers and urban planners are increasingly utilizing this research on nature connectedness to strengthen arguments for sustainable urban environments that not only benefit the natural world, but also benefit human well-being (United Nations General Assembly, 2016). High level organizations such as the WHO and the United Nations have created policy documents and global frameworks touting the value of constructing urban green spaces to improve human health outcomes (WHO, 2013, UN General Assembly, 2015). And conviction is gaining ground among public health practitioners that health and healthy behaviors are not derived solely from personal factors, but additionally from one’s surrounding physical and social environment (Brug et al., 2006). This has increased the number of health practitioners embracing the benefits of contact with nature, resulting in the phenomenon (typically referred to as “Nature Rx” or ”Park Rx”) of healthcare professionals prescribing time in nature to their patients (Seltenrich, 2015).

4 METHODS

The UC Davis Nature Rx program was piloted in the fall of 2016 with a not-for-credit student seminar (“Aggie Connection”) and then officially launched in the fall of 2017 to specifically target two campus populations (staff/faculty and students) with separate interventions. Freshman and incoming transfer students could register for a weekly, two-hour, two-unit seminar that met on Friday afternoons, while faculty and staff were invited to sign up for one of three or four hour-long lunchtime sessions. Although the specifics of the programs varied, the goal for each was the same: to teach participants the therapeutic value of nature through immersive, experiential programs. The Nature Rx first-year student seminar was offered for a 10-week quarter in fall of 2017 and again in fall of 2018. Three staff and faculty Nature Rx health and well-being sessions were offered in fall of 2017. A fourth session was added for fall of 2018.

A mixture of quantitative and qualitative methods was used to determine the effectiveness of the two Nature Rx programs. For the first-year student seminar, data were compiled through the use of pre- and post-class survey instruments (from 2018 only) and written personal reflections (2017 and 2018). For the faculty/staff series, data were collected from online evaluation forms distributed at the end of each program (2017 and 2018).

A total of 23 students from two universities, the University of California, Davis (UC Davis) and Cornell University, participated in the pre- and post-class survey. The study’s sample size was drawn from 18 students in the first-year Nature Rx student seminar at UC Davis and 7 students from a similar Nature Rx class at Cornell University also offered in the fall of 2018. The two courses varied in scope, length, and format, but shared similar learning objectives, including: how time spent in natural settings contributes to holistic self-care and can improve overall well-being; how nature is accessible and all around us, both on campus and at nearby sites; and how to identify campus organizations and activities to stay regularly connected to nature. The study utilized identical pre-and post-class surveys at both campuses. One was distributed in the beginning of the course to assess a baseline of information and the second was distributed at the end of the course to gauge changes in attitudes and learning outcomes. Quantitative and qualitative response analysis was conducted upon course completion and data from both courses shared between instructors. Responses for both surveys were collected anonymously and voluntarily. Additionally, students in the UC Davis Nature Rx first-year student seminar were required to write personal reflections at the end of the course. In 2017, 13 of 15 students submitted reflections. In 2018, 16 of 18 total students submitted reflections.

The Staff and Faculty Health and Wellbeing Nature Rx program utilized evaluation forms distributed electronically to participants in each of the hour-long Nature Rx sessions that made up the series. In 2017, there were 54 registrants for the program, and an average of 16 people attended each session. In 2018, the sample size was drawn from a total of 56 participants with 16 respondents from the Watercolors in the Arboretum session, 16 from the Mini Succulent Gardens session, 14 from the Terrarium Building session, and 10 from the Fall Harvest session. Responses for the evaluations were collected anonymously and voluntarily.
4.1 First-Year Student Seminar - Nature Rx: Exploring the Power of the Natural World

UC Davis launched the First-Year Seminars program to ensure that “every incoming student to UC Davis will have the opportunity to take a transformative small enrollment course that fosters intellectual curiosity, active discussion, critical thinking, a sense of community and engagement with faculty and peers.” With class sizes limited to 19, the first-year seminar format presented a unique opportunity to introduce nature therapy to incoming students new to UC Davis and its campus. Inspired by a similar program launched at Cornell University, the first-year student seminar, entitled Nature Rx: Exploring the Power of the Natural World, launched in the fall of 2017. The seminar served the dual purpose of orienting incoming freshman and transfer students to the natural communities of UC Davis (instructors, places, resources, one another) while simultaneously introducing them to the concepts and research supporting the healing power of nature. Through experiential outdoor experiences such as walks, bike rides, and guided tours, students explored the natural components of UC Davis and learned about activities, internships, and scientific research occurring all over campus. Assigned readings and discussions focused on literature exploring the health benefits associated with such activities.

A not-for-credit pilot version of the seminar (First-Year Aggie Connection) was held in the fall of 2016 with an enrollment of 25 students (maximum enrollment). 19 students (maximum enrollment) enrolled in the first-year student seminar of 2017 and 19 students enrolled in the first-year student seminar of 2018. There was a waitlist to get into the seminar both years it was offered, but ultimately 15 students matriculated in 2017 and 18 students in 2018. Students came from a variety of majors, including landscape architecture, environmental studies, chemistry, and math. The class was worth two units and could only be taken on a pass/fail basis. Lasting 10 weeks, the seminar format was simple: students received a weekly email telling them where on campus they would be meeting. There they would be introduced to the nature activity for the day and the campus expert that would be leading them. Examples of activities included water coloring in the Arboretum with a professor of landscape architecture, practicing yoga and harvesting fruit at the Student Farm, discovering the favorite trees of the campus arborist, wading through the local creek with a professor of fish biology, and exploring the principles of Kundalini meditation with a professor of medicine. At the end of the activity, students were required to write reflections (or draw pictures, write poems, etc.) about what they had experienced. In addition, students were given weekly assignments to discover outdoor spots on campus (“Great place to take a date,” “Cool tree on campus,” “Best spot for daydreaming”), and then photograph and post them on Instagram.

4.1.1 Survey Structure – First-Year Student Seminar
The purpose of the survey was to assess changes in attitudes and behavior over the course of the seminar and to give students the opportunity for self-reflection. Of the fourteen total questions asked, seven were multiple choice and seven were open-ended to allow students to explain their answers. The same questions were used for both the pre- and post-survey, with the exception of the final question, which asked “What do you hope to get out of this class?” in the pre-survey and “What one or more things do you feel you got out of this class?” in the post-survey. Students in the UC Davis Nature Rx first-year student seminar and students in Cornell University’s Nature Rx class participated in the survey.

4.1.2 Personal Reflections – First-Year Student Seminar
All students enrolled in the UC Davis Nature Rx first-year student seminar (2017 and 2018) were required to submit a personal reflection at the end of the class. Students were asked to reflect on how the seminar had impacted them by selecting two questions from a list of four to answer thoroughly. Responses varied from one or two paragraphs to several written pages.

4.2 Staff and Faculty Health and Well-Being Program – Nature Rx
The second component of UC Davis’ Nature Rx program falls under the umbrella of the campus Staff and Faculty Health and Well-being Program (SFHWB). Launched in the summer of 2016, SFHWB’s stated mission is to “develop, promote and support a thriving culture of health and well-being throughout the UC Davis community so that staff and faculty can learn, teach, innovate and contribute.” SFHWB health and wellbeing programs include physical activities such as tai chi, yoga, biking, and walking, mental and emotional activities such as meditation, mindfulness, happiness, and self-care, and food activities with nutrition workshops and farmers’ market events. In fiscal year 2018, 3,298 unique individuals participated in SFHWB programs. (SFHWB Annual Report, 2018)
The Nature Rx component was first offered in the fall of 2017 in collaboration with the Arboretum and Public Garden as part of SFHWB’s health and well-being series. The goal of the lunch time one-hour sessions was to provide staff and faculty an opportunity to interact with nature as a means of decreasing stress levels. Three sessions were offered in 2017: Propagation, Planting, and Mini Succulent Gardens. In 2018, participants could choose from four different activities: Watercolors in the Arboretum, Mini Succulent Gardens, Terrarium Building, and Fall Harvest. Led by a campus staff member, the sessions provided hands-on opportunities for staff and faculty to take a break from their work and immerse themselves in the outdoors.

4.2.1 Program Evaluations – Staff and Faculty Health and Well-Being

Participants in the Staff and Faculty Health and Well-Being program - Nature Rx were asked to complete an on-line evaluation of the session in which they participated. The evaluation questions for each of the three sessions in 2017 (Plant Propagation, Planting in the Arboretum, Mini Succulent Gardens) and four sessions in 2018 (Watercolors in the Arboretum, Terrarium Building, Fall Harvest, Mini Succulent Gardens) were identical.

5 RESULTS

5.1 Survey Results – First-Year Student Seminar

Table 1. Survey Results

When you are in school, how frequently do you intentionally engage in nature?

<table>
<thead>
<tr>
<th></th>
<th>UC Davis Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 – 3x/week</td>
<td>36.8%; daily: 15.8%</td>
<td>40%; daily: 20%</td>
</tr>
<tr>
<td>Cornell University Initial</td>
<td>18%; daily :45%</td>
<td>57%; daily: 43%</td>
</tr>
</tbody>
</table>

How frequently do you think about your role in the complex web of nature?

<table>
<thead>
<tr>
<th></th>
<th>UC Davis Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequently</td>
<td>26.3%; all the time: 5%</td>
<td>20%; all the time: 33.3%</td>
</tr>
<tr>
<td>Cornell University Initial</td>
<td>9%; all the time: 36%</td>
<td>28%; all the time: 14%</td>
</tr>
</tbody>
</table>

How would you rank your concern for the environment relative to the majority of fellow students?

<table>
<thead>
<tr>
<th></th>
<th>UC Davis Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than the majority</td>
<td>26.3%</td>
<td>60%</td>
</tr>
<tr>
<td>Cornell University Initial</td>
<td>Greater/much greater than majority: 84%</td>
<td>Greater/much greater than majority: 85%</td>
</tr>
</tbody>
</table>

How many natural or landscaped areas on the campus have you discovered?

UC Davis
5.2 Personal Reflection Results – First-Year Student Seminar

While the pre- and post-survey results helped to quantify the effectiveness of introducing students to nature on campus and any resulting changes in their behavior towards it, the personal reflections truly shed light on the learning outcomes of the students. We ranked the reflections on a scale of positive, neutral, and negative. Of the 29 personal reflections received (representing 13 students from the 2017 seminar and 16 students from the 2018 seminar), we found that 28 were quantified as positive (96%) and one was quantified as neutral (4%). Reading through the reflections, it became clear that the first-year student seminar was unlike any of the students’ other classes and that it had made a strong impact on them. Reactions tended to fall across four broad categories: 1) anticipation for the seminar’s unique activities and adventures; 2) the refreshing/relaxing/destressing effect of the weekly nature activities; 3) a broader understanding of the social aspects of nature and the community it cultivated; 4) increased self-awareness and demonstrated behavioral changes towards nature.

Students reacted positively to the diversity of the seminar’s content and structure, citing the “variety of meaningful interactions,” “something completely new and adventurous,” “a surprise where and what we would be doing next,” and “refreshing, especially after a long week of ‘normal’ classes.” Wrote one, “it didn’t even feel like an actual class because of all the different things we would do every week.” Many reflections opened with how the student regularly looked forward to the weekly Nature Rx seminar. One student commented, “I learned how much it affected me to have a fun nature activity/class to look forward to every Friday. When things felt overwhelming, I would just think ‘I have my fun class Friday/tomorrow/soon and it always helped my perspective.” Another wrote, “Every time I would have a rough day, whether it was because I was missing home or stressed about a class, I would remind myself of the fun and calm two hours in Nature Rx that I had waiting for me at the end of the week.”

Frustration with typical lecture-format classes ran through a number of responses, with students commenting on how “it becomes more about the grade and passing the class than it is about learning the material,” “everything can get quite impersonal repetitive and stressful: go to lecture, take notes, learn the material, take a test, repeat,” and, “my experience with my classes were all exactly what I expected, boring and long.” With Nature Rx, however, students wrote about the low-pressure atmosphere, learning for the sake of learning, and of being able to enjoy the activities more and better absorb the information because of the structure of the course. “It’s literally a breath of fresh air to have an outside classroom.”

The seminar’s weekly contact with nature also had the intended effect of relaxing students and helping them reduce their levels of stress. “It gave me a sense of relaxation that no other class has ever given me,” wrote one student. “I find that being outside stabilizes my mood and comforts me in distress,” noted another. “Nature has the magical quality of destressing, bringing happiness, and creating new definitions to life, and this seminar is so sincerely aimed toward that.” One student, who described himself as originally skeptical about the seminar, admitted that “I had never really paid attention to nature before, and, within a few weeks, I was stopping on my way home to examine the leaves on a tree. It was good. I felt refreshed.”

Several students commented on how the yoga, meditation, and mindfulness activities had helped reduce their anxiety, stabilized their mood, and comforted them in distress. “This process was intriguing to me, someone with anxiety,” wrote one, “and I started meditating in my daily life at short intervals to calm my mind and achieve a sense of well-being. I plan to meditate more frequently in the future, preferably in a natural setting, and I never would have discovered this coping mechanism if it wasn’t for Nature Rx.” The biggest impact, however, was a newfound appreciation of the power in taking even a short break outside, with students mentioning setting daily goals to spend time outside, taking time out of their day to reflect, and practicing “more indirect learning, where I soak in what’s around me.” In summary, “I’m now aware of how I choose to go about my day. I know that if I isolate myself behind walls all day, I get frustrated and anxious, but if I take a moment to go outside, I instantly feel better.”
A third effect of the seminar, as recorded in the personal reflections, was the role it played in establishing community by connecting students to each other, the campus, and the natural world. Participants stated that the class made them feel connected to the Davis community, that they enjoyed being with “like-minded people,” and that “it was fun to find people with similar interests outside of our specified major courses.” Other students wrote about the diversity of each week’s experts. As one wrote, “Bringing in professionals and people from all different walks of life involved in nature was truly inspiring and fun to watch and get involved in.” Another summed it up by saying, “Not having the regular classroom setting was pretty amazing because we got hands on experience observing different plant species, fishing like a professional fish biologist, and practicing meditation outside. I have never had a class that was so interactive and full of experts in their own field.” For one student, the connection to community went even beyond the campus. “I gained a sense of how special this relationship we have with Earth is, and we can connect with the community through it.” Interestingly, students reflected on the desire to share nature with others, writing, “now I want to show everyone nature. I tell all my friends to go out in nature and de-stress yourself from school,” or “I will also definitely go back to all the places we explored with my friends so I can show them the extent of how beautiful the campus is, which is right under our noses!”

Students reflected on the lasting impact of the seminar and how it modified their everyday behaviors. They reported taking greater risks, being more outgoing, and feeling better grounded than they had when the quarter began. “I was reminded of how important and necessary it is for me to try new things on a regular basis in order to maintain a curious, open-minded, and adventurous attitude,” wrote one. “This class revealed to me that I am perfectly capable of conquering my fears, no matter how irrational they are” stated a student who had previously been afraid of fish. “This is a transformative idea to me because I can apply it to other fears and new experiences.” Almost all reported a greater sense of self-awareness, resulting from taking time to pause, observe, and reflect. Referring to the weekly required journal entries, a student explained, “At first it seemed like a chore because it was a homework assignment, but I found myself either reminiscing of fond moments or realizing how much I admire our sessions and nature in general” Another added, “I didn’t think of them as assignments; they were more like a fun escape from reality.” Students wrote about taking time out of the day to take care of themselves, setting regular times to practice meditation, inviting friends to go for walks with them, and trying new experiences outside of their comfort zone.

Most profoundly, the seminar seemed to change students’ overall attitude towards nature. “I usually picture nature as being something I have to go to, some sort of destination, like a National Park or a lake, but Nature Rx showed me that nature is all around me at all times.” In talking about the insights gleaned from the class, one student explained “I’ve learned that nature is so non-judgmental about who we are as individuals. It is way too easy to judge myself harshly sometimes – what I haven’t done or haven’t accomplished… and yet nature is simply here for us to enjoy even if we do or do not deserve it.” By the end of the class, there was a greater sense of environmental stewardship and responsibility. “Nature Rx has inspired me to be more alert with my surroundings, to focus more on nature, for where I am from nature is not of an importance.” And finally, “It all culminated in me realizing that I have some work to do if I truly want to be a part of nature the way I assumed I was.”

5.3 Program Evaluation Results – Faculty/Staff Health and Well-being

Post-class evaluation data revealed that in 2017, a total of 30 faculty/staff participants in the Nature Rx program completed evaluations. Of those, 80% of participants strongly agreed or agreed that the classes contributed positively to their health, 93% of participants strongly agreed or agreed that they contributed positively to their well-being, and 73% of participants strongly agreed or agreed that they contributed positively to their work performance.

In 2018, the response to the class was overwhelming. All of the available spots for the four sessions filled up within five minutes of registration opening, and the watercolor and succulent sessions had waitlists of 20+ people in each. Overall, results from the evaluations changed very little from the previous year. A total of 57 staff/faculty filled out an evaluation for one of the four Nature Rx sessions, with 85% strongly agreeing or agreeing that the classes contributed positively to their health, 93% strongly agreeing or agreeing that they contributed positively to their well-being, and 73% of participants strongly agreeing or agreeing that they contributed positively to their work performance.

Unexpectedly, seventeen participants in the faculty/staff Nature Rx series have since made independent inquiries asking for a version of the Nature Rx program tailored specifically to their departments.
6 DISCUSSION

When Charles Lewis presented his keynote speech at the Healing Dimensions of People-Plant Relations symposium, he did so armed with overwhelming evidence correlating human physical, psychological, and social well-being with nature contact. In the twenty-five years since his presentation, the relationship between people and nature has, in fact, changed, but not in the direction he anticipated. Lewis got it right when he forecasted great strides in nature therapy research and a preponderance of scientific data to support the central thesis that spending time outdoors is good for you (Louv, 2011; Williams, 2017). What Lewis failed to understand is that “spreading the word” about the benefits hasn’t been working, and the message to spend time outside simply hasn’t sunk in. Our findings suggest that, in an era where teens spend an average of six hours a day in front of screen media (Common Sense, 2015), creating experiential programs that require participants to deliberately engage with nature may be the best way to try and reverse this worrisome trend.

Data from the pre- and post-student surveys and faculty/staff evaluations confirm that participants enjoyed the Nature Rx programs, believed that they improved their overall health and well-being, and would recommend similar Nature Rx activities to friends. The survey results from Cornell University and UC Davis highlight that students interacted more with nature and reported a greater sense of responsibility towards the environment as a direct result of their Nature Rx seminar. It’s the qualitative data, however, that tell the true effects of the Nature Rx Program.

Results from the student reflections corroborate previous research that place-based education, which utilizes field trips to teach about the local community and environment (Sobel, 2005), increases student engagement with learning (Emekauwa, 2004). Students praised the format of the class, lauding the fact that it was held outside, in a new location each time, and that they never knew what to expect. The variety of program and location, combined with a lack of pressure to excel academically, revived weary students and led them to look forward to the weekly meetings. “There was meaning hidden, or not so hidden, in the variety of things we did. It kept us interested, yes, but the real beauty behind it all was the fact that it showed us the vast expanse of how nature intertwines with UC Davis,” explained one student. By immersing students directly in nature, engaging them in hands-on activities, and utilizing campus experts to introduce them to nature-themed concepts and practices, we were able to remove academic constructs and transform the experience into one that promoted learning for the sake of learning. As one student noted, “In this class, I was able to enjoy the activities more and better absorb what I learned each week.”

Students wrote that dedicating a weekly two-hour block to Nature Rx “helped wind down my mind” and “decompress,” supporting the growing body of research demonstrating reduced stress levels and decreased feelings of depression after spending time in nature (e.g. Astell-Burt et al., 2014; Bratman et al., 2015; Ward Thompson et al., 2016). One participant admitted feeling “rejuvenated and happier” after each class, another said the class helped ground her, and a third described the class as “filling a void in myself that I will be forever grateful for.” They reflected that that they were deliberately setting aside time to incorporate nature into their daily lives through walks, recreation, meditation, or observation.

Interestingly, a number of students commented on the social and community aspects of the seminar. Beyond exploring the connections they made with each other and nature-related campus organizations, students reflected on the desire to share their experiences in nature with other people. This corroborates research demonstrating that experiences in nature are deeply social and that they connect people to one another (Groenewegen et al., 2012; Kellert et al. 2017). Human connection lies at the heart of well-being, and so, in speaking to the importance of nature to humans, we cannot forget the nature of humans, that we are social creatures and thrive when we are part of a community. In an era of increased suicide rates on college campuses (ACHA, 2015) and a rise in loneliness across all age brackets (CIGNA, 2018), any intervention that can pull people away from the solitude of their screens to share the wonders of nature in the company of others is bound to be a good thing.

The most striking aspect of our study, however, are the resulting self-described changes reported by students. We expected participants would enjoy the class and ultimately take away some new insights about the healing powers of nature, but we had no idea of the extent to which they would internalize the message. Their reflections demonstrate the true power of experiential education. When provided with the opportunity to participate in concrete experiences and reflect on the outcomes, these students ultimately modified not only their attitudes towards themselves and their personal well-being, but also their behavior towards nature. “Everywhere I look now, I see nature in a new light. It may seem like I’m exaggerating,
but I’m really not. When I look at the trees in front of me, I notice them. Actually, I search for them and explore them. I want to find that one tree that makes me feel at peace, or inspired, just by looking at it."

It is also important to note the limitations of the study. Small sample sizes limit the statistical power of the study, and the self-selected nature of course enrollment means that participants may already have been somewhat more inclined to appreciate nature than the general student population.

### 6.1 Future Directions for Teaching

For students of landscape architecture in particular, inclusion of a Nature Rx-type seminar within the curriculum requirements makes sense. The role of a landscape architect is to create outdoor spaces that evoke emotion and hold meaning for people, spaces to find peace and take refuge. Before students can design this type of space, they need to experience it first-hand. Google maps, AutoCad files, PowerPoints or even site visits won’t elicit the “child-like giddiness” or “curious, open-minded attitude” that comes as a direct result of full immersion into nature. It is only by taking the time to stop, observe, soak everything in, and reflect that students will gain a true appreciation for nature and be able to authentically re-create it for others. Requiring a Nature Rx seminar will not only produce better designers, it will also have the added benefit of producing healthier and happier designers, who understand the benefit of taking a nature break in the face of a looming deadline and recognize the value of nature as a form of stress management and self-renewal.

### 7 CONCLUSION

The healing dimensions of people/plant relations have not, and likely never will be, successfully disseminated through typical channels of communication. Media campaigns, scientific articles, and lectures outlining the benefits of spending times outdoors have had little practical effect on people’s mindsets. Until there are more experiential classes and immersive interventions like Nature Rx, people will continue to stay indoors, staring at screens. Our hope is that this study inspires others to take steps to create their own version of a Nature Rx program.

### 8 REFERENCES


Williams, F. (2017). The nature fix: Why nature makes us happier, healthier, and more creative.
THE NEXUS STUDIO: A SYNERGISTIC PEDAGOGICAL APPROACH FOR INTEGRATING RESEARCH AND EVALUATING LEARNING IN A LANDSCAPE ARCHITECTURE STUDIO

CRONAN, DANIEL
University of Idaho Landscape Architecture Program, dcronan@uidaho.edu

1 ABSTRACT
Evaluating a student’s development is key to understanding effective techniques for teaching and learning, applying relevant research, and developing competencies for practice. The purpose of this project is to evaluate student learning in an integrated landscape architecture and planning research project addressing socio-ecological issues for a landscape. This project focuses on landscape architecture and planning education, using a studio course framework, surveys, and a geospatial evaluation model as vehicles for experimentation. This planning and design studio uses relevant research, an alternative futures research methodology, geospatial design and evaluation as vehicles for building key competencies in sustainability for landscape architecture students (Wiek et al, 2011). It systematically evaluates student learning within a studio course by analyzing self-reported and spatially explicit evidence of learning concerning Food, Energy, and Water Systems (FEWS) at the landscape scale. The method gathers, assesses, and evaluates evidence of student learning. It uses measurement and mapping combined with student surveys to evaluate these two forms of evidence. The results of this study present and interpret the evaluation of the self-reported and spatially explicit evidence of learning. This paper concludes both spatially explicit and self-reported evidence together best indicate learning for design and planning students, with the evidence in this project most compelling regarding student-driven evaluations and revision. The results are intended to equip educators in Landscape Architecture and Planning with effective tools and methods for evaluation and course revision.

1.1 Keywords
Student Learning Outcomes, GeoDesign, Planning, Evaluation, Spatially explicit metrics
2 INTRODUCTION

Evaluating student learning reflects the program goals of a higher education institution. Our current education system asks educators to maintain standards for skills learned or conveyed throughout a curriculum, and students are required to exit academic programs with a specific set of competencies pertinent to their field. These competencies have the potential to be viewed as indicators of student strengths and weaknesses. They can be measured to understand if, and if so, how knowledge is acquired.

The aim of this project is to develop and apply an evaluation framework, relevant to the field of Landscape Architecture, to determine learning within design instructional courses by measuring, evaluating, and comparing student skills and competencies using two forms of evidence. The project also intends to utilize studio outputs with a concurrent research project, thus creating a synergy between research, pedagogy, and service. As a contribution to landscape architecture and planning pedagogy, this project is intended to enhance professional skills for efficient and effective educators as well as others within the field of Landscape Architecture.

2.1 Project Purpose

The purpose of this project is to provide and demonstrate a systematic approach for evaluating student learning within a Landscape Planning and Design Studio using two forms of evidence: self-reported and spatially explicit. This approach will provide educators with guidance for developing instructional courses to aid student learning. The project evaluates student knowledge, skills, and competencies throughout courses related to current planning issues for a particular geography. The results indicate students’ self-understanding of key concepts from self-assessment and provide a faculty-produced spatial evaluation of student designs.

This project intends to contribute to Landscape Architecture and Planning education. This paper also intends to contribute to Landscape Planning education by creating, delivering, and revising Landscape Planning and Design modules to site and evaluate suitable locations for landscape interventions. This project aims to address the need for initial and final self-reported and spatially explicit student evaluations as guides of how to improve instruction about this topic. Reporting the relationship of learning to this evidence will indicate what revisions need to be made to course materials and instruction.

By proposing the use of a combination of mixed evidence, this project seeks to answer the following research question: What types of evidence best indicate student learning in semester-long and module instruction in landscape planning and landscape design studios?

2.2 Current Methodology for Evaluating Student Learning in a Studio

The field of Landscape Planning and Design can be defined as “a particular form of planning at a regional scale which integrates land use, physical planning, and environmental issues” (Frank, 2006). Within the past three decades, Landscape Planning and Design education has undergone significant advances to develop student learning within formal course instruction. Studios and workshop course types focus on current and relevant issues, and they are effective in initiating student interest and preparing students for practice with the field (Lusk & Kantrowitz, 1990).

Landscape Planning and Design studios and courses ask students to provide solutions to current problems for a specific geographical location using tools and guidance. Studios typically span an entire academic semester or term, and focus on a wide range of topics, theories, and specific circumstances relevant to a given study area. Workshops or modules are often briefer, and are generally designed to “foster learning how to learn” (Frank, 2006). These modules can potentially be used to comprise a complex structure for a studio. The currently methodology for evaluating evidence of student learning in a landscape architecture studio is proctored through a rubric of learning objectives and alignment of outputs at a given stage in the student’s education. Whether through a module or a studio, the alignment of learning objectives to outputs results in a demonstration of evidence of learning (LABOK, 2004). This method for course evaluation is intended to provide instructors with guidance for revising particular components of a Landscape Architecture or Planning Studio.
2.3 Limitations in Current Evaluation Methodologies

"Landscape Architects have a tougher time finding seats at the table alongside planners and architects when broader planning decisions are being made" (Hough, 2013). Studios typically fall short of presenting students with landscape-scale issues. A peer-to-peer evaluation metric, created by learners but facilitated by an instructor addressing landscape-scale change, can potentially guide this larger scale decision-making. Student self-evaluation metrics give students actionable guidance for revision to their designs based on peer-to-peer feedback. Peer feedback also promotes critical thinking and higher quality learning outcomes (Lynch et al., 2012).

Pedagogical methods are also limited as educators in design, more than often, do not incorporate self-evaluations of learning. Self-reported evidence of learning, can potentially give guidance as to where students are reporting when and what kind of learning occurred within a studio-based environment (Gonyea, 2005). In a practice-based field, gauging improvement from the learner can provide qualitative data to be used to analytically determine misfires and cognitive overload in sequencing of modules and workshops (Kirschner, 2002).

Evaluating student success in landscape architecture projects typically requires a spatially-explicit evaluation metric. However, choosing individual metrics for success comes with myriad limitations (Pati et al., 2013). Metric determination can be biased or driven towards a biased version of success from a stakeholder group and/or designer of the evaluation. Again, encouragement for students to create a peer-reviewed approach for design evaluation metrics can provide students with a sense of the bias of this process.

2.4 Incorporation of Self-reported and Spatially explicit evaluations through an interdisciplinary research project

Limitations of learning, such as lack of self-reported evaluations, spatially-explicit evaluations, and a disconnect between broader landscape planning decisions, have the potential to be addressed through an integrated research project. Interdisciplinary research projects have the capacity to encourage standard definitions and clarity within research projects (Committee on Facilitating Interdisciplinary Research, Committee on Science, Engineering, and Public Policy, 2004). The same can be true of practice-based research projects. Utilizing an iterative approach, using the geodesign framework, within an interdisciplinary research project can potentially provide the means to mitigate the current limitations in determining learning success through design evaluations.

2.5 The GeoDesign Framework

Carl Steinitz’ GeoDesign Framework is centered on the question, “How do we get from the present state of this geographical study area to the best possible future?” (Steinitz, 2012). This process occurs across scales, temporal and geographical, to produce “constructed physical change” in site-scale projects and to “influence the way society values and changes its geography” in landscape-scale projects (Steinitz, 2012). GeoDesign relies on an interconnected, representative matrix of experts including regional stakeholders that Steinitz describes as “the people of the place,” geographic scientists, design professionals, and information technologists (Steinitz, 2012).

The framework includes six inquiries: “How should the study area be described? How does the study area operate? Is the current study area working well? How might the study area be altered? What differences might the changes cause? How should the study area be changed?” (Steinitz, 2012). Multiple iterations through these questions are employed to calibrate the models and refine stakeholder and researcher assumptions. Results of this iterative process demonstrate plausible futures for a given landscape or site. The GeoDesign Framework was utilized in the studio because of its iterative nature.

2.6 INFEWS Project

The INFEWS (Innovations at the Nexus of Food, Energy, and Water Systems) Research Project uses an integrated approach to investigate effective means of stakeholder engagement for a National Science Foundation-funded (NSF) waste solutions project in the Magic Valley, Idaho, USA. These key issues in stakeholder engagement require a framework to represent anticipatory trajectories of change driven by the stakeholder’s understandings of the system. For this process, we used the GeoDesign
Framework (Steinitz, 2012), described in the previous section. The following diagram illustrates the INFEWS process for incorporating researcher assumptions with stakeholder input (Figure 1).

Figure 1. INFEWS Project Process Diagram

Complex adaptive system management is key to biological and socio-economic integrity within landscapes. Drivers of landscape ecology, population growth, climate change, and economic pressures necessitate a profound understanding of both the processes and future conditions of the landscape (Kliskey et al., 2017). The determination and interconnection of these assumptions for change demand organization through an integrated approach to model existing conditions, future processes, and solutions to address issues within Food, Energy and Water Systems (FEWS). Stakeholder input requires various tools and strategies to develop effective and useful results; however, specific challenges and limitations of participatory research arise throughout the process. An alignment of stakeholder and researcher assumptions considering plausible futures of a landscape can require a large amount of time. Probabilistic model simulations take the form of land-use and land-cover representations, which are outputs of the project, also require calibration, parameterization, and revisions from stakeholders and researchers. ‘Key Uncertainties’ were developed from the stakeholder group. Various scenario narratives were scripted from researcher and stakeholders assumptions and the ‘Key Uncertainties’ about the future for the region (Figure 2).
The NEXUS Studio project uses student designs as the first iteration of land-use and land-cover representations from each scenario narrative using the GeoDesign Framework (Steinitz, 2012). The outputs of the studio used in a stakeholder meeting to illustrate each scenario and to validate researchers' models with stakeholder assumptions.

2.7 The NEXUS Studio

The NEXUS Studio was divided into four modules for instruction: Module 1, Inventory & Analysis; Module 2, Initial Designs; Module 3, Evaluations; Module 4, Design Revisions (Table 1). Within the modules, instructional sessions were focused on delivery of content relevant to the INFEWS project, the project site, and deliverables noted in Table 1. INFEWS researchers gave presentations to students concerning their areas of expertise. "Key competencies in sustainability," at varying degrees, were used to compile instructional materials. Survey instruments were distributed to students prior to and post instruction. Spatially explicit evaluations were used to assess student design within Module 3, and upon completion of the final landscape scale and site scale designs in Module 4.

During Module 1, Students were presented with the Scenario Narratives compiled by the INFEWS research team. Each student was given a narrative to depict a plausible future dictated by the stakeholder group. Students were asked to explore design decisions at the landscape and site scale for the scenario distributed to them. For 'Module 1, Inventory & Analysis' students were asked to form groups to develop presentations about their understandings of the site and inherent processes under each scenario. The students were, again, asked to divide into teams during 'Module 3, Evaluations' to assess initial scenario designs created by each student for their assigned Scenario Narrative.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expectations</strong></td>
<td><strong>Design Questions</strong></td>
<td><strong>Deliverables</strong></td>
<td><strong>Key Competencies in Sustainability</strong></td>
<td></td>
</tr>
<tr>
<td>- Identify opportunities and constraints</td>
<td>- How does the study area operate?</td>
<td>- How should the study area be redesigned?</td>
<td>- NEXUS Studio Modules</td>
<td>- Final Survey - END of studio (3 weeks)</td>
</tr>
<tr>
<td>- Map and photographs</td>
<td>- The current study area working well?</td>
<td>- The conditions through photos, tables,</td>
<td>- Systems Thinking Competence</td>
<td>- Initial Design Evaluation (2 weeks)</td>
</tr>
<tr>
<td>- Digital presentation</td>
<td>- How should the study area be changed?</td>
<td>- Digital presentation</td>
<td>- Interpersonal Competence</td>
<td>- Initial Design Evaluation (3 weeks)</td>
</tr>
<tr>
<td>- Initial shape design</td>
<td>- What differences might the changes</td>
<td>- Initial shape design</td>
<td>- Strategic Competence</td>
<td>- Initial Design Evaluation (2 weeks)</td>
</tr>
<tr>
<td>- Initial landscape scale design</td>
<td>- Initial process design</td>
<td>- Initial shape design</td>
<td>- Normative Competence</td>
<td>- Final Survey - END of studio (3 weeks)</td>
</tr>
<tr>
<td>- Initial scale design</td>
<td>- How might the study area be altered?</td>
<td>- Initial shape design</td>
<td>- Normative Competence</td>
<td>- Final Survey - END of studio (3 weeks)</td>
</tr>
<tr>
<td>- Systems Thinking Competence</td>
<td>- Systems Thinking Competence</td>
<td>- Systems Thinking Competence</td>
<td>- Interpersonal Competence</td>
<td>- Final Survey - END of studio (3 weeks)</td>
</tr>
<tr>
<td>- Interpersonal Competence</td>
<td>- Strategic Competence</td>
<td>- Strategic Competence</td>
<td>- Strategic Competence</td>
<td>- Final Survey - END of studio (3 weeks)</td>
</tr>
<tr>
<td>- Strategic Competence</td>
<td>- Normative Competence</td>
<td>- Normative Competence</td>
<td>- Normative Competence</td>
<td>- Final Survey - END of studio (3 weeks)</td>
</tr>
<tr>
<td>- Normative Competence</td>
<td>- Anticipatory Competence</td>
<td>- Anticipatory Competence</td>
<td>- Anticipatory Competence</td>
<td>- Final Survey - END of studio (3 weeks)</td>
</tr>
<tr>
<td>- Anticipatory Competence</td>
<td>- Systems Thinking Competence</td>
<td>- Systems Thinking Competence</td>
<td>- Systems Thinking Competence</td>
<td>- Final Survey - END of studio (3 weeks)</td>
</tr>
</tbody>
</table>
3 METHODS

This study seeks to evaluate student learning within courses regarding land use planning, with a focus on improving teaching and coupling pedagogy with a concurrent research project. The methods section explains the process by which evidence of student learning was gathered and the methods used to evaluate whether or not learning occurred. It offers an approach for evaluating two forms of evidence: self-reported and spatially explicit. Within this project, the term ‘STEPS’ is used to describe the process.

The following approach was used for course instruction and student learning evaluation: STEP 1: INSTRUCT; During the studio modules, material concerning the siting of land use interventions was conveyed to students. A method for designing such at the landscape scale and site was explained through individual formal workshops and desk critiques. STEP 2: COLLECT; The self-reported evidence on which assessment of learning is partly based, takes the form of responses to a survey administered both before and after a formal course of instruction. Student designs from the Studio were also collected for the spatially explicit evaluation. STEP 3: EVALUATE; The evaluations of this evidence consist of a comparison of the initial survey responses with the second, and a comparison of the first spatially explicit designs of landscape scale and site scale designs with the second. Both stages of evaluation seek to identify specific evidence of learning. The spatially explicit evidence takes the form of student designs for land use planning related interventions in the form and pattern of a landscape. One such design was produced midway through the course of instruction, and the other at its conclusion. STEP 4: PRESENT RESULTS; The evidence of student learning was used to determine instructional context or means of delivery in need of revision for subsequent courses of instruction concerning planning and design using suitability criteria for landscape planning. STEP 5: REVISE; Revisions based on the overall process were made to the studio and course curriculum.

This paper will focus on STEPS 3 and 4 to demonstrate the evaluation process of student learning for the studio course. The objective of this evaluation strategy is to merge these two forms of evidence to demonstrate student learning quantitatively (spatially explicit evidence) and qualitatively (self-reported evidence). This project also uses deductive strategies to evaluate learning and diagnose needed changes in course content and delivery to improve learning. Evaluation and diagnosis is a strategy to develop generically transferable approaches for educators within planning and design.

3.1 Self-reported evidence: Surveys

Surveys were given to students at two intervals during the studio to assess learning. Based on the ‘Key competencies in sustainability’ criterion (Wiek et al, 2011), an interpretation of relevant landscape planning factors was developed for the survey. By conducting an investigation of relevant landscape planning criteria and competencies for sustainable planning and design, the following factors were addressed in the surveys: Systems Thinking Competence, Anticipatory Competence, Normative Competence, Strategic Competence, and Interpersonal Competence. The initial and final survey questions reflected aspects of each competence as noted in Table 2.

3.2 Spatially explicit evidence: Design Evaluations

As a method of inquiry, spatial analysis was used to indicate evidence for the NEXUS Studio at the landscape and site scale. After completion of the studio, student designs were evaluated using student-driven evaluation metrics. In Module 3: Evaluations, students were asked to develop evaluation models to measure the success of landscape scale and site scale scenarios. At the landscape scale, students were asked to develop evaluations models using ESRI’s ‘Modelbuilder’ (Figure 3) to measure and rank scenarios answering the questions: What differences might the changes cause? How should the study area be changed?” (Steinitz, 2012). Each model for landscape evaluation was developed in relation to the INFEWS ‘Key uncertainties’ driven by INFEWS stakeholder assumptions. Site scale evaluations were conducted by using a rubric (Table 3) developed by student teams also during Module 3: Evaluations.
Table 2. Key Competencies in Sustainability applied to the NEXUS Studio survey questions

<table>
<thead>
<tr>
<th>SURVEY QUESTIONS</th>
<th>KEY COMPETENCIES IN SUSTAINABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Which role would you identify with for solving the planning and design</td>
<td>Interpersonal Competence</td>
</tr>
<tr>
<td>components of the project?</td>
<td>- Functions, types, and dynamics of collaboration</td>
</tr>
<tr>
<td></td>
<td>- Concepts of solidarity</td>
</tr>
<tr>
<td></td>
<td>- Concepts of leadership and team dynamics</td>
</tr>
<tr>
<td>2) How reasonably professional of a knowledge base do you think you have for</td>
<td>Systems Thinking Competence</td>
</tr>
<tr>
<td>integrating terrain-related patterns of land-use type, planning systems related</td>
<td>- Complex cause-effect chains</td>
</tr>
<tr>
<td>solutions, and land-use suitability for available and potential spaces?</td>
<td>- Across/multiple/coupled domains: Environment, Equity, Economy</td>
</tr>
<tr>
<td></td>
<td>- People and social systems: values, preferences, needs, perceptions, (collective) actions,</td>
</tr>
<tr>
<td></td>
<td>decisions</td>
</tr>
<tr>
<td>3) Please describe how well you think you understand how to integrate systems-</td>
<td>Anticipatory Competence</td>
</tr>
<tr>
<td>related factors of land-use interventions at the site and landscape scale.</td>
<td>- Concepts of time including temporal phases</td>
</tr>
<tr>
<td></td>
<td>- Concept of uncertainty, possibility, probability, desirability of future</td>
</tr>
<tr>
<td></td>
<td>- Concepts of consistency and plausibility of future developments</td>
</tr>
<tr>
<td>4) With your current understanding, what are some viable and probable solutions</td>
<td>Strategic Competence</td>
</tr>
<tr>
<td>that you expect to plan and design?</td>
<td>- Obstacles and synergies</td>
</tr>
<tr>
<td></td>
<td>- Success factors</td>
</tr>
<tr>
<td></td>
<td>- Intentionality, Success factors, feasibility, effectiveness, efficiency</td>
</tr>
<tr>
<td>5) What are the key uncertainties to address in landscape planning for the given</td>
<td>Normative Competence</td>
</tr>
<tr>
<td>site?</td>
<td>- Sustainability principles</td>
</tr>
<tr>
<td>i) Please list some land-use conflicts that you expect to model for Magic Valley,</td>
<td>(Un-)sustainability of current states and future states</td>
</tr>
<tr>
<td>Idaho.</td>
<td>- Concept of risk, harm, damage</td>
</tr>
</tbody>
</table>

Key Uncertainty 1: Will there be sufficient water supply for demand?

Key Uncertainty 3: Will allocation of resources impact growth?

Key Uncertainty 2: Will water quality regulations change?

Key Uncertainty 4: Will highest and best use be the driver of change?

Key Uncertainty 5: Will highest and best use be the driver of change?

Diagram of Key Uncertainty 1 and Key Uncertainty 3.

Diagram of Key Uncertainty 2 and Key Uncertainty 4.

Diagram of Key Uncertainty 5.
4 RESULTS

The results section presents and interprets results regarding learning in the Nexus Studio. It provides overall results for the entirety of the studio. This section summarizes the connection between the evidence of learning and the possible approach for future research-driven GeoDesign studios in Landscape Architecture and Landscape Planning.

Self-reported evidence was combined with spatially explicit evidence by using percent increase from both initial and final instruments for evaluation. The initial and final survey results were analyzed to understand if specific information and concepts presented by course instruction were learned by the student. Also, when offered by the student, relevant and specific responses were marked as learning for each of the key competencies of sustainability (Wiek et al., 2011) related to landscape planning. For example, in the initial survey a student may have used general and non-specific language to describe system factors, whereas in the final survey responses the same student may have specifically mentioned suitability criteria siting for these system factors and solutions. Questions were weighted equally. Spatially explicit evidence of learning was also evaluated by comparing percent increase from the initial and final design for an average of the site scale and landscape scale designs. Increase from the existing conditions aligned with assumptions from each scenario narrative dictated an increase for each scenario.

Results from both forms of evidence were combined by creating an average of the spatially explicit evidence percent increase with the self-reported percent increase using a scale to understand the degree of learning from low to high. The following scale was used to understand degree of student learning from low to high: LOW (0% – 33%), MEDIUM (34% - 66%), HIGH (67% - 100%). A simple equation was used for replicability in future studios.

\[ i = \left( \frac{(x-y)^2 + (a-b)^2}{2} \right) 	imes 100 \]  

(1)
4.1 Combination of Results

The project results indicate various levels of learning per scenario and student. The combination of the surveys and design evaluations disclosed four of the six student-driven design scenarios reported as being a “high increase” in learning. The results are interpreted as mixed due to the combination of qualitative and quantitative data creating inconsistencies. The results of this study a combined relatively low statistical significance between percent increase in the self-reported evidence of learning and spatially explicit evidence noted in Table 4 and Figure 4. However, all students demonstrated an “increase” in learning based on the survey responses and backed by student designs.

<table>
<thead>
<tr>
<th></th>
<th>Initial Survey Results</th>
<th>Final Survey Results</th>
<th>% Increase (Survey)</th>
<th>Initial Design</th>
<th>Final Design</th>
<th>% Increase (Design)</th>
<th>AVERAGE % Increase</th>
<th>Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>35%</td>
<td>75%</td>
<td>114%</td>
<td>30%</td>
<td>65%</td>
<td>117%</td>
<td>115%</td>
<td>HIGH Increase</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>25%</td>
<td>60%</td>
<td>140%</td>
<td>35%</td>
<td>75%</td>
<td>114%</td>
<td>80%</td>
<td>HIGH Increase</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>75%</td>
<td>85%</td>
<td>13%</td>
<td>25%</td>
<td>45%</td>
<td>80%</td>
<td>47%</td>
<td>MEDIUM Increase</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>55%</td>
<td>65%</td>
<td>18%</td>
<td>30%</td>
<td>70%</td>
<td>133%</td>
<td>76%</td>
<td>HIGH Increase</td>
</tr>
<tr>
<td>Scenario 5</td>
<td>60%</td>
<td>90%</td>
<td>50%</td>
<td>50%</td>
<td>70%</td>
<td>40%</td>
<td>45%</td>
<td>MEDIUM Increase</td>
</tr>
<tr>
<td>Scenario 6</td>
<td>40%</td>
<td>75%</td>
<td>88%</td>
<td>30%</td>
<td>65%</td>
<td>117%</td>
<td>102%</td>
<td>HIGH Increase</td>
</tr>
</tbody>
</table>

Evaluation Scale:
- LOW (0% – 33%)
- MEDIUM (34% - 66%)
- HIGH (67% - 100%)

Table 4. NEXUS Studio Survey, Design Results, and Averaged Percent Increase in Learning

![NEXUS STUDIO Student Learning Percent Increase](image)

Figure 4. NEXUS Studio Student Learning Percent Increase Graph
5 CONCLUSION

Upon completion of this study, I have concluded that spatially explicit and self-reported evidence together best indicate learning for design and planning students. Student self-awareness of land use factors, methods for siting and modeling, and design reasoning is a crucial component to warrant the validity of planning and design decisions. However, further investigation for combining qualitative and quantitative evidence of student learning is needed. Within the following section, the rationale supporting the conclusion for the need of spatially explicit and self-reported evidence of learning for evaluation is presented.

This project illustrates the utility of a course framework, which couples a research project a landscape architecture and planning studio. Course objectives and competencies for both research and the studio were successful from indications of learning outcomes and the production of multi-scalar representations used in an INFEWS stakeholder meeting. There are many advantages to employing this framework including the following: a) pairing studio outputs with an active research project, b) utilizing geodesign framework for organization, and c) developing an understanding of multi-scalar dynamics expressed in landscape and site scale design.

A union between landscape architecture studio objectives and deliverables of the INFEWS research project provided an effective learning experience for students and researchers alike. This contribution to research motivated and gave enthusiasm to students. The project exposed students to research in landscape planning aligning. The sample size of the project was small, which can reduce the efficacy of the study and increase the margin of error. Using second order polynomials as means to determine correlation, both percent increase in survey results and designs demonstrated positive correlation with surveys exhibiting a stronger statistical significance over the designs. However, again, sample size skewed this statistical analysis. Per Table 4, overall, there was a medium to high average percent increase in evidence of learning within this project. With this, I conclude that both spatially explicit and self-reported data in combination provide indication of learning within a landscape architecture studio.

The research project and modules within the studio were initially complex for student understanding, however upon conducting the methods and running tools, students found an understanding through a guide: the GeoDesign Framework (Steinitz, 2012). As a tool, it gave students a roadmap to follow throughout each course module. The students in the NEXUS studio demonstrated a high level of systems-thinking competence (Wiek et al., 2011). “Systems-thinking competence means that graduates have the ability to understand the immediate and root causes of complex sustainability problems including the actions, needs, motives, intentions, and mandates of key players in the problem constellation (Wiek et al., 2011).”

The crosswalk between research, education, and service was accomplished by giving a multi-scalar component to a problem statement within instructional modules. Students modelled and revised landscape scale designs and understood the impacts at the site scale. Production of site scale designs and evaluation led to direct outreach for particular sites within Magic Valley, Idaho currently in the process of conceptual design. Students were able to propose designs for a community park with a focal area study within Magic Valley based on assumptions from designs and evaluations at the landscape scale. The designs have been used by the city for future consideration for management, planning, and possible implementation.

Evaluation metrics have become a crucial component for Landscape Architecture and Landscape Architecture Education. This research project has provided a systematic evaluation framework which acts as a foundation for future research. A continuation of this framework will be needed in other courses of instruction in various settings, course materials, and content. However, this coalescence of research, education, and service gave a demonstration of a transferable process, which can be used for landscape architecture educators and researchers alike.
Figure 5. NEXUS Studio Student work & INFEWS Models used for a Stakeholder Meeting
REFERENCES


HOW VIRTUAL REALITY IMPACTS THE LANDSCAPE ARCHITECTURE DESIGN PROCESS AT THE SITE-SCALE DURING THE PHASES OF ANALYSIS AND CONCEPT DEVELOPMENT

HILL, DREW
Utah State University, drew.hill@aggiemail.usu.edu

GEORGE, BENJAMIN
Utah State University, benjamin.george@usu.edu

EVANS, DAVID
Utah State University, david.evans@usu.edu

1 ABSTRACT
Virtual reality (VR) offers many benefits for spatial awareness. In the field of landscape architecture, the technology is primarily being used as a tool for design review in the late stages of the design process. Many of the benefits that make VR valuable in the later stages of the design process suggest that VR may be equally valuable when used in earlier stages such as analysis and concept development. However, the present body of research does not provide a detailed study of truly immersive design within VR in the early stages of the process. This research tested incorporating VR in the design process phases of analysis and concept development and integrated its use with traditional landscape architecture methods to measure the impacts on a small-scale site design project. This research suggests a positive outlook for VR as a creation tool for small scale design and explores its affordances and limitations.

1.1 Keywords
Virtual reality, design process, immersive design
INTRODUCTION

Virtual reality (VR) is an important emergent technology that offers the promise of significant benefits to landscape architects through improving a designer’s ability to understand the spatial nature of design decisions. Unlike traditional design tools, which invariably include forcing the designer to work through a series of perception filters such as dimension and scale, VR has the ability to situate the designer in a virtual re-creation of a site that closely imitates physical reality. While research has been conducted on the power of VR in late-stage evaluation of design concepts, research exploring the use of VR as a design generation tool is limited. This study presents a case study analyzing the use of VR in a collaborative design project, where the tool was used from the earliest stages of the design process in order to assess the value of VR in supporting design creation. The design team relied on VR as the primary design mechanism in developing their concepts and supplemented their work with other traditional design tools. It is theorized that VR will enhance students’ design thinking and enable them to produce a more thoughtful and rational design.

LITERATURE REVIEW

Noted data visualization expert Edward Tufte describes the value of visualization as bringing clarity to complex data through graphical means. The visual representation of data has several advantages over non-visual representations, such as written text or verbal description (Tufte, Goeler, and Benson, 1990). This is because the human mind is wired to prioritize the visual sense, and the brain has evolved to be able to rapidly and intuitively process complex visual information (Bruce et al. 1996; Rose, 2012). Research has demonstrated that visualization is effective for conveying information regardless of field or discipline (Hansen & Machin, 2013; Valiela, 2009; Ware, 2013). In addition to having dominant visual senses, the human brain is adept at processing spatial information and tasks, and the awareness of space is an integral component of the awareness of self (Gersmehl and Gersmehl, 2007). Logically, the understanding and expression of spatial concepts is a critical skill for landscape planners and architects, both for designing and for communicating ideas with clients. Because of this, tools which provide landscape architects and planners with improved spatial awareness should expand the capacity of designers to more effectively engage with clients and stakeholders to develop appropriate design solutions (Chamberlain, 2015). For these reasons, VR should benefit designers in their work by enabling the designer to natively work in a highly spatial and visual environment.

The visual and spatial power of VR stems from its use of multiple sensory inputs to convince the user that they are present in an artificial world (Castronovo, Nikolic, Liu & Messner, 2013). VR can be divided into two categories: semi-immersive and immersive. A semi-immersive VR environment is when the user is only partially immersed in the virtual world or where the user is unable to interact with the digital environment. In a semi-immersive VR environment the user is aware that they are participating in a visualization. A common example of a semi-immersive environment is a VR theater, where imagery is projected onto surfaces surrounding the viewer on multiple sides (commonly referred to as CAVE system). In contrast, immersive VR is a digital environment that fully surrounds the user in a multi-sensory experience to convince the user that they are in a virtual world (Slater & Usoh, 1993). To be truly immersive, the virtual environment must be interactive and respond to the user’s actions (Grau, 2003).

Having the ability to craft and enter a digital world that is an accurate representation of the real world empowers designers and researchers to explore complex spatial issues in a more realistic manner (Horne & Thompson, 2008). This type of visualization technology is valuable to researchers and designers by providing a mechanism to more closely represent and understand the complexities of the landscape (Horne And Thompson, 2008). Despite these benefits, most use of VR in landscape architecture has been limited to visualizing design concepts prepared outside of VR as a form of design review and presentation. This has led to VR being used as a passive tool that provides powerful visual feedback, but is not informing the design as much as may be possible. Several studies documenting the use of VR in design and construction fields reveals the large majority of research has evaluated using VR to passively view design (Portman, Natapov, & Fisher-Gewirtzman, 2015; Wang, et al., 2018; de Freitas and Ruschel, 2013).

This research has demonstrated the clear value of VR in this role and has also strengthened the case to experiment with the use of VR in earlier design phases. Identified benefits of VR that would support conceptual design activities include immersions and increased spatial awareness. Immersive VR
has been attractive as a late-stage evaluation tool because the wide field of view creates a realistic viewing experience for the user (Castronovo, et al., 2013). Beyond visual immersion, VR also provides the user the opportunity to interact with design elements, which further heightens the sense of immersion and provides the user with a more realistic experience (Dunston, Arns, and McGlothlin, 2011). This high level of immersion has also produced some concerns in the research, as it has been suggested that the user may draw flawed conclusions because they accept at face value the environment that they are immersed in (Lange, 2011).

An ancillary benefit of immersion is that the user also has improved spatial awareness while in VR (Castronovo, et al., 2013; Rahimian & Ibrahmi, 2011; Portman, et al., 2015). This increased spatial awareness allows users to intuitively respond to a site and design. George (2016) had students utilize VR to conduct a site analysis of a residential site, and found that students were able to successfully conduct an analysis that accurately responded to the site conditions. However, caution should be exercised to not rely exclusively on VR when making design decisions, as the current level of detail supported by VR may constrict the ability to make some decisions (Bullinger, et al., 2010; Gill, et al., 2013).

There have been mixed results on the effects that VR has on collaboration. In their review of VR research, de Freitas and Ruschel (2015) conclude that VR has been demonstrated to improve communication and comprehension. In example, Gu, Kim, and Maher (2011) used semi-immersive VR to enable students collaborate on simple design exercises. However, when George, Sleipness, and Quebbeman (2017) tasked students with collaborating on designing a micro park in immersive VR, students found it difficult to work together to collaboratively create a design concept because the experience between those in and out of VR was markedly different.

Despite some limitations, VR is being steadily adopted in the design fields and a recent ASLA survey found that 82% of firms in the United States either have or intend to adopt VR into their workflow (George and Summerlin, 2018). This follows the broader trend of practitioners quickly adopting new digital simulation and visualization technologies over the preceding decade (Lange, 2011). As technology continues to improve, it is expected that VR will be integrated into more and more aspects of the design process.

Despite the increased adoption of VR, there has been relatively little research into expanding the use of VR beyond visualization applications, but what research has been done has been encouraging for the use of VR to facilitate design creation (George, Sleipness, and Quebbeman, 2017; George, Blauer, Hill, Quebbeman, 2018; Lombardo, 2018). Chamberlain’s (2015) work combining video game engines and VR has shown that VR can be used to teach design principles. George, et al. (2017) found that students could successfully use VR to design and that the students responded to the affordances provided by VR to adapt their design concepts. Rapid prototyping of loose conceptual designs has also been found to be successful in VR (Sleipness and George, 2017). These successful precedents warrant continued experimentation with VR in the design process using sites and projects that have a greater degree of complexity.

4 METHODS

This research is a case study of a project worked on by a six-student team consisting of four females and two males, and a class distribution of three juniors and three sophomores. The project was part of the Community Design Team (CDT) program, which is a program of the student ASLA chapter wherein students volunteer to work on real world extracurricular design projects in the community. This project focuses on the site design of an inclusive play environment at an innovative charter school in Providence, Utah. The team used a combination of VR and traditional methods to analyze the site and develop design concepts to test the impacts of integrating virtual reality into the landscape architecture design process.

4.1 Preparing VR materials
Several preparatory steps were taken to facilitate the virtual reality analysis and design in this study. A three-dimensional site model was needed to serve as a basemap in VR. This enables students to understand the surrounding context in 3D, and virtually visit, interact with, and design on the site as if they were there. A DJI Mavic Pro drone and Pix4D photogrammetry software were used to create the model. The drone was used to fly a single 20-minute drone mission, during which the drone flew 100 feet above the site in a pre-determined grid pattern controlled by the Pix4D mobile application. During the flight, the drone took pictures of the ground below, with each image overlapping by seventy five percent. Approximately 300 images were collected from the flight, which were then put into the Pix4D photogrammetry software and processed to create a point cloud and 3D model. This resulted in a detailed 3D terrain and vegetation model of the 15-acre site and the additional surrounding landscape. The photogrammetry model included the school building, but this was replaced with a model of the building created in Rhinoceros to increase detail and render quality. The building model was then inserted onto the terrain generated from the photogrammetry process in Rhinoceros. The preparation process took several hours to complete, including computer processing, but yielded a detailed site survey with contour data optimized for use in VR.

### 4.2 Carrying out the design

Apart from those previously listed, the hardware and software used for this project consisted of a Puget Systems PC with a high-performance CPU and GPU, HTC Vive VR platform, and Google Tilt Brush software. The 3D terrain model with the new building was exported out of Rhinoceros and imported into Tilt Brush in VR, where it was ready to be used by the design team. The project was conducted in a studio space with a projector and large screen (180°), on which a feed of what the designer was seeing inside VR was projected. A mixed reality capture system was used that digitally composited the student into the VR scene so that students outside of VR would be able to have improved contextual understanding of what the designer in VR was seeing and doing, with the limitation of it being seen on a 2D screen. In addition to VR, the students also utilized traditional design process methods such as 2D basemaps and trace paper to assist in conducting site analysis and developing design concepts. Students worked

![Drone Images Processed in Pix4D](image)

**Fig. 1:** Drone images are processed in Pix4D to create a 3D terrain model of the school
interchangeably between the two methods for three sessions, each one week apart, and data was collected after each session.

Four data collection rounds were used. Rounds 1 and 2 consisted of surveys distributed directly after the design session concluded to collect preliminary data. These surveys consisted of five questions and covered topics such as how much time was spent inside VR, what were the benefits they experienced using VR, and what were the challenges they experienced using VR. Round 3 data collection was a survey that was distributed after the third design session. This was a more comprehensive survey that consisted of seven open response questions and nine questions to be rated on Likert-scales. Round 4 data collection was a focus group held several days after the last design session and consisted of nine open response questions. Examples of questions that were asked in the focus group are, how long did it take you to feel comfortable using VR, how effective was communicating designs ideas in VR, and what about collaboration worked and did not work in VR.

In Round 1, 5 participants responded to the survey and in Round 2, 4 participants responded. In Round 3, which was the longest and most comprehensive survey, all 6 participants responded. Finally, in Round 4, all 6 participants were present for the focus group. The data collection resulted in 148 open answer responses and 66 Likert-scale rankings. The open response questions were then coded and produced 13 different codes (see Figure 2). This resulted in 198 combined coded comments, considering that some responses include multiple codes. For example, in response to the question “What part of analyzing the site was easier in VR?” a participant responded that “You could get an understanding of the site and design quickly”. This comment was then coded as improved understanding of a design through immersion, and improved site orientation and navigation. The mean of the Likert-scale responses was then calculated, and these results are represented in Tables 1 and 2.

5 RESULTS

Several important findings resulted from this study. Over the course of all four rounds the code most mentioned by participants was *improved understanding of a design through immersion in VR*. This code was talked about 42 times over the four rounds and is more than double the number of the next highest code. Other codes with significant mentions included *site orientation and navigation* (22), *improved communication of ideas* (19), *limited technology capabilities* (19), *learning curve* (18), *improved process* (18), and *improved self-expression* (14). A complete representation of the codes illustrating the changing nature of the conversation about VR is show in Figure 2. Students reported that VR presented several new challenges, such as always thinking and designing in three dimensions and a software learning curve. This is further illustrated by a student’s comment which states, “Developing concepts in 3D was challenging because it is new. It made me think about how to design in 3D.” However, once they got over the learning curve and became accustomed to thinking in 3D, they reported that they had a better understanding of the spaces that they were creating.

Another important finding is that verbal team collaboration was found to be less efficient than the traditional design process with the current limitation of only one designer in virtual reality at a time, while the rest of the team observes. However, visual communication and sharing of spatial ideas with a team was found to be very effective.

Working in VR affected and improved the students’ design process in multiple ways. Students responded that they were more aware of the three-dimensional character of their designs. They also commented that they experienced an improved ability to express their design ideas and get their points across to other students quickly. Students also stated that using VR improved the quality of design critiques from other students because of their improved ability to understand designs and communicate ideas visually. Overall, students were very positive in their assessment of VR as a design tool and would want to use it on future projects.

The quantitative data revealed that, overall, students had a positive experience using VR to design. Student ratings were high for issues related to visualization, immersion, value, and desire to use again. However, students disagreed that VR was a valuable collaboration tool (see Table 1). When asked to rate which tasks are easier in or out of VR, students preferred using VR to develop, visualize, and interact with a concept, but preferred to be outside of VR to refine the design and collaborate (see Table 2).
Figure 2: Coded comments of student responses

<table>
<thead>
<tr>
<th>Comment</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Neutral</th>
<th>Somewhat Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using VR made me more aware of the 3-dimensional character of my design</td>
<td>6.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using VR improved my ability to visualize my design</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using VR altered my approach to design</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My team could collaborate effectively using VR</td>
<td>3.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would be interested in designing using VR in the future</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VR was a useful tool in my design process</td>
<td>5.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Likert-scale results.
6 DISCUSSION

The results of the codes from Figure 1 suggest a positive outlook for VR as a tool for analysis and design in landscape architecture. However, limitations were also documented. Codes that suggest affordances of VR include positive technology capabilities, positive team collaboration, improved site orientation and navigation, improved understanding of a design through immersion, improved self-expression, increased process efficiency, improved sensory experience, and improved communication of design ideas. Codes that suggest limitations consist of physical effects, limited technology capabilities, limited team collaboration, learning curve, and decreased process efficiency.

The largest, and perhaps most significant, cluster of codes was related to spatial experiences, and included improved understanding of a design through immersion, improved site orientation and navigation, improved self-expression, and improved sensory experiences. Improved site orientation and navigation and improved understanding of a design through immersion were the two highest codes in the project, these two correspond with 64 of the 198 coded comments, or roughly one third of the total. Improved self-expression also scored relatively highly with 14 coded instances, and an improved sensory experience received the lowest of this cluster with 5 instances. These codes suggest important affordances that VR brings to the design process. The Likert-scales in Table 1 show that VR made students more aware of the three-dimensional character of their designs, improved their ability to visualize their designs, and altered their approach to design. Students understood spatial components of their designs and were able to interact with their designs much better in VR than via traditional methods, and they showed a slight preference for using VR to design a concept. However, students slightly favored traditional methods for collaborating and refining a design.

The spatial benefits of VR are especially beneficial to landscape architects, who benefit from the ability to visually and spatially communicate their ideas. This benefit is clearly visible in several student comments, such as “seeing 3D is quicker to understand,” “understanding spatial relationships of the site and architecture was made easier in VR,” and “I was able to make better informed decisions.” Viewing the site in VR made it easier for students to understand and respond to complex concepts such as landform, as one student describes “understanding topography was easier in VR, and was helpful for laying out paths and trails.” Just as digital drafting and modeling software accelerated and made possible more complexity in design, it is possible that VR will eventually lead to similar leaps forward as the tool becomes more refined.
Ultimately, VR appears to improve the ability of the designer to understand and interact with their design by immersing them in it, and this provides the designer with the opportunity to engage in a reflective conversation with their own design decisions (Schön, 1984).

Physical effects was mentioned frequently during the start of the project and decreased in the subsequent rounds. A couple students experienced dizziness or felt disorientated in the first round, but that seemed to not be present as the project progressed and they became accustomed to working in VR. One of the six students reported nausea in Round 1 and did not use VR for the remainder of the project, but continued collaborating with those inside VR and suggested design ideas. In the later rounds, the physical effects that were most reported were annoyance factors from using the headset such as hat hair. Learning curve also showed decreasing frequency between rounds 1 and 3. During the focus group in Round 4, students reinforced that there was a learning curve present that they had to overcome, and some expressed that they still were not fully comfortable with it. This suggests that the basics of the technology are intuitive, but advanced usage, as with other skills, can take time and effort to become highly proficient. This might be best illustrated by a student’s comment who stated in the focus group, “I understood the basics quickly, it was just challenging to get comfortable with the controls for designing detailed and precise ideas”.

Decreased process efficiency was mentioned by several students throughout the project. Comments in this category included, “Drawing in 3D took me a little longer,” and “It was hard to get a lot done.” A majority of the comments received that fit this code seemed to be referencing negative impacts of the learning curve to proficiently use the software, and these comments were also coded under learning curve. While there were several comments in this category, there were substantially more comments that gave feedback about how their design process was improved. In total, 4 comments were about decreased process efficiency and 18 talk about an increase in process efficiency. Many of the student’s comments about improved process efficiency expressed thoughts about fast and efficient communication of ideas, and one student commented, “I was quickly able to mock up my ideas and show them to the team”. This suggests an overall increase in the efficiency of the design process through integrating VR once a designer is comfortable with the software.

The positive and limited technology capabilities of VR showed clear results and the limited capabilities outscored the positive capabilities by a score of 19 to 8. Regarding limited capabilities, many students expressed that they wanted the ability to use more precise measurement and design tools. This is a constraint of Tilt Brush which, while useful for basic gestures, left students feeling limited in further refining their concepts because they wanted specific tools regularly found in design software that have not yet been developed for Tilt Brush. Tilt Brush is primarily designed for artists and, while other programs exist that offer more technical tools, they also come with a steeper learning curve and larger price tag, and none of these support the scale of site needed for landscape architectural design. This contributed to why Tilt Brush was chosen for this research. Unfortunately, there is not a VR design program available at this time that provides an interface, toolset, and scaling capacity equivalent to what is commonly available in landscape architecture design software. Such programs may be available in the future.

However, it is possible that students’ comments about being limited by software may be more closely associated with a lack of experience with the software and not knowing the capabilities of what is possible to create. There are many different tools in Tilt Brush that can be used in a variety of ways to closely imitate features of common design software such as SketchUp. There are also many examples built into Tilt Brush that showcase the capabilities of the software, many of which show intricately detailed scenes. However, this requires a greater amount of experience and comfort with both VR and Tilt Brush than the students were able to achieve during this project. Overall this data suggests that there are both positive and limited capabilities of the technology depending on the tasks being performed. In this project the limitations outweighed the capabilities, and more research is needed in order to better understand how these limitations might be overcome and how they affect design outcomes.
Collaboration is another set of codes that had both positive and negative responses, and like the technology capabilities, this set of codes revealed substantially negative results. Limited team collaboration was mentioned much more than positive team collaboration, and students’ responses show that it was a challenge working as a group to make modifications to a design. Student comments described how there were times when they experienced confusion or frustration because those outside VR could not completely understand what the person inside was verbally describing or vice versa. This proved to be a limitation throughout the project and confirms the findings of George, Sleipness, and Quebbeman (2017). The Likert scale responses to the question “My team could collaborate effectively using VR” also showed limitations in this category and the mean response was 3.6 out of 7 (7 being ‘strongly agree’ and 1 being ‘strongly disagree’). Although collaboration was identified as being limited in several ways, the majority of the time that students reference collaboration they are referring to verbal communication, and it is important to note that collaboration can happen in more than one way. This is further highlighted in the related code improved communication of ideas. Responses in this category specifically reference visually sharing ideas and concepts. This code was especially high during the final round and many of the students mentioned that they were able to easily mock-up ideas to share with their peers, and that their teammates were able to quickly see and understand their design intent, which in turn enabled them to get their points across quickly and improved the design conversation. One student commented, “When one of us had a good idea but had a hard time telling others about it or showing it in 2D, they just drew it in VR and the group was able to understand. This seemed like it reduced team compromises because we understood everyone’s ideas and were able to make decisions quicker.”

The word ‘visual’ was brought up many times in this category. This highlights the difference between verbal and visual communication in collaboration. These results suggest that while verbal communication and collaboration is hindered in VR, visual collaboration and communication is greatly improved. The hinderance is likely due to the designer being visually separated from the team and as virtual team environments become more accessible, more research is needed to assess team collaboration in the same VR space. Because of this, a recommended workflow for collaborating in VR would need to include frequent sharing of the VR design space so that the entire team is tapping into the visual communication benefits of VR, which in turn should help to alleviate some of the difficulties with verbal communication.

Fig. 3: A student creates a design concept and receives feedback from the team
Overall, considering the identified affordances and limitations, this research suggests that there is a positive outlook for the use of VR as a tool for design creation in small-scale site design applications, and the benefits observed validate the efforts used to collect additional materials to facilitate VR design that is not required in traditional methods. While VR is still an emerging technology, the expansion of available software and capabilities has expanded substantially over the last two years, and ongoing investment in the technology will further drive technical innovation. While some software already exists that is tailored towards design professionals, such as IrisVR, it can be expected that in the near future more programs will be

Fig. 4: A mixed reality view into what a student is seeing while designing in VR
developed for specialized fields such as landscape architecture. This will create many opportunities for future research and exploration into improvements that are expected to be, made such as team collaboration.

7 CONCLUSIONS

This study examined the use of VR during the analysis and concept development phases of the design process on a small-scale site design project. Instead of using VR in the late stages of the design process as a tool for design-review, students successfully integrated VR into a workflow that utilized both traditional and VR methods to analyze a site and develop a series of concepts. The results yielded that using VR for analysis and concept development on a small-scale project improved students’ understanding of their designs, allowed them to better express their ideas, and make better informed design decisions. However, limitations were also observed, such as difficulties with verbal team collaboration, technology issues, the possibility of adverse physical effects, and a learning curve to proficiently use the software. However, with virtual reality technology rapidly improving and adoption expanding, future research will be needed to quantify the impacts of VR on design decisions and monitor how technological advances impact current limitations, such as team collaboration and the effect of VR on the design process. Overall, this research suggests that VR can be fineffectively incorporated into the analysis and concept development phases of the design process, and while it offers both benefits and limitations, this study concludes that the benefits outweigh the limitations.

8 REFERENCES


Fig. 5: Design ideas developed by the team of a play environment around the school.


George, B. H. (2016). Distributed Site Analysis Utilizing Drones And 360-Degree Video. Digital Landscape Architecture, 1, 92-96.


CELA MEDIA STATEMENT

Title of Paper or Research: HOW VIRTUAL REALITY IMPACTS THE LANDSCAPE ARCHITECTURE DESIGN PROCESS AT THE SITE-SCALE DURING THE PHASES OF ANALYSIS AND CONCEPT DEVELOPMENT.

Authors: Drew Hill, Benjamin George, David Evans

Institution or Professional Affiliation: Utah State University

Authors please select one of the following: I DO X DO NOT want to prepare a media statement for general release from the 2018 CELA Conference.

Media Statement: This research examines the benefits and challenges of incorporating virtual reality into the landscape architecture design process. Virtual reality and traditional design process methods were used together in the analysis and concept development phases of the design process to create an inclusive play environment around a charter school. Data was collected from the six member design team throughout the process, and the results suggest many benefits and a positive outlook for the use of virtual reality as a tool for analysis and design creation in the landscape architecture design process.

Graphic Abstract:
NOTES ON COMMUNITY DESIGN-LED COLLABORATION:
WAIPAHU TRANSIT-ORIENTED DEVELOPMENT

Ho Schar, Cathi
University of Hawai‘i at Manoa School of Architecture. E-mail: cathi@hawaii.edu

1 ABSTRACT
This paper examines a multi-departmental, multi-curricular, and extramural collaboration on the Waipahu Transit-Oriented Development (TOD) Collaboration Proof of Concept (PoC) Study for the State of Hawai‘i Office of Planning (OP). This project mobilized eight faculty members representing intersecting academic units: the Department of Urban and Regional Planning (in the College of Social Sciences); the Center for Public Policy; School of Architecture; and Sea Grant Colleges, through the newly established University of Hawai‘i Community Design Center (UHCDC). The project aims at a new interagency planning and design framework for state-owned lands surrounding Honolulu’s controversial billion dollar rail line. To accomplish this, the UHCDC team sequenced and aligned coursework and contract work to provide community engagement, an ecological hazards assessment, an ecological asset study, a tree canopy study, infrastructure and transportation studies and recommendations, strategic planning sessions, flood mitigation measures, a design futures digital optimization model, block typologies, site development options, and costing studies for the state parcels. This paper assesses the internal and external collaborations involved in this project through metrics that describe costs, benefits, and outcomes to faculty members, students, the state, and community. These metrics provide a basis to reflect on UHCDC’s unique model as a driver for academic, institutional, and community collaboration.

1.1 Keywords
Community design, transit-oriented development, transdisciplinary action research, collaboration
2 INTRODUCTION

A university-based community design center is typically a hybrid practice constituted of academic and professional methodologies applied in service to diverse communities at all scales of built environments. In this respect, CDCs are necessarily cross-disciplinary: they both create and inhabit unique academic space within which its agents—faculty, researchers, students, and consultants—move freely across disciplinary boundaries ordinarily constricted by university departmentalization. Community design centers therefore offer unique space for cross-disciplinary collaboration. The impact of this collaborative model on communities is widely documented, however we tend to pay less attention to the impact of this model on university collaboration. For example, one well-recognized but under-examined consequence of the university tenure system is its concentration of disciplinary identity and resources within units that reward individual specialization. Universities are working to develop criteria for tenure and promotion that recognize cross-disciplinary, collaborative scholarship. This paper offers the University of Hawai‘i Community Design Center (UHCDC) as a case study that demonstrates ways CDCs can provide interdisciplinary opportunities that circumnavigate traditional obstacles to collaboration both within and between traditional departments. This case study features a specific project, the Waipahu Transit Oriented Development (TOD) Collaboration for the State of Hawai‘i Office of Planning (OP), as it provides opportunities to assess the collaborative model at work in a project aimed at supporting large-scale state collaboration surrounding TOD.1 With collaboration as both problem and process, this reflection on both aims at the same goals of transdisciplinary action research, to increase our understanding of these types of collaborations.

2.1 University of Hawai‘i Community Design Center (UHCDC)

The University of Hawai‘i Community Design Center was established in 2016 as a hybrid teaching practice and outreach initiative led by the School of Architecture, to provide a new platform for students, staff, faculty, and partnering professionals to collaborate on interdisciplinary applied research, planning, and design projects that serve the public interest. The center’s projects offer research-based design and service-learning opportunities for students through academic instruction, internship, and post-graduate employment. This practice model was developed in close collaboration with a state senator, who was chairing the Capital Improvement Project (CIP) committee, which oversees the state’s $3 billion CIP budget. This partnership positioned the UHCDC to serve at the intersection of government, university, and community, introducing a novel, top-down model to a conventionally bottom-up model of practice.

2.2 University-led Community Design

In its inception, UHCDC was modelled after two well established university-led community design centers: the Detroit Collaborative Design Center at the University of Detroit Mercy, and the University of Arkansas Community Design Center at the University of Arkansas. Both highly esteemed directors, Dan Pitera and Stephen Luoni provided generous mentorship in visits to their operations and as invited guests to Hawai‘i. Both use the “teaching hospital” as an analogy for their model of practice, which aptly describes their center’s autonomous and supportive relationship to their universities and communities. Their work, staff, and collaborations are multi-disciplinary in their internal teaming and external outreach, especially with regard to public agencies. While UHCDC aims at similar collaborative work, its internal structure is notably different. As a platform, UHCDC offers opportunities and an infrastructure for any faculty to work on projects as principle investigators with autonomy and sole authorship over their own work. The work is not done

1 Faculty members on the Waipahu TOD team include: Simon Bussiere, Assistant Professor, School of Architecture (SoA), Priyam Das, Associate Professor, Department of Urban and Regional Planning (DURP), Wendy Meguro, Assistant Professor, SoA, Sea Grant College, Colin Moore, Associate Professor, Center for Public Policy, Hyoung-June Park, Associate Professor, SoA, Cathi Ho Schar, Adjunct Assistant Professor and Director UHCDC, SoA, Daniele Spirandelli, DURP, Sea Grant College.
under the purview of the director. This horizontal orientation evolved as the center started to navigate the quantity and diversity of work that the state was offering. In order to meet demand, UHCDC embraced the notion of the university as the design center, and began to establish itself as its hub.

2.3 Community as Classroom

As a university-wide resource, UHCDC also looked to new models for university-wide academic collaboration. The University of Oregon’s Sustainable Cities Year Program (SCYP) represents an established model for university-wide academic collaboration focused on one city or town. The proliferation of this model into a network of similar university programs is represented by EPIC-N, also established by the founders of SYCP. Early on, UHCDC invited the SYCP co-director and co-founder Marc Schlossberg to speak about both entities. While UHCDC collaborations typically involve less partnered faculty on each project than SYCP, the underlying aim is the same: to connect the academic resources of the university to the needs of the community, or for UHCDC, the needs of a state agency, in this case the Office of Planning.

2.4 Honolulu Rail Transit Project

The state created the Honolulu Rail Transit Project in 2005 to provide a transit route connecting the south side of the island of Oahu, comprised of 21 key transit stations accessing significant destinations from Central Oahu’s “second city” to the urban core. shown in Figure 1. The controversial $8.3 billion estimate for the entire 20-mile system, makes the rail the largest public works project in Hawai‘i’s history (HART, 2016). Originally financed by the City and County of Honolulu and the Federal Transit Administration, recent overruns led to the state legislature providing $2.4 billion in state funding, bringing all three tiers of governance into the project.

![Figure 1. Honolulu Rail Transit Map (2018). Map by UHCDC.](image)

2.5 Hawai‘i Interagency Council for Transit Oriented Development (TOD Council)

Pursuant to Act 130 Session Laws of Hawai‘i (SLH) in 2016, the Hawai‘i state legislature established the Hawai‘i Interagency Council for Transit Oriented Development (TOD Council), to coordinate statewide
TOD planning. As the largest landowner along the 20-mile corridor of the Honolulu Rail Transit Project on Oahu, the state has the potential to capitalize on its properties along the rail, and to work toward revitalizing adjacent neighborhoods, in particular through new affordable housing and improved access to public facilities and services. As part of its role leading the state’s interest in all TOD areas, the council also identifies annual priority Capital Improvement Project (CIP) funding requests for each legislative session.

2.6 State of Hawai‘i Office of Planning

The Office of Planning (OP) heads the TOD Council, which is nested within their purview to provide the state with “central direction and cohesion in the allocation of resources and effectuation of state activities and programs, and to effectively address current and emerging issues and opportunities.” (OP, 2019). To assist in this process, the state legislature appropriated $250,000 in capital improvement project funding to OP, to work with the University of Hawai‘i Community Design Center to produce a proof of concept (PoC) research, planning, and design study aimed at developing a framework for subsequent state-led TOD projects.

2.7 Waipahu

OP selected Waipahu as a pilot site for the study, a town of 40,000, that was originally a plantation town, home to the many ethnic groups that immigrated to the islands for agricultural employment (Waipahu Town Action Plan 17). Approximately 10 acres of state lands are within the ½ mile radius from the Waipahu rail station and bus transit center. These lands are owned by Hawai‘i Public Housing Authority, Department of Accounting and General Services, and Hawai‘i Housing Finance and Development Corporation, with current uses including elderly housing, the Waipahu Library, Waipahu Civic Center, and surface parking. The site was selected because of the manageable area and smaller number of state landowners included within the TOD area, providing a context with less challenges to interagency collaboration.

Figure 2. Waipahu Pouhala station area state parcels. Map by UHCDC.
2.8 Collaboration

Kurt Lewin and his colleagues at the Center for Group Dynamics at MIT coined the term “action research” to describe the process of convening government officials, scholars, and community leaders to translate psychological research principles and findings into practical solutions for wicked problems, like prejudice and conflict nearly 60 years ago. (Stokols, 2006). This integration of academic and applied research gained widespread interest in 1960s and 70s in response to social issues, prompting a critical look at the impact of these collaborations. As Stokols notes, “effective practice of action research—especially the development of evidence based sustainable community interventions—depends heavily on the adoption of community partnering strategies in which researchers, lay citizens, and community leaders work together, often over extended periods, in a highly collaborative and equitable fashion.” (Stokols, 2006)

In 2006, Stokols identified a need for what he called “a science of transdisciplinary action research,” to provide an integrative analysis of cross disciplinary efforts to resolve existing gaps in our understanding of these types of collaboration (Stokols, 2006). In his discussion, he defines distinctions for cross-disciplinary research, describing three different types: multi-, inter-, and transdisciplinarity. Multi-disciplinarity is defined as a process in which researchers from different disciplines work independently or sequentially, within their disciplines to address a shared topic; interdisciplinarity, in contrast, entails increased exchange of information between the researchers across disciplines; transdisciplinarity involves research across disciplines integrating multiple perspectives within a shared framework. The metric for measuring success in transdisciplinary work is the extent to which they promote novel conceptual models and investigations (Stokols et al., 2005). Stokols also defines three separate facets of transdisciplinary action research—scientific (academic); community coalitions between researchers and practitioners; and intersectoral collaboration, spanning organizations and agencies. The Waipahu TOD Collaboration project offers experience with all three of these facets in its engagement between academics, community members, and public agencies.

This reflection is positioned at a transitional time in the center’s development. The first generation of collaboration projects near completion, providing lessons learned for the center as it starts its sophomore phase. The Waipahu PoC project offers insights on its multiple forms of curricular and extramural faculty and student collaboration and interagency effectiveness. In this aim, the paper aligns the science or scholarship of transdisciplinary action research, which entails studying the processes and outcomes of team research projects for the purpose of identifying circumstances that facilitate or constrain effective collaboration (Stokols, 2006)

3 METHODS

3.1 Proof of Concept

In partnership with the chair of the State Senate Capital Improvement Project (CIP) Committee, which controls the state’s $500 million CIP budget, UHCD's drafted a Proof of Concept (PoC) scope of work described in the state budget as “stakeholder engagement, applied research, and conceptual planning and design investigation that informs state agencies ahead of project definition, annual budget requests, and procurement of professionals.” These services are preliminary. They typically include (but are not limited to) a set of analyses, design schemes, criteria, and initial costs that assist CIP with project justification and definition. PoC services are typically ahead of—not in lieu of—commercial design services provided by professional consultants. The legislature approved $1.85 M in the 2017 State CIP budget for PoC project allocations to five agencies: Department of Land and Natural Resources, Department of Public Safety, Department of Accounting and General Services, University of Hawai’i, and Office of Planning, which received $250,000 to fund this Waipahu TOD collaboration.

The prelude to the funding of this project began with invitations to the deans and directors of the University of Hawai’i at Manoa School of Architecture, the Department of Urban and Regional Planning, and UHCD to attend the first TOD Council meeting, a large body representing over 25 agencies and interests. The motivation behind this invitation was to see how the university could align its resources in support of the council’s aspirations, largely surrounding the question of how the state might mobilize and address the
opportunities and challenges of TOD as a landowner. In response to this inquiry, both departments gathered faculty members with relevant expertise, course assignments, and interest in addressing this question as a team. UHCDC became both convener and platform for a team of eight faculty members:

UHCDC convened the project team prior to the $250K CIP appropriation, which required each faculty member to define scopes of work based on what he or she could integrate into coursework or develop with minor additional funding. This prompted the team to assemble smaller scopes of work that were largely generated or incubated in six different courses. The absence of initial funding helped facilitate this exercise in leveraging, sequencing, and aligning multi-departmental curricula. Participating faculty conceived each of the scopes of work as parts to a whole that would contribute to the development of an overall framework appropriate for all future state-led TOD studies. It is important to note that the scope was defined by the project team primarily based on teaching assignments and available expertise, not by the state Office of Planning. This model fits Stokol’s recommendation that transdisciplinarity should be transepistemological, differentiating between knowledge cultures and traditional disciplines. The UHCDC team was defined by knowledge cultures and/or the teaching/research interests of each professor more so than individual disciplines. Each faculty member in their own way provides unique but complementary and overlapping vantage points.

3.2 Curriculum and extramural coordination

UHCDC structured the project as a sequential, multi-disciplinary collaboration, beginning with studies in Urban and Regional Planning, followed by architecture, landscape architecture, and urban design studies in Architecture, with extramural funding providing opportunities to refine, develop, and synthesize the work produced by all. These various scopes and sequences of work are included in Table 1. The project team met formally once per semester; faculty members who expressly aligned courses and work coordinated more frequently. Courses with scheduled mid-term and final reviews offered natural venues and opportunities to share work, both internally to the project team and externally to stakeholders. The scopes of work produced outside of coursework employed typical client meetings, coordinating with various city, state, and professional organizations. The team presented both the Urban and Regional Planning and Architecture scopes to the TOD Council for feedback, allowing teams direct access to an audience composed of members from almost every major city and state agency related to the built environment, including the governor’s office and select designees representing elected officials.

<table>
<thead>
<tr>
<th>Date</th>
<th>Dept</th>
<th>Faculty</th>
<th>Coursework</th>
<th>Directed Scope</th>
<th>Research</th>
<th>Deliverable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2017</td>
<td>ARCH</td>
<td>Prof. Simon Bussiere</td>
<td>ARCH Studio Speculative design of transit station</td>
<td>Ecological asset study</td>
<td>Tree canopy study</td>
<td></td>
</tr>
<tr>
<td>Fall 2017</td>
<td>DURP</td>
<td>Prof. Priyam Das</td>
<td>PLAN 678 Site Planning Stakeholder interviews, site visits, planning research to support site selection, program development, site analysis, and conceptual site designs.</td>
<td>Develop report</td>
<td>Planning study</td>
<td></td>
</tr>
<tr>
<td>DURP</td>
<td>Prof. Daniele Spirandelli</td>
<td>PLAN 620 Ecological Hazards Hazards analysis with past, present, and future ecological conditions</td>
<td>Develop report</td>
<td>Ecological hazards study</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Spring 2018 | DURP | Prof. Priyam Das | PLAN 751 Practicum  
Development of baseline research from PLAN 678 and 620 to provide a comprehensive planning report. Student-hosted share and learn event with the Waipahu community including important stakeholders and legislators. | Develop report | Planning study Community workshop |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DURP</td>
<td>Prof. Suwan Shen</td>
<td>PLAN 642 Infrastructure Community infrastructure needs survey, stakeholder interviews, build-out land use scenario analysis, and GIS based suitability analysis to estimate the capacity and constraints of existing infrastructure, identify opportunities for multimodal transportation and green infrastructure.</td>
<td>Develop report</td>
<td>Infrastructure and transportation Study</td>
<td></td>
</tr>
</tbody>
</table>
| Summ er 2018 | DURP | Prof. Wendy Meguro | ARCH 478  
Preliminary flood mitigation studies for the transit station area. | Flood Mitigation Measures – criteria and recommendations | Flood mitigation criteria and recommendations |
| ARCH | Prof. Colin Moore | | Strategic Planning Sessions with each state agency to understand the structure of multi-agency collaboration and provide recommendations for best practices. | Interviews, Recommendations, Best Practices |
| CPP | Prof. Hyoung-June park | | Design Futures Digital Optimization Study use Urban Network Analysis computational approach to look at reach, gravity, and closeness to investigate walkability, accessibility, desirability for future development. | Digital optimization model |
| Fall 2018 | ARCH | Prof. Cathi Ho Schar | Block Study  
Inventory of existing block typologies and characteristics. Synthesize team deliverables – develop | Typological survey, site designs, cost magnitude |
urban design options for
the 5 state parcels.

3.3 Community engagement

A community workshop hosted in Waipahu provided an opportunity for true inter-disciplinary collaboration, distinct from the sequential or parallel working relationships between faculty and students involved in the other scopes of work. The PLAN 751 practicum class, led by Professor Priyam Das, organized and hosted an evening community workshop event—what we in Hawai‘i call a “talk story”—to gather feedback on course research related to climate change, place-making, affordable housing, transportation, and economic development. They solicited help from architecture students, who in turn developed promotional graphics and interactive tools based on participatory design methodologies. Architecture students devised a Post-it based “Keep it, Toss it, Create it” exercise, a sketching worksheet, and a large ‘co-design’ site model, finished with chalkboard paint that allowed participants to use colored wood blocks and chalk to represent desired future developments. While the community workshop gathered a diverse group from neighborhoods, the city, and the state government, planning students were disappointed in the absence of young people, which prompted UHCDC to reprise their engagement exercises at a Waipahu High School digital technologies class later on in the month. The follow-up also provided students with a chance to critically reflect on the effectiveness of their engagement tools in two very different outreach scenarios. Most importantly the departmental overlap introduced students to the similarities between the two programs.

![Figure 3. Waipahu Talk Story event (2018). Photo by UHCDC project team.](image)

4 FINDINGS

The findings from this process are limited to this vantage point in time and can only describe observations and short-term outcomes from this effort. More detailed analysis will need to be made after the project is
complete, and evaluations by the client and faculty can be collected. The findings in this report only represent the perspective of the author of this paper, who acted as the point of contact and organizer for the team, and was responsible for the compiling and synthesis of the reports into a final document and a highly graphic summarizing State-led TOD Design Considerations document.

As Stokols notes, evaluating the success of collaborative teams must distinguish between process and outcome. The following table compiles information on processes that help measure the effectiveness of the center, based on its mission—teaching, service-learning, research, and service, with costs, benefits, and outcomes listed below in Table 2, Table 3, Table 4, and Table 5.

### 4.1 Teaching

**Table 2. Costs, Benefits, Outcomes for Teaching**

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Additional collaboration with other faculty</td>
<td>• Shared knowledge of other departmental programs</td>
<td>• Engagement tools integrated into professional practice</td>
</tr>
<tr>
<td>• Additional coordination with agencies</td>
<td>• Shared syllabi</td>
<td></td>
</tr>
<tr>
<td>• Additional skillsets needed to be taught in order to produce</td>
<td>• Knowledge of how syllabi can provide meaningful services</td>
<td></td>
</tr>
<tr>
<td>desired results</td>
<td>• Motivated students</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Knowledgeable and invested feedback on student work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Opportunity to teach community engagement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Newsworthy coursework</td>
<td></td>
</tr>
</tbody>
</table>

### 4.2 Learning

**Table 3. Costs, Benefits, Outcomes for Student Learning & Professional Development**

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Additional transportation costs</td>
<td>• Students able to follow a project over multiple semesters</td>
<td>• 65 students enrolled in Waipahu TOD project related courses</td>
</tr>
<tr>
<td>• Additional time commitment outside of class</td>
<td>• Students able to follow a project under different faculty expertise</td>
<td>• Over 2,500 in-class hours</td>
</tr>
<tr>
<td>• Complex problem</td>
<td>• Students able to follow a project under different disciplinary lens</td>
<td>• Over 1500 paid internship hours toward NCARB architectural licensure</td>
</tr>
</tbody>
</table>
4.3 Research

Table 4. Costs, Benefits, Outcomes for Research

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large number of collaborators means reduced research funding and scope for each individual</td>
<td>Funding for faculty</td>
<td>2 papers (up to date)</td>
</tr>
<tr>
<td>Large number of collaborators to coordinate with</td>
<td>Outcomes based research</td>
<td>Infrastructure Study</td>
</tr>
<tr>
<td>Sequential collaboration means that research partners are not working at the same time</td>
<td>Applied research opportunity</td>
<td>Ecological Hazards Study</td>
</tr>
<tr>
<td>There was no single person providing a continuous thread between all research and design scopes</td>
<td></td>
<td>Tree Canopy Study</td>
</tr>
</tbody>
</table>

The CIP context for the research studies in this project required the formative “process oriented” nature of design research to also transition to summative, “outcomes based” research. For example, feedback from the TOD Council for the Tree Canopy Study included requests to measure the effects of tree canopies on temperature and projected reduction in energy use and costs, in addition to increases in property value.

4.4 Service

The costs, benefits, and outcomes from the project with respect to services to OP are indicated in Table 5.

Table 5. Costs, Benefits, and Outcomes for Office of Planning

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>$250,000</td>
<td>All-in-one study includes research, planning, and design</td>
<td>Community workshop</td>
</tr>
<tr>
<td>2 years total</td>
<td>Access to research expertise in disciplinary fields of study*</td>
<td>Planning report</td>
</tr>
<tr>
<td>9 months to execute contract</td>
<td>Neutral party working between agencies and with community members*</td>
<td>Infrastructure and Transportation study</td>
</tr>
<tr>
<td>Coordination/project management</td>
<td>Curricular work provided at no cost*</td>
<td>Ecological Asset Study – Tree Canopy Study*</td>
</tr>
<tr>
<td>Proof of concept does not include conventional planning material (Environmental Assessment, Environmental Impact Study, Archaeological Inventory Study, Entitlement due diligence).</td>
<td>Political goodwill working with students*</td>
<td>Flood Mitigation recommendations and Criteria*</td>
</tr>
<tr>
<td></td>
<td>Better prepared students entering the workforce*</td>
<td>Digital Optimization model*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block typology Study*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site Design Options</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost magnitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RFP template for future Waipahu developments*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strategic Planning Sessions and Recommendations*</td>
</tr>
</tbody>
</table>
UHCDC work is carefully scoped to provide services that fill-in industry gaps in research, planning, and design, and minimizes overlap with work typically provided by commercial practices. To assess this distinction, the items in Table 5 with an asterisk denote costs, benefits, or outcomes that would not typically be procured by the state or within the capacity of a commercial practice. These items highlight the unique resources that UHCDC offers to the public sector.

4.5 Administration

This novel alignment between UHCDC and the state CIP process introduced a new funding mechanism, contracting process, and account protocols, which required steep learning curves that imposed hardships on collaborators. All CIP-appropriated funds require the governor’s approval and release. Additionally, the first-time agreements required approvals by two state attorney generals, took nearly nine months longer than originally expected. Faculty members who committed to the project taught their courses as originally planned but had to seek loans to cover funding for teaching assistants, materials, and supplies. Faculty collaborators noted that this mis-synchronization of academic and legislative timetables would rule out similar collaborations in the future.

5 CONCLUSION

In many fields, cross-disciplinary collaboration is encouraged by public funding agencies (e.g. NIH, NSF) and private foundations (e.g. MacArthur, Robert Wood Johnson). This paper offers community design centers as an additional catalyst for cross-disciplinary alliances. UHCDC has adopted a platform model that provides an infrastructure for cross-disciplinary collaboration similar to the growing number of programs adopting the EPIC-framework, which provides a model for university-wide curricular collaboration on city projects; and the SUNY University Center for Community Design Research, which produced a Community Assistance Directory compiling all community service-oriented entities in the university.

While community design is not new, this public sector proof of concept model offers new scenarios. Whereas community design has traditionally attracted faculty members who identify with collaboration and service as distinct from those who prefer individual, autonomous, design speculation, the PoC model allows for both. In its alignment with the state legislature and state agencies, UHCDC offers faculty members new collaborative opportunities with levels of significance and funding that support academic productivity, tenure, and promotion. This win-win scenario is critical to continued faculty collaboration. Only through faculty members can the center connect projects to curricula and problems to the research expertise available within the university.

The Waipahu TOD Collaboration project also demonstrates that there are costs and challenges to collaboration both internally and externally that require continuous adjustment. Administrative burdens need to be streamlined to allow for repeated collaboration. UHCDC needs its own framework for large faculty collaborations that lays out a road map, schedule, coordination, and accountability protocols. Faculty members tended to work at the core of their disciplines, largely due to the fact that their work was defined by coursework or their own expertise. The students and staff who worked with or between multiple faculty members moved closer to and across the boundaries between disciplines. If success is measured by novelty and innovation that occurs from the intersection of disciplines, as previously mentioned, UHCDC project teams would benefit from paying greater attention to these boundaries, and allocating more time to that space.

In spite of the challenges and lessons learned, extramural funding for research remains highly competitive. Community Design Centers have the capacity to access design service fees as distinct from research funding, and in doing so, bring opportunities, funding, staff, and recognition to the academic programs they represent. In two years, UHCDC has engaged approximately 20 faculty members across 6
departments and executed over $2M in contracts with public agencies. Building on a 50-plus year tradition of university-based community design, UHCDC creates unique space for academic collaboration; unique agency for institutional collaboration, and unique resources for community collaboration. The traditional academic structure of most universities—departmental autonomy, the tenure system, disciplinary silos—can inhibit the potential for authentic hybridity, whereas the community design center model offers space.

6 REFERENCES


CELA MEDIA STATEMENT

Dear CELA Authors:
Please consider include in this space a research summary in 100 words or less that would best describe your topic, its principal results and/or impacts, written in clear language that would be of interest to public media outlets. In addition to the research summary, you may provide an optional graphic abstract that further explains the topic.

Title of Paper or Research: Notes on Community Design-led Collaboration: Waipahu Transit Oriented Development

Author: Cathi Ho Schar

Institution or Professional Affiliation: University of Hawai‘i at Manoa School of Architecture

Authors please select one of the following: I DO_____ DO NOT___X____ want to prepare a media statement for general release from the 2018 CELA Conference. (If you choose DO NOT, you do not need to prepare a media statement).

Media Statement (100 words max.):

(Optional) Graphic Abstract: please insert the illustration below.
Authors: please seek copyright permission if copyrighted materials are used.
The Living Green Infrastructure Lab: Advancing Interdisciplinary Teaching and Experiential Learning in Landscape Architecture Pedagogy

Tao, Zhihan
Texas A&M University, tabris2tabris@tamu.edu

Newman, Galen
Texas A&M University, gnewman@arch.tamu.edu

Arnold, Michael
Texas A&M University, ma-arnold@email.tamu.edu

Li, Ming-Han
Michigan State University, minghan@msu.edu

Kim, Jun-Hyun
Michigan State University, junhkim@msu.edu

1. ABSTRACT

Demonstrating and experimenting interdisciplinary teaching and experiential learning, faculty and students across three colleges (Agriculture and Life Sciences, Architecture and Engineering), and 4 departments (Landscape Architecture and Urban Planning, Horticultural Sciences, and Civil, Biological and Agricultural Engineering) designed, implemented, and are monitoring effects of a rain garden. This collaboration presents a model for multi-scalar, interdisciplinary studio instruction involving a project conducted by over 200 undergraduate and graduate students across allied fields. Landscape Architecture students provided designs, construction details, and performance monitoring of the site as well as developed a large-scaled campus master plan. Horticultural Sciences students propagated and produced the plants. Civil engineers assisted with constructed infrastructure design and water quality/quantity assessment. Professional landscape architects, urban planners, horticulturalists, engineers and campus facilities maintenance personnel evaluated student work. This paper specifies lessons learned from the application of a program that sought to educate and train students in LID alternatives to traditional stormwater management through hands-on outdoor classroom activities. While opportunities for interdisciplinary networking, knowledge of the landscape construction process, and the ability to utilize scientific rationale for design decision making all increased, challenges included coordination efforts across disciplines, overcoming unknown nomenclature specific to each field, delays due to unforeseen circumstances, and budgetary increased as a result of maintenance issues. However, Collaboration between multidisciplinary professionals enabled students to experience the professional design process and have a deeper understanding of the positive impacts of green infrastructure through interdisciplinary experiential learning.
1.2 Keywords:
green infrastructure, stormwater management, design pedagogy, low impact development, high impact experience

2. INTRODUCTION
In recent decades, higher education has been emphasizing the importance of interdisciplinary experiences and high impact learning for students to be better prepared for immediate employment. According to Kuh (2008), “collaborative assignment and projects” is considered one of the high-impact educational practices in higher education because it deepens one’s own understanding by “listening seriously to the insights of others, especially those with different backgrounds and life experiences (p.10).” To facilitate more cross campus collaboration, Texas A&M University (TAMU) launched a series of initiatives with funding to support interdisciplinary teaching and experiential learning in 2015. Faculty from three colleges (Agriculture and Life Sciences, Architecture, and Engineering), and four departments (Landscape Architecture and Urban Planning, Horticultural Sciences, and Civil, Biological and Agricultural Engineering) formed the research team and collaborated to propose a project that addresses the importance of green infrastructure, and the project was selected to proceed with funding.

The project team focused on the green infrastructure topic because drought has had a statewide impact on Texas with current groundwater reservoirs at only 67% fill level (down from 81%) and reservoir storage rapidly declining with losses of up to 64,000 acre-feet per week from lack of rain, lack of stormwater infiltration, and over-consumption of water (Newman et al., 2018). Groundwater has declined in most aquifers while areas closer to the Gulf have subsided up to 8 ft. since 1940 due to groundwater consumption. Low Impact Development (LID) provides an alternative to traditional approaches that require costly maintenance and waste resources. As flood events become more frequent and impervious land cover increases, management of stormwater runoff becomes increasingly important (Thiagarajan et al., 2018). Planning strategies emphasizing stormwater management, such as Low Impact Development (LID), are increasingly utilized in sustainable design/development, minimizing impacts of impervious land cover. LID is an innovative approach treating stormwater at the source, using uniformly distributed facilities such as stormwater collection devices, filtering systems, and water reuse mechanisms. However, the interaction of different scales (from master plan to site-scaled facilities) and disciplines within the design process are rarely conducted in academic settings. Current design studios have both limited funding and limited interdisciplinary cooperation. In most cases, products created within a landscape architecture studio conclude at the conceptual level and are never installed, nor does post occupancy evaluation occur (Newman et al., 2017). This is typically due to licensure/insurance/oversight issues with faculty and student work, along with ethical issues in performing work that could/should be done by practicing businesses. If installed, the performance of the project is seldom calculated and physical inspection of the built out product does not occur.

To overcome the typical structural, legal, and ethical dilemmas involved with such an undertaking
(such as academics competing with professionals for jobs), we chose a site that was not, nor has ever been, scheduled for any design intervention. It was simply an open ditch that carried runoff from a parking lot into a nearby creek. Secondly, maintenance crews working for the university typically undertake such planning ventures so that no bidding would occur on such a job. Thirdly, funding for the project was obtaining internally from specific outlets which allow for faculty to conduct such interdisciplinary applied research and teaching and create programs specifically for campus enhancements. Finally, we worked with campus landscape architects, campus planners, and maintenance personnel to ensure the project adhered to current university goals and plans.

Using a site on the TAMU campus, the project team and participating students designed and implemented a rain garden, which serves as a living green infrastructure (GI) lab. In this living GI lab, different courses under the landscape department were connected from the design studio to construction courses, and interaction between multi-disciplinary departments was promoted. In this way, a comprehensive masterplan, a detailed rain garden design, a feasible construction layout, a planting plan, an irrigation plan, a maintained plan, and substantial performance monitoring involved the students across all four departments, which provided the opportunity for interdisciplinary cooperation, design application, and landscape performance assessment. Landscape architecture students have been experiencing the real time project design and implementation process, allowing for a better understanding of the utilization of LID, as well as providing a hands on experience for conceptual design to detail and implementation.

This paper presents lessons learned from a framework for interdisciplinary site design studio teaching integrating landscape development, stormwater management, professional feedback, landscape performance, and the integration of site scaled design into existing larger-scaled masterplans. General benefits of this project were to raise awareness of hydrological issues and to demonstrate the feasibility of widespread implementation and to educate a new generation of practitioners in LID applications. Several objectives were sought to achieve this focus:

1. Strategically implement a set of structural and non-structural LID facilities on each test site and link their core functions through education, research, and demonstration provided by outdoor classrooms.
2. Operationalize the construction, performance measurement and long term monitoring of each site assessing the impact of LID treatment versus non-treatment as an educational mechanism for students.
3. Assess the learning outcomes of the interdisciplinary teaching and experiential learning outcomes.

2.1 Disciplinary Roles

Like professional landscape architecture projects, the design and implementation of a project usually requires interdisciplinary cooperation (Meyer et al., 2018). For designs involving planting plans, an expertise in regional horticultural knowledge is an essential facet to bringing a landscape design into reality as well as its long-term success. To demonstrate this process and expand the
border of the traditional landscape courses, the instructors from different departments interacted in this project to provide feedback and instructions on the design and strengthen its feasibility.

In this project, the landscape architecture department played a leading role with the design, revision, implementation, and performance monitoring, the horticulture department played an important role of plant propagation and planting design, and civil engineering department took charge of construction plan feasibility as well as assisted in the monitorization processes. During this process of design and implementation, multiple courses were involved: In the Department of Landscape Architecture and Urban Planning, 5 Construction and Site Engineering Courses (LAND 329/330/331/612/614), 6 Design Studio Courses (LAND 318/319/320/321/601/602), and 1 Practice Diversity Course (LAND 645) were utilized. In the Horticultural Sciences Department, 6 courses were utilized (HORT 306/308/425/485/608/609), and in the Civil, Biological and Agricultural Engineering, 4 courses were utilized (CVEN 301/413/627/665). In total, the students involved in the design and implementation phases totaled more than 200 across all departments.

2.2 Site Description
The site of this project was located on the western portion of the TAMU campus, on a site adjacent to White Creek. This portion of campus was recently designed in part by White Oak Studio, a professional landscape architecture firm, as a component of the Leach Teaching Gardens. It is also a part of the 2020 vision of the TAMU masterplan to become a campus greenway. The implemented rain garden portion is adjacent to the Borlaugh Institute, which was an open grass swale which transported runoff from an adjacent parking lot. The mission of this living lab was to design a comprehensive masterplan and a detailed rain garden design. After a planting plan consultation with horticulture department and a construction plan consultation with civil engineering, the SSC Campus Facilities Service helped install and currently maintains the student and faculty led raingarden design. Funding for construction of this project was provided by both the Aggie Green Fund ($61,500.00) an organization for sustainable built projects at TAMU as well as a TAMU Tier one Grant ($300,000.00), a three year interdisciplinary research and teaching opportunity. Both offer major funding to empower students, faculty, and staff to take action and bring creative environmental improvements to the TAMU campus.

3. FRAMEWORK DESCRIPTION
3.1. Learning Objectives and Outcomes
The primary intent of this project is for students to learn what hydrological and ecosystem services are and the important role that LID facilities can play in mitigating urban flood issues. Students were exposed to multi-disciplinary approaches and learned how to analyze, interpret and present data from complex projects. The program addressed six learning outcomes of each department: 1) mastering the depth of knowledge required in design, construction and plant biology and landscape function; 2) demonstrating critical thinking in problem solving for the design and evaluating effectiveness from the collected data; 3) communicating results effectively to a variety of audiences; 4) learning socially responsible uses of water management; 5) preparing the students for lifelong
living by stimulating curiosity and learning to acquire knowledge from multiple sources and assembling it into a coherent purpose; 6) working in many collaborative groups and teams to accomplish the various stages of the project. It also directly linked to 5 of the university’s student learning outcomes: 1) developing a coherent understanding of the subject matter through synthesis across courses and experiences; 2) application of subject knowledge in a range of contexts to solve problems; 3) using a variety of sources to analyze and integrate information; 4) using appropriate technologies to communicate, collaborate, conduct research, and solve problems; 5) conducting valid and data supported appropriate research. Table 1 describes these learning outcomes and the assessment methods which accompanied them.

Table 1: Learning Outcome Breakdown and Assessment Tools

<table>
<thead>
<tr>
<th>University</th>
<th>Learning Outcomes</th>
<th>Assessment Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nurture critical thinking and life-long learning skills needed for deep and continuing engagement within the built and natural environments</td>
<td>Determine the degree of self-motivation increase and understanding of the causal linkages of developmental decisions</td>
</tr>
<tr>
<td></td>
<td>Demonstrate leadership and informed decision-making skills in professional practice and in the community</td>
<td>Monitor and analyze the roles of each student and their devotion to the program’s development</td>
</tr>
<tr>
<td></td>
<td>Build a broad knowledge base of natural and cultural systems</td>
<td>Identify the multiple components which comprise the composite of the natural and cultural environments</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Landscape Architecture and Urban Planning</th>
<th>Learning Outcomes</th>
<th>Assessment Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Develop and apply knowledge of landscape architectural materials, methods, and performance, from source through extraction, design use, and place</td>
<td>Construction detailing examinations and professional critique</td>
</tr>
<tr>
<td></td>
<td>Demonstrate a deep knowledge of and ability to apply the processes of design, planning, preservation and construction of exterior spaces</td>
<td>Juried review by faculty and visiting professionals</td>
</tr>
<tr>
<td></td>
<td>Develop and apply knowledge of landscape architectural materials, methods, and performance, from source through extraction, design use, and place based characteristics</td>
<td>Portfolio, technical report, and design package development</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horticultural Sciences, &amp; Civil, Biological and</th>
<th>Learning Outcomes</th>
<th>Assessment Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Identify horticultural plant characteristics and their uses</td>
<td>Measure students’ understanding of the importance of matching the correct plants with the desired functions in the</td>
</tr>
</tbody>
</table>
### Agricultural Engineering

<table>
<thead>
<tr>
<th>Design</th>
<th>Design.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrate knowledge of the movement of water, nutrients and energy through the biosphere and the resulting impacts on plant growth and physiology</td>
<td>Identify the extent to which students understand the bio-filtration and water collection systems modification of hydrology and nutrient movement in the test systems.</td>
</tr>
<tr>
<td>Critically evaluate options for sustainable plant management, including natural, urban and engineered horticultural systems</td>
<td>Determine the extent to which students have gained an understanding of the alternative water saving technologies into urban landscape designs.</td>
</tr>
<tr>
<td>Collect, manage, analyze and interpret data</td>
<td>Measure the extent of involvement of student in analysis and presentation of data generated.</td>
</tr>
</tbody>
</table>

#### 3.2. Project Phases

As noted, this program sought to educate and train students in LID alternatives to traditional stormwater management through hands-on outdoor classroom activities involving development, installation, monitoring, management, and evaluation within interactive test plots on the site.

The first phase of this project was the conceptual master planning for west campus. Students were introduced to LID, instructed to investigate existing drainage problems, and applied LID strategies and design elements to solve said problems.

The second phase of the project was to link the conceptual design to the goals of the Texas A&M Gardens and Greenway at White Creek, a public greenway for conducting teaching, research, and extension/outreach activities. In this phase, landscape architecture students were required to integrate the LID facilities and apply of GI as a means of assisting in stormwater management while connecting to the current greenway system. Since the masterplan is part of the 2020 TAMU vision masterplan and adjacent to the landscape design site of horticulture buildings under construction, the studio had the consultation with the university planning faculty and landscape architecture professionals from the White Oak Studio. Students in this masterplan phase received feedback from professionals as well as planning faculty about large-scale design, and gained practice-wise feedback from practicing professionals. The studio was divided into four groups based on different themes. Their final masterplan was modified throughout the self-reflection and a series of feedback sessions with professionals, faculty, and maintenance associates.

The third phase was the conceptual design of the rain garden, located near a series of Borlaugh Institute green houses. Horticulture faculty members cooperated with landscape faculty on plant selection and evaluation/feedback for the planting plan. Plant selection process for LID was conducted under their instruction and utilized mostly native, low maintenance species. Students
gained a deeper understanding of plant characteristics for LID and suitability under certain conditions. Later the designs were illustrated and presented to the horticulture faculty members and professionals. The best design was selected to move forward for revisions and an eventual construction plan for implementation.

After the conceptual design phase, the project was integrated with civil engineering students and faculty. In consideration of performance and feasibility, an overflow detention structure was put into the design to divide the first flush and better handle the peak runoff during rainfall. The structure of the overflow structure was designed under by both landscape architecture and civil engineering faculty/students. After the design with the civil engineering group, instructors in the horticulture department cooperated in a review and revision of the planting plan according to the current nursery inventory within the horticulture department and what was available to grow. During this phase, the students collaborated with more disciplines and professionals, and gained better understanding of the practical landscape implementation such as budget control, material selection, sourcing, and plant combinations for maintenance considerations.

To compare the pre-construction condition and post-construction condition, a program to monitor the water quality and quantity of runoff into and out of the site was installed. Landscape architecture students used ISCO water samplers to collect rainwater, and H-flumes to test runoff speed. After retrieving data and water sample from the samplers, the water samples were sent to the TAMU AgriLife Extension Service Soil, Water and Forage Testing Laboratory to compare the water quality before and after entering our pre-construction site. When the construction is completed, and the plants are fully established, students will use the same method to test the water quality and runoff velocity in and out the rain garden again, to compare pre and post conditions. The research will provide a powerful longitudinal case study for future education for LID from the perspectives of site design, construction design, and design practice.
4. RESULTS
During this three-year period, over 200 undergraduate and graduate students across four different departments collaborated with one another and working professionals within their related fields. From the perspective of landscape architecture education, this course was well received. There
are students interested in construction design who worked with the civil engineering faculty to develop the final construction documents of the on-site overflow device. Meanwhile, the students with special interest in planting design cooperated with the horticulture faculty and students to finalize the feasible planting plan. In addition, among the four student design teams, three teams won the state chapter ASLA student awards; two of which won awards of Excellence in the General Design, and Planning and Analysis Categories. During the three-year duration of the lab, the participating department earned experience with multi-discipline cooperation across different colleges, and has poised itself to develop a solid scientific case study for future education of the impacts of GI on stormwater mitigation.

Figure 3. Texas Chapter ASLA Student Award for Excellence in Planning and Analysis.

Image credit: Zhihan Tao, Bingjie Zhao, and Kaidi Ye

The traditional landscape architecture studio course usually consists of a process entailing site analysis, case studies, conceptual design, and design schematics. There are few opportunities for
students to explore multiple scales of design and implementation of these projects is quite rare. The isolated environment of landscape architecture students from other disciplines in traditional design studios can be different from most of the multi-disciplinary working environments in professional practice. Furthermore, traditional studios can limit opportunities for students to be involved in real projects and have a more comprehensive understanding of construction materials, the construction process, and planting materials.

In the living GI lab, because the project is both multi-scalar and interdisciplinary, students have the opportunity to have different experiences with both large-scale master planning and small-scale site design while providing an in-depth multi-disciplinary learning experience. With the feedback loop with planning and maintenance crews and well as professionals, students were able to be intimately involved with the many revisions and sacrifices required to actually get a project installed. Furthermore, the landscape performance measurement provides great opportunity to examine the research associated with GI and LID benefits.

As noted, prior to the installation of the project, the runoff speed, volume, and water quality were monitored and recorded using water samplers produced by ISCO and consultation with the TAMU AgriLife Extension Service Soil, Water and Forage Testing Laboratory. The entire construction process was recorded by time-lapse cameras to produce videos for further inspection and to educate students about the different phases: site preparation, grading, paving installation, metal
structure installation, and planting. After the installation, post-design water quality measures were conducted and compared to pre-installation data. The results of the performance monitoring are more than study material for this lab, but also a case study for future course materials of construction, theory application, and practice diversity classes to demonstrate the outcomes of LID and future interpretation of this rain garden to improve its performance.

5. CHALLENGES
Despite the positive outcomes of this project, there are a few challenges for future process of this lab and usage of this lab model. The first challenge of this model is its time consuming process. Since the different phases of this project are dependent on different groups of faculty and professionals, the timeline often changes according to the changes of human resources, curriculum, weather conditions, and other emergencies. In this case, the construction of the rain garden can be influenced by the surrounding construction (which delayed the installation of the raingarden for more than three months) or other outside circumstances. The delay of installation forced the timetable to change, which made this project exceed the duration of planned 3 years. The excessive amount of time causes challenge of costs of the project. A majority of the costs of the project were construction costs, since the plants were grown by students. However, the equipment of the monitoring devices was also a significant financial burden. Since the devices will be implemented in the outdoor environment under raining weather, they are very easily influenced by wind and rainstorm events. The devices for conducting pre-development condition tests were actually broken by the storm during Hurricane Harvey. The substantial cost of repair also ate into the budget. The shipment of replacement parts for the devices required extended time as well. Relatedly, since the designed device for the overflow structure on site was custom, the work for the metal flume was extremely costly and required an excessive amount of communication work with the custom metal workshops and fabricators. Having said these, these challenge are real in the industry and therefore, allow true learning for the students and faculty.

Figure 5. Monitoring devices influenced by hurricane event and the final installed design. Photos by authors.
6. CONCLUSION
This project is an experimental approach to integrating different disciplines into a single living lab which covered site analysis, campus masterplan, site design, LID application, planting design, construction documents, construction process, and landscape performance testing. It allowed landscape architecture students to go through the full process from sketch of design to actual installation. Further, it provided opportunities for students to find their own interest area and expertise, which is very helpful for their career planning and development. Since this project also provided a glimpse of the research process involved with landscape performance, students interested in landscape research were able to explore its potential. Despite the cost and time spent on this project, the students gained opportunities for their future, and better understanding of systematic green infrastructure and application of low impact development. In addition, the nature of this project, course organization, multi-disciplinary network, and performance monitoring methods were helpful for the future educational opportunities in the future.

7. REFERENCES
HISTORY
THEORY AND CULTURE

Edited by Judith Wasserman, Stefania Staniscia & Elisabeth “Lisa” Orr
IAN MCHARG’S OPERATIONAL AESTHETICS

Zhang, Bo
Oklahoma State University b.zhang@okstate.edu

1 ABSTRACT
Though he was neither an aesthetician, nor a practitioner of landscape architecture in the traditional sense, Ian McHarg produced an inevitable impact on the aesthetics of landscape architecture. This contribution has never been systematically codified. By inductively examining McHarg’s rhetoric and practice from articles, books, drawings, project reports, and archived materials, and deductively constructing philosophical arguments, this article deciphers McHarg’s legacy, an aesthetic nihilist’s vision of ecological design. The first part of this research discusses what made McHarg an outward aesthetic nihilist using three angles: 1) the truth of ecology over the beauty of a landscape, 2) form-process theory, and 3) environmental sin. When McHarg was developing his ecological design approach, aesthetics was methodologically excluded from the landscape suitability method, and they were intellectually deprioritized by environmental considerations. Also, the legitimacy and morality of aesthetics was challenged against the ecological design backdrop.

The second part summarizes McHarg’s operational aesthetic literacy into three visions: pristine nature, recluse landscape, and Picturesque landscape. Design literacies are summarized, with project imageries illustrated. These three aesthetics are also woven into the theoretical frameworks as constructed in the first part. Finally, McHarg was included in the discussion of the schools of Visual Impact Assessment and Ecological Aesthetics, where his lasting contributions and possible damage to aesthetics were reconciled.

1.1 Keywords
Ecological design, landscape suitability method, aesthetic principles, aesthetic literacy, ecological aesthetics
2 INTRODUCTION

In 1990, U.S. President George H. W. Bush granted Professor Ian McHarg (1920-2001) the National Medal of Art in recognition for his exquisite contributions to ecological design. This was the first time a landscape architect – which McHarg is generally regarded as – was awarded this honor, which might be the highest honor ever received in the discipline. In his presentation speech, President Bush said, “It is my hope that the art of the twenty-first century will be devoted to restoring the earth” (See McHarg, 1997a, p.331). The ironic part about McHarg receiving the medal was its name: National Medal of Art. Art was a topic that McHarg ignored, despised, or attacked while he was constructing a novel ecological planning focus across forty years of his career.

From the 1960s on, McHarg always regarded himself as a spokesman for ecological determinists (1966). Though President Bush was not necessarily an ecological design expert, his statement reflected the lay public’s expectation of the role landscape architects played in the environmentalism context, which finally concluded a lengthy confusion about aesthetics and ecology in recent landscape architecture history. Soon after he received the National Medal of Art, McHarg, for the first time, accepted the legitimacy of aesthetics during a 1992 ecological design symposium at Arizona State University (see Thompson & Steiner, 1997). Recognizing art as a dimension critical to ecology, he ultimately admitted that ecological design “will require a fusion of science and art” (McHarg, 1997a, p.331).

Though he was neither an aesthetician, nor a practitioner of landscape architecture in the traditional sense, Ian McHarg provided a substantial impact on landscape architecture aesthetics since publication of his seminal book *Design with Nature* in 1969. A pioneering promoter of the landscape suitability method, an eloquent public speaker who endorsed ecological planning, and a tireless advocate for protecting and restoring the environment, McHarg was also recognized by his indifference for, and even his intent to subdue, aesthetics in the landscape design and planning field (Thayer 1976; Corner, 1997). The powerful leadership in ecological design combined with fiery verbal attacks on art (McHarg, 1966, 1970, 1971) overweighed the theories of most other contemporary aestheticians in directing landscape architects. Receiving the National Medal of Art and recognizing the legitimacy of art in ecological design late in his life barely changed McHarg’s image as a radical opponent of art and beauty.

Though not consistently outlined in his work, McHarg’s ideas and visons of beauty not only represented the style of his fellow ecological planners, but also inculcated visions and principles to the landscape architect community. Today, few would regard McHarg as an all-purpose ecological “preacher.” However, McHarg’s impact on aesthetics has been fundamental and everlasting, a fact that should be reconciled but is frequently overlooked. While the landscape suitability method has involved broader scales and more complex elements incorporated into the consideration of practice, landscape architects have still sought consensus about preference, vision, and composition, all associated with aesthetics (Nassauer, 1995, 1997; Gobster, 1999; Meyer, 2000).

3 DEFINITIONS AND METHODS

The term aesthetics refers to the philosophical branch that deals with the nature of art, beauty, and taste. It studies the process by which art is created, as well as the way that art is appreciated. In the field of art history and design history, aesthetic studies always admit certain ideal visions of beauty and the associated operational principles for certain eras or schools of artists/designers. Besides the specific aesthetic principles, one’s aesthetics also include how those aesthetics are weighted with other considerations in one’s world view. Given beauty as an autonomous and universal entity, the domain of aesthetics can study almost any visions and ideas related to form and order.

Recognizing McHarg as a lead design thinker in the environmental movement, the scope of aesthetics in this study is very specific. The focus is on the appropriate appearance or visions of the designed environments, their generation process, as well as the underlying principles that validate or disprove the appearances and processes. Other aspects of aesthetic studies, such as empirical proof of the beholders’ sensory and cognitive reactions, are not the focus. An internal dilemma of McHarg’s association with aesthetics should be accepted as a premise of this study. On the one hand, he outwardly labeled himself as an aesthetic nihilist and disparaged art and design; on the other hand, evidence in his remarks and practices revealed his ideal images of good landscapes. The inconsistency in rhetoric as well as in practice, reflected McHargian complexity, which still awaits resolution.

Therefore, the examination of McHarg’s aesthetics is divided into two different levels. First, we seek to understand what made McHarg an outward aesthetic nihilist. An inductive study was conducted to assess
his books, articles, biographies, slides, and interviews from the bottom up. The interpretation was conducted from three lens: the landscape suitability method, form-process theory, and his development through the use of environmental ethics. The landscape suitability method not only reset the goal of landscape design from an ideal aesthetic vision to biophysical health as a survival need, but also methodically estranged aesthetics. The form-process theory suggested a laissez-faire mechanism in which landscape form is generated. McHarg’s further criticism of human society and design professionals rendered aesthetics as an environmental sin.

Second, we seek to understand McHarg as a designer, who inevitably has a set of aesthetics just as other designers do. Though scattered and even buried, McHarg’s visions and ideas of beauty can be uncovered by looking at his comments on historical and cultural styles, his descriptions of sceneries in different places, his remarks about other designers, and most importantly, the projects with which McHarg was deeply involved. Some may argue that most McHargian projects were accomplished by the firm Wallace, McHarg, Roberts, and Todd (WMRT), where McHarg, as stated in his biography, played a leadership role rather than having hands-on experiences. Yet, these projects were supervised and approved by McHarg, and always cited by him in articles and speeches, which constituted the closest evidence to reflect McHarg’s visions, a precious opportunity we cannot afford to waste.

For the present research, we selected six projects, including Green Springs, Worthington, and Western Run Valleys (1963-64), the Princeton I-95 Highway (1965), Amelia Island (1971), Wilmington and Dover, Vermont (1972), Medford (1972-1974), and The Woodlands (1971-77). The selections were based on three criteria. First, McHarg suggested his deep involvement in the project; second, the project generated clear images or the appearance of a built or planned environment; and finally, the project records were available at the Ian McHarg Archives at the University of Pennsylvania.

As a result of this analysis, the codification of each vision included four aspects. First, the elements and principles of each ideal vision was summarized. Second, we explored how McHarg justified the validity of this vision. Third, the vision was evaluated for its ecological attributes and its compatibility with the Landscape Suitability Method. Finally, the application of each vision was discussed.

4 AESTHETICAL NIHILISM

4.1 Paradigm Change: Truth of Ecology over Beauty of Landscape

The Landscape Suitability Method, one of McHarg’s major contributions to the landscape architecture discipline, could be seen as an inevitable entity that estranged aesthetics. The impacts were nothing like the style or trend changes previously practiced, but the legitimacy of aesthetics in landscape architecture was shaken. Many scholars later found embryonic forms of this method utilized prior to McHarg’s ecological planning process (Steinitz et al., 1976), which may invoke debates on the attribution of specific concepts. However, it is almost routinely acknowledged that McHarg was the most important figure who popularized the method and made it a disciplinary norm in landscape architecture, planning, and beyond. This method prescribed a process of inventory, analysis, synthesis, interpretation, and planning decision-making in order to generate environmentally friendly development schemes. Various natural processes (and later social and economic processes) were summarized into categories, inventoried on respective layers of same-scaled-maps similar to a layered cake, analyzed for their compatibilities, and finally synthesized into a single map as segmented parts of different suitability in order to inform land development. During the environmental movement of the 1960s and afterwards, this procedure provided an actionable means of converting understanding from various scientific disciplines into the perception of the biophysical health of the land and suitability for future land uses. This revolutionized the subject and the process of landscape planning and design.

A deeply rooted triad of truth, goodness, and beauty in Western philosophy can explain this design priority change (Gardener, 2011). Historically, landscape architecture developed its theory and criticism as an alliance between goodness and beauty. In this reciprocal model, a landscape was rarely described as true or false since landscape beauty was created from metaphysical concepts rather than empirical data. Landscape architects designed by envisioning certain aesthetics, and landscape projects achieved goodness because of related symbolisms and metaphors. This type of beauty-goodness alignment evolved as design styles adapted to different chronological, cultural, social, climatic, and geographic changes. The principles of beauty were explored through design techniques such as proportion, scale, texture, and color, which did not address ecological necessities.
By redefining biophysical health as a critical good, the landscape suitability method deprioritized, if not excluded, aesthetics from the design objective. Compared with survival needs, the emphasis on landscape goodness led to an abdication of aesthetics. The new truth that McHarg pursued was to recognize “the actual environment, the actual world” (McHarg, 1964, pp.23–24). Learning from devastating environmental hazards of the 1950s and 1960s, McHarg realized that many hazards were derived from natural forces, especially those not understood and falsely deployed by humans. The opposite of good was not disorganized, but not following natural rules might result in danger, survival risk, and inappropriate processes. The contemporary scientific community provided tools to McHarg to reveal the actuality of the environment with great accuracy and comprehensiveness. In addition, mapping layer categories, such as relief, geology, hydrology, slope, soil, wood coverage, and land use were created to absorb systematic understandings from relevant disciplines. A robust structure of “truth-goodness” discourse elbowed out the “goodness-beauty” discourse. The landscape suitability method not only reset the major goal of design on land, but also created a methodological conquest over the traditional domination of aesthetics. This could be understood from the following aspects.

First, the analytical quality of landscape suitability outweighed the experiential quality of aesthetics. McHarg named this logical rationale “ecological determinism” (1966). Ecological determinism is a projection of science that is central to environmental studies. System theory by von Bertalanffy (1968) inspired the landscape suitability method, which suggests that all design activities have clear reasons, using a rational and analytical or even repeatable process. This style ultimately leads to predictable outcomes. The rigid landscape suitability process, from inventory, analysis, synthesis, interpretation, and planning decisions, indicated a clear causality, initiated by evaluations of different geological and biological layers and ending with the synthesis that summarized development suitability. In this closed construct, McHarg aimed to change the “random, inconsequential, or indeed malevolent” design method used in landscape architecture. Instead, he suggested that the discipline should “follow medicine and espouse science, biology, perhaps ecology and anthropology, and justify a more central and consequential role” (1997b, p.188). In McHarg’s viewpoint, the application of aesthetics seemed shabby and random compared with the logic of ecological determinism. Aesthetics not only lacked a formative structure that seemed analytical, but they also required a defined information deduction process to be logical. The application of aesthetics lacked the robustness of analytic quality, and its intuitive nature resisted repetition. Aesthetics, therefore, had to make concessions to the logical consistency of landscape suitability.

Secondly, the landscape suitability process does not complement aesthetics. Scientific data from various disciplines dismantles the wholeness of human experience into components – the process can lose the gestalt. As shown in Figure 1, the approach categorized lands into different segments according to different ranges of certain biophysical features. Each range was coded with a uniform color. No matter whether in process drawings or in conclusive synthesis drawings, the representation of land was summative rather than representative. This was because all the land information that was closely related to users’ experiences, such as that of space, pattern, form, texture, and color, were removed. Many of McHarg’s projects were presented with a bird-eye view perspective, which represents a higher comprehensibility to viewers. While the pattern of land was still comprehensively depicted, the singular site experience was still not utilized.

Third, during a landscape suitability process, data richness and comprehensiveness overwhelms aesthetics. Previously, landscape understanding was based on the experiences of individual designers. Due to the time and energy limits, these experiences were often spontaneous, scattered, and segmented. The generated insights could be shallow, isolated, or even over-representative. The introduction of data from various scientific disciplines offered a viable amount of information better “approximat(ing) reality” (1969, p.29). By inventorying information on the flat map with defined scale and resolution, the analysis of every inch of the map created a continuous quality of accuracy. Moreover, quantitative data were imposed into layers, which offered the measurability and refinement of understanding (McHarg & Sutton, 1975). With support from an overwhelming number of scientific discoveries “provid(ing) the best evidence” (1969, p.29) about water resource protection, hazard prevention, biodiversity, brown field remediation, and other processes, the quantity, extent, and depth of understanding from the landscape suitability model was advanced. As a result, important survival issues were revealed beyond individual experiences. By comparison, aesthetics revealed thinness and superficiality.
Fourth, the invisible nature of landscape modeling information incorporated in the landscape suitability model posed another threat to aesthetics. For thousands of years, land had been seen and understood according to its visible features, such as plant coverage, topography, form, color, texture, spatial enclosure, and others. More recently, proposed natural and societal factors, such as permeability, usage, connection, and interaction, were originally insensitive to visual sense. The multidisciplinary approach that engaged scientific disciplines provided the possibility of penetrating through the visible land surface and presenting the information underneath. As shown in Figure 1, geological, soil, and hydrological conditions were presented by collaborating with other disciplines. This change demonstrated the limits of sense of sight, which aesthetics used to fully rely upon.

Fifth, for the visible data categories, the working scale of landscape architecture expanded remarkably, and eventually exceeded the conventional scope of aesthetics. McHarg suggested the significance of the viewing angle of astronauts. First acquired in 1972, this perspective coincided with his view of looking at the environment. The distant and comprehensive view lifted humans from the "surrounding" environment, and enabled them to look at the environment through the viewpoint of "other." The experiential view of "ours" was diminished because of changes in both scale and angle. In many of McHarg's projects, broad-scale satellite images are used as the base medium for each layer of analysis. As a result, in this presentation, singular human experience disappeared. The patterns collectively reflecting the land uses were clear, such as different plant communities, human habitats, structures, facilities, waters, and mountains. When the synthesis was presented, the clues of singular tangible space and place were still missing. McHarg suggested using the scale of the landscape suitability method, which "reveals the megaform of natural process at the national level, the mezoform of the region, the microform at the city" (1966, p.46). The design at site scale seemed to be relinquished.

In sum, the landscape suitability method not only reset the goal of landscape design from ideal aesthetic vision to biophysical health as a survival need, but also methodically estranged aesthetics. The powerful analytic logic, the abundance and depth of data incorporated, the invisible nature of data, all challenged the intuitive, synthetic-based, superficial aesthetics. The broad scope and data flattening alienated individual experiences by embracing the design of "a structure system" (1966, p.45).

4.2 Form-Process Theory

A form-process theory, which McHarg also developed and reinforced as the ecological deterministic rationale, offered clues about how landscape forms should be derived under an ecological backdrop. In this theory, the concepts associated with visual vocabulary, such as art, beauty, and aesthetics, were tenaciously excluded from this theory, and instead, the word "form" was used. "Form and process," McHarg
suggested, “are indivisible aspects of a single phenomenon” (1970, p.182). Form should be a sole outcome of natural process; otherwise, it is faulty. “Every form reflects processes engaged in the business of creative adaptation toward the end of survival; form is only the superficial expression of the process” (McHarg, 1970, p.182). According to this theory, any “capricious” form is only an automatic outcome related to biophysical process.

When McHarg proclaimed that “all form is meaningful” (McHarg, 1970, p.182), the meaning of landscape form was deprived of social implications and rigorously confirmed as “fitness” or “suitability” of the biosphere. McHarg borrowed the concept of fitness from Charles Darwin’s *The Origin of Species* (1859) and Lawrence Henderson’s *The Fitness of the Environment* (1913) to describe biosphere health “both for natural objects and creatures and for artifices” (1969, p.163). McHarg’s definition of fitness is very vague. He refers to “the degree to which meaning can be perceived [as] a function of the ability of the observer to the meaning which is intrinsic” (McHarg, 1970, p.182). More specifically, fitness was always accessed by its relevance to the environmental survival of organisms (McHarg, 2007, p.23). To carry out the form-process theory in design, “architecture should not be called architecture; it should be called fitting” (1970, p.181), or “adaptation for survival” (1970, p.181).

McHarg endowed nature with a personality. A term always used to describe the innovation of human beings, creativity, was redefined by McHarg as the fantastic fitting effects of biosphere, which “has nothing to do with previous art” (1970, p.179). It was suggested that nature, being creative by itself, was capable of generating appropriate landscape forms. Ecological design and the planning process, therefore, could be a “creative fitting revealed in intrinsic and expressive form” (1997a, p.332). A landscape’s form had been decided, even predetermined, by impersonal forces of nature beyond human control. In other words, nature should be the sole driving force that pushes forward the form generation process.

Since nature is creative enough, the “form follows...” structure was no longer needed, despite inspiring generations of designers. Unlike the slogan “design with nature,” which suggested that designers could be inspired by nature, the form-process model suggested that all forms were designed by nature. The personality of God was borrowed to interpret nature’s creativity and expel aesthetics created by humans. McHarg explained that “the view of the Reformation that beauty is a vanity,” was expanded upon by this statement “that any intent to create beauty by man is assumption of God’s role, is a vanity, and is sacrilegious” (McHarg, 1963, p.8). Hence, a designer should maintain an impersonal tone and a disinterested point of view in the design process, while any free will generated by aesthetics should be eliminated.

McHarg cited non-human habitats such as those of beehives, coral, and the chambered nautilus to interpret the form-process (1963; 1964; 1969; 1990). The examples possessed “great beauty” “in human eyes” (1966, p.32) and “survived periods of evolutionary time vastly longer than human span” (1964, p.21). These forms are in the “richest biotic environment,” which are “benign, bountiful, and orderly,” “dynamic,” and “natural” (1990, p.187). McHarg respected the slow, even sluggish half-billion-year generation process by nature. Yet, the question pertinent to landscape architects is whether this process should be considered the only source for form and space creation.

In sum, the form-process theory suggested a laissez-faire mechanism in which landscape form was generated. According to Treib (1999), McHarg implied that if designers followed the landscape suitability process, the final landscape form would automatically be beautiful. This mechanism plainly did not offer landscape architects a handy design tool (Eckbo & Porterfield, 1970; Laurie, 1971). The process of design and construction involves human programming, material composition, components alternation, and implementation destined to be different from natural processes, which were not distinguished in the form-process theory. The form-process theory, largely derived from describing natural processes, cannot automatically provide a perfect landscape form that suits the prospective human program (Thayer, 1976; 1989). Neither can a design process solely directed by landscape suitability analysis generate an adequate landscape form, as this imploded approach lacks attention on the site scale. The non-human habitats cited by McHarg, which were associated with such different chronological and geographical scales, hardly demonstrated any conclusion relevant to daily landscape practice.

### 4.3 Morality: Aesthetics as Environmental Sin

The landscape suitability process suggested a NIMBY (“Not in my back yard”) attitude towards aesthetics, while the form-process theory indicated a laissez-faire (“It will work itself out”) view regarding aesthetics during a design process. McHarg’s further criticism of human society and design professionals
rendered aesthetics a more malicious status, as an environmental sin, not only insignificant, but also unclean.

To McHarg, environmental degradation had an exterior cause as well as an internal cause. While the intense and massive human power and technology were behind the exterior cause, the internal cause was the notion of human’s “presumption of superiority, dominion and licensure to subdue the earth” (McHarg, 1963, p.12). He suggested the adoption of a moral stand for treating the environment equally, and cast off the notion that nature could be freely exploited. A dichotomy between nature and humanity was commonly seen in his rhetoric, which revolted against the human dominance rationale. Instead of treating nature as “a storehouse existing for his delectation” (1996, p.210), nature should be regarded “as a source of life, milieu, teacher, sanctum, challenge, and, most of all, of rediscovering nature’s corollary of the unknown in the self, the source of meaning” (1969, p.19).

Although the landscape suitability process provided a handy tool for identifying sensitive areas, McHarg always felt the necessity of accusing humans from an internal angle for their corporeal avarice and environmental idiocy, as a human being “plunders, rapes, poisons, and kills this living system, the biosphere, in ignorance of its workings and its fundamental value” (1996, p.210). Regarding humanity’s broad and intense disruptive power in diminishing the physical environment, McHarg called this species “the land rapist, the befouler of air and water, the uglifier, and the gratified bulldozer” (1969, p.51).

By contrast, nature was pristine, innocent, vulnerable, and therefore beautiful. It was the greedy and arrogant human who made it risky, chaotic, and ugly. The proposition of "Man as Planetary Disease" (1971) culminated in the contemplation of human dominion and unrestrained power. McHarg traced the notion of the origin of human dominance further back to the Judeo-Christian traditions, where the Bible says that man was to have dominion over the earth. McHarg suggested that Scriptures could only be treated as an allegory rather than as literal truth for the sake of the survival of humanity and earth. Later in his life, McHarg corrected his bold statement about humanity as a disease. He stated, “I looked about me at friends, faculty, students; were they pathogens, agents of diseases, epidemics? Surely not.” His accusations were instead made towards “institutions and men whose fulfillment threatened the humans and all life” (1996, p.237). However, the branding of humans as a “Planetary Disease” was not easy to erase. Neither were the attacks on art and beauty.

While the moral ground of humanity was shaken, the morality of aesthetics was redefined. In scrutinizing the human-environment relationship, aesthetics involuntarily became an ethical scapegoat, as they embodied human activities and justified pertinent tastes. Since human activities were harmful and devastating, aesthetics, a largely human possession, was considered wicked. It was implied that the monumental vision of development drove ruthless exploitation with ignorance about the sensitivity of nature. The imposition of already justified and ideally preset aesthetics was not only unnecessary but also immoral, as it fostered greedy and ruthless environmental alternation. Therefore, McHarg called upon his fellow environmental designers to reject this 2,000-year-old tradition of aesthetics and art, and to “replace it with … the ecological view” (1970, p.185).

While the ethical and aesthetic issues remained unresolved, landscape architects bore the greatest pressure as the ecological realm was constructed. Landscape architectural practice was where environmental sin and humanity as a planetary disease converged. As McHarg once stated, “Almost all the architects, planners, and landscape architects should be handcuffed and their licenses taken away until they learn the way the world works” (1970, p.179). While McHarg’s rhetoric sent designers to the moral judgment desk, landscape architects considered taking more environmental stewardships, and began to question their societal status.

As a part of human society and as a group of professionals serving human society, landscape architects confronted inevitable pressures. Was landscape architecture a destructive profession because it planned and designed projects that altered the pristine land? Should landscape architects be held responsible for all the environmental degradation, even for projects programmed and commissioned by clients? If landscape architects were responsible for all these procedures, should they sacrifice aesthetics for a better natural process (if there was better practice)? Moreover, McHarg’s form-process theory challenged the professional status of landscape architects. Given that Nature itself was creative enough in manipulating a generative process that could lead to a fitting landscape, the landscape architecture profession seemed superfluous. Did we still need landscape architects to arrange and design land?

Due to McHarg’s theories, anxieties prevailed in this most traditional territory of landscape architecture. Since aesthetics were methodically trivialized, the necessity and morality questioned, the
specific actionable design strategies were left at loose ends. After comprehensive analysis and planning were implemented, the design literacy vacuum at a site might retard the design process. Were any of the conventional aesthetics in landscape design still considered valid? How could they guarantee that each sketch stroke represented an ecologically integral effect rather than one that would prove disturbing? Could any new aesthetics be derived when the landscape suitability process was applied? Moreover, should there be stylistic landscape aesthetics that echoed ecological considerations? While preaching ecological design, McHarg did not suggest any solutions for these questions.

5 AESTHETICS IN SPECIFICS

Aesthetics are unavoidable in landscape architecture. Landscape architects still deal with aesthetic issues on a daily basis, such as the composition of a plaza plan, the spatial enclosure of a garden, or the scene from a viewing deck. This was true for McHarg as a landscape architect. When we review his practice and read his autobiography (1996), it is clear that beauty was a major motivation for many projects as well as the focus of publicly recognized images for others. In his rhetoric, comments on form and beauty appeared unavoidable in some circumstances or came across accidentally. He used images in project reports and books to illustrate ideal visions as well as to describe undesirable disturbances. The design documents and the realized projects constitute the major sources required to understand McHarg’s visions (or more colloquially put, his tastes), as these were never codified. The codification in this paper shows a preliminary effort to summarize McHarg’s visions, and to justify their validity and relevance to ecology as well.

5.1 Pristine Nature and Descriptive Ecology

McHarg asserted that “the only beauty is natural beauty” (1963, p.8), a theory he spent a lifetime trying to protect. However, nature is polysemantic. If asked what natural beauty is, the answers could vary greatly among landscape architects, other professionals, and the public. All elements acquired from the external world, such as rock, water, soil, and most notably, plants, are natural. On the other hand, natural can refer to the occurrence of conformity within the ordinary course of nature, free of human intervention. For landscape design, one may argue that natural beauty is associated with the amount of natural elements utilized (for example, the plants), or associated with the degree of the original status retained for the land. Asserting that “wild nature” should be exemplified, McHarg’s ideas of natural beauty have dual meanings, as the visible “natural” elements and as the original status of land should be kept “naturally” untouched.

The pristine nature aesthetic vision, or at least the components of pristine nature under a comprehensive scenario, was compatible to the landscape suitability process, which McHarg named “descriptive ecology” (1966, p.34). In this concept, the landscape’s biophysical structure is the major source that outlines the compositional framework for future landscape designs. A series of prohibitions and permissiveness regarding limiting factors for future development were enacted to define the sensitive landscape elements/areas as preservation lands (McHarg, 1970). The intrinsic carrying capacity related to the long-term health of the land was therefore calculated.

Because this method was originally developed to defend natural land from the development encroachment, it was no surprise that preservation was always recommended as a suitable landscape program. In the analytic process, the original morphology of the sensitive lands should be retained as the spinal structure. Considering that “nature is the gardener’s best designer,” McHarg wrote, “the meadow was the single artifice, the remaining components were natural expressions” (1966, p.33). Original plants, including trees, shrubs, and ground covers, which were kept for their indispensable ecological service, constituted another major component of McHargian aesthetics. Because of the interdependence of geology, soil, topography, hydrology, and vegetation, McHarg always denounced the idea of deforestation, even for light human use, such as agriculture.

Primitive nature may also include more images than the “total greenery” suggested by previous conversationalists. In Design with Nature (1969), a variety of natural landscape types other than “greenery” were presented, such as sand dunes, permeable soil, and swamps. Multiple versions of The Woodlands Project reports showed scenes of messy ponds and muddy grounds (Figure 2). These landscape components are not as revelatory as those primarily composed of plants, but they were crucial to biophysical health. Yet, none simply abide with conventional aesthetic principles, such as balance, outlines, texture, depth, and spatial enclosure, nor can they be appreciated easily according to a formalized design style.
McHarg might imply that descriptive ecology could justify the instinctive beauty of these unconventional pristine imageries. According to the ecological meaning, they could be considered equally as respectful and as beautiful as those conventionally visual pleasing natural elements – at least their images didn’t need to be hidden from sight. Hence, the beauty of all the landscape elements of biophysical functionality could be legitimized.


The beauty of primitive nature was unconsciously used by McHarg as a medium to promote environmentalism. To him, the primitive landform was the true representation of ecological fitness, “deriving in the first place from that observed in nature” (1966, p.33). Compared to previous preservationists, such as John Muir (1918) and Aldo Leopold (1949), McHarg’s vision of natural beauty presented a very similar appearance. Yet, the McHargian method offered a clearer underlying mechanism for ecological service, a more convincing planning process, and a guideline for more delicate protection and development. What’s more, the coarse quality of landscape elements advocated by McHarg expanded the conventional images of primitive nature.

The form-process theory that glorifies the lengthy formation process lends a divine sense to the aesthetics of pristine nature. At the same time, it is worth noting that the aesthetics of pristine nature (sand dune and marshes included) could be an outcome of an analytic process rather than a formulaic style, though which “descriptive ecology” presents only those results of biophysical significance. Rather than the time of their formations, the selectively retained wilderness resulted from the purposeful evaluation of ecological functionality. This analytic process was not the same as that used in the form-process theory. Human designers, including landscape architects, played a vital role in preserving the pristine beauty, and
were motivated by the pristine beauty itself. In landscape architecture practice, the beauty of pristine nature could hardly apply to any program other than preservation, as McHarg always advocated. Also, its reception awaits visual assessment studies among the beholders.

5.2 Recluse Landscape

While McHarg tirelessly promoted primitive beauty preservation and yearned for the “natural, nonhuman process” (1964), he clearly knew that “there can be no conception of a completely ‘natural’ environment” (1964, p.21). Meanwhile, almost all the projects that he was involved in presented conflicts between the inevitability of development and the urgent necessity for preservation. The beauty of pristine nature could not be fully applied, and man-made elements had to be integrated, which gave rise to another aesthetic, the beauty of a recluse landscape.

The concept of the recluse landscape suggests an austere and self-sufficient aesthetic for the human environment. The recluse landscape image features a low development intensity, a large proportion of plants in an image, local construction materials, and a self-sufficient lifestyle. McHarg’s comments about his colleague, Sir Peter Shepheard, perfectly convey his own aesthetic of the recluse landscape, that the beauty “eschews bombast and virtuosity,” and “selects modesty, simplicity, appropriate materials and form” (1996, p.136). McHarg suggested that designed landscapes should learn from nonhuman habitat to “take inert materials” and be “constructed with great economy of means” (1964, p.21). The alteration of land should be minimized, and the appearance of necessary structures and facilities to support human living should adhere to their functionality.

The cover image of the Wilmington and Dover, Vermont Project visualizes this aesthetic (Figure 3). Natural structures (such as topography and hydrological patterns) and natural elements (such as trees, bushes, and groundcovers) constitute the major images, with a scarcity of built elements which visually complement rather than detract from “natural beauty.” An appropriate level of human care was demonstrated, in which nature was respected rather than exploited. McHarg admired the lovely blending of humble and useful human elements into the land. For the Valley project, he inferred that the recluse beauty represented a planning motivation. As he described, “expensive horses and cattle gaze in the pastures defined by white rail fences, handsome stone houses sit barely visible among the trees, rural roads fold over the gently undulating landscape” (1996, p.177).

![Figure 3. Cover image showing recluse landscape. Wallace, McHarg, Roberts, and Todd (WMRT). (1972). WMRT: Philadelphia, PA. p.66.](image)

The recluse landscape could also find suitable indications from the Landscape Suitability Method. While the intrinsic appropriateness derived from suitability analysis suggested the sensitive areas that required preservation, it also suggested areas suitable for moderate development. In McHarg’s words, the suitability analysis “provide(s) form in a most dramatic way from the level of the house on the shore to the form of metropolis” (McHarg, 1966, p.45). The primitive land was no longer a holistic untouchable piece, but
could be broken down into its appropriate uses and images. In the Valleys Project, the housing development in the wooded areas were prescribed as one unit per acre, and even one unit per three acres on wooded slopes (1966, p.42). This density was not justified anywhere in the report, but it nevertheless satisfied the image of scarce structures surrounded by a lush forest.

The recluse landscape image was also pursued for higher density projects. To avoid the arrogant stand-out of designed elements or formal image compositions, trees were envisioned to encompass, if not purely hide, human structures. In the Woodlands Development, apartment buildings were embedded in the pervasive greenery, part of a preserved area and part newly planted, rendering a tranquil ambience (Figure 4). This aesthetic recalled an appealing reclusive moment in history, just as living in the country was a remedy for city syndromes, much like an Italian villa that was built away from the city. Another example was the Chinese ancient retreat that was described as an escape from the “dusty world.” But compared with these precedents, McHarg’s recluse aesthetics seemed looser and resisted formality.

The recluse aesthetic was also practiced by McHarg in his own residences. After his second marriage in 1977, the McHarg family moved to Marshallton, Chester County, to achieve seclusion from Philadelphia. The family lived a self-sufficient lifestyle on his fifty-five-acre Old Mill Farm, where dogs and cats multiplied, and pigs, hens, ducks, pheasants, bulls, cows, horses, and sheep were raised. Also, using only a wheelbarrow, pitchfork, and shovel, McHarg and his wife kept a vegetable garden and orchard where they grew fruits such as red and black cherries, red and yellow apples, peaches, pears, nectarines, plums, apricots, currants, blueberries, gooseberries, and raspberries. McHarg described the appreciation for the land cultivated by the living experiences as “emotional and physiological” (1996, p.310).

When a housing development adjacent to Old Mill Farm was built, McHarg felt that their recluse life was threatened, and moved to the thirty-five-acre King Ranch in Chester County, Pennsylvania. The self-planning, design, and construction process for the new house further illustrated a recluse aesthetic. Biophysical determinants, especially geology, soil, and existing plants were examined. The family house was situated on the old farmhouse site on the rock pile, which also minimized the disturbance to existing vegetation. By being built below the high point and shielded by the wood lot, the residence achieved visual seclusion, with “short views of the woodlot and long views of the horizon in all directions” (1996, p.313). As a result, the existing land features experienced only nominal debasement. The only non-meadow area in

the property was a gravel parking lot. The horticulture growth were all put “in the pots on decks and porches” (1996, p.315). Austere materiality and constructability of the house added to the beauty and modesty of the residence. White oak, hemlock, and chestnut floorboards were used to recall nature. Instead of using quarried stones, weather-worn stones were field collected and mortared using a “cheek masonry” technique, in which mortar was concealed (McHarg, 1996).

5.3 English Picturesque

Compared to McHarg’s fascination with pristine and reclusive landscapes, his remarks on formalized landscape styles revealed more design specifics. Noticeably, McHarg constructed a dualism between English Picturesque landscape and French garden design. He regarded the former as “the finest accomplishment of art in the western tradition” (1997b, pp.189-190) and described the latter as “the worst possible admonition” to earth explorers (1997b, p.189). His obsession with English landscape suggested a clearer vision of naturalness instead of a vague totality of pristineness, or greenery as the best design element. The English Picturesque landscape style arranged natural materials in layers and scattered them in balance in order to compose a pastoral-looking image. In almost all his project reports and the Design with Nature book, pastoral-type images were included. And in the French Garden, the compositional vegetative elements, such as trees, shrubs, flowers, and ground covers were trimmed and organized by rigid geometrical ordering principles to form geometric shapes and to reinforce perspective lines.

Under a rigid ecological examination, McHarg’s opinion towards French and English Picturesque was more metaphorical than biophysical. McHarg regarded the French Garden’s rigid symmetrical pattern as being “imposed relentlessly upon a reluctant landscape” (1963, p.8), which represented “an image of flexed muscles” (1963, p.11). This view of aesthetics as an “imprint of humanist thoughts” (1963, p.8), symbolized “anthropomorphism, dominion, and subjugation” (1997b, p.189).

Since McHarg was always on guard for the potential disruptive power of humans in the landscape, he depicted these aesthetics as more “suited to suicide, genocide, than survival and success” (1997b, p.189). In contrast, the Picturesque style resembles an unexploited scene, recalls a nostalgia for pastoral scenery, and suggests a high ecological integrity. Yet, when McHarg cited English picturesque as a perfect aesthetic, this landscape tradition was not examined for its ecologically stabilizing effects, nor was a landscape suitability analysis conducted.

A serious examination of the Picturesque landscape may challenge its ecological integrity. The Red Book, by the Picturesque master Humphry Repton, clearly demonstrated magnificent changes exempted in order to achieve dramatic pastoral aesthetics. The original topography and vegetation were greatly altered. Compositional elements, such as water, vegetation, structure, and paths, were manipulated to accomplish a balanced and layered scenery. This did not affect McHarg, who regarded Repton as a precursor of ecological design (1966). Besides, Meyer (2008) suggested that the pesticide and herbicide used to retain this pastoral scenery proved ruinous to the biosphere of the environment.

McHarg’s English Picturesque obsession suggested a formal cultural need to visualize the abstractive ecology, in order to convey a tangible vision of design with nature. The image of Picturesque fits human culture as an ideal representation of the biophysical world, which was emphatically accepted by many landscape users, viewers, and designers. More metaphorically, McHarg regarded the Picturesque landscape as an “occult balance” (1966, p.33). The rich contrast and the mystical depth created by layers symbolized the complexity and diversity, as “evidence of higher evolutionary forms” (1968, p.57). A hierarchy of aesthetics resulted that prioritized the well-composed natural landscapes over the randomly preserved ones. This intent was illustrated in photographs in the Woodlands Project reports, which captured undeveloped scenes according to Picturesque compositions, with a degree of roughness tolerated (Figure 5). This suggested that, although artificial manipulation of land should never be encouraged, a curation of natural elements towards Picturesque was preferred.

McHarg’s depreciation of the French garden prescribed design interdictions, such as “nature abhors a straight line” (1966, p.33). Rigid geometry should be banned, because that “simplicity and uniformity reveal a primitive stage, while complexity and diversity are evidence of higher evolutionary forms” (1968, p.57). Even though this reasoning could not be used against biological effects, these claims against geometry (Euclidian geometry, of course) and grandness were coherent within the modest recluse landscape, which could potentially be extrapolated into the design of urbanity.
The designed landscape appearance can help disseminate environmentalist values, partially when legitimizing the theory of aesthetics in ecological design. Knowing that English Picturesque “clearly did not exist in the raddled landscape of eighteenth-century England” and “it had to be created” (1966, p.33), McHarg implied that a degree of modification could be tolerated to achieve an ideal-appearing nature. Hence, the need for designed landscape could be validated to some degree. Following this rationale, it is not difficult to understand McHarg’s comment on Japanese gardens as a “valid tradition” (1969, p.29). This intuitive acknowledgement of visual beauty was vulnerable to the examination of its “natural process” and ecological performance. Also, this valid tradition does not necessarily align with the process and outcome of the ecological analysis. McHarg visited Japan in 1973, where his suggestion to the Japanese government to conduct a comprehensive ecological study was politely but ironically turned down (McHarg, 1996).

6 Conclusion

McHarg’s operational visions were evident and diverse, and his thoughts about aesthetics were incomplete, and sometimes even contradictory. The tangible landscape images were illustrative of a design with nature rather than illusory, as suggested by McHarg himself (1990, p.187). A spectrum of aesthetics, consciously or unconsciously held, was always palpable in driving the analytic landscape suitability process, or setting parameters for it.

Of the three visions codified here, wild nature presents McHarg’s ideal vision for landscape planning, a model which resisted any preset design styles. A compromised but more applicable aesthetic was the recluse aesthetic, which suggests an austere and potentially self-sufficient beauty in tranquil and vast greenery. This type of aesthetic seemed the bottom line for McHarg, one which would allow for many human programs in development but which he could still regard as beautiful. The English Picturesque landscape was promoted as a materialized ideal vision of nature, the compositional principles of which could better “curate” and preserve natural landscapes.

These three types of aesthetics, pristine nature, recluse landscape, and the English Picturesque, bear some differences. But they unanimously embrace “total” greenery. They all use predominantly natural elements as the major scenery components, as we can see in the Valleys, Vermont, Woodlands, and other projects. None of these visions were McHarg’s artistic creations, but were instead confirmations against an ecological backdrop. He also included elements of visual coarseness and roughness, which expanded landscape literacies to some degree. At the same time, McHarg’s syntax prioritized irregular forms and...
multilevel layer composition over rigid geometry, uniform lines, and prodigious aesthetics, which might paralyze design projects under urbanized settings.

Studying their association with ecology suggested that the three visions were ecology-representative, and compatible with the Landscape Suitability Method; but none can be derived only from ecological considerations. Conversely, the processing of the ecological planning process was partially motivated or guided by aesthetic visions. The landscape suitability process always acts as a gatekeeper for the three aesthetics, meaning that while visual quality is maintained, landscapes for specific sites need to have their ecological characters evaluated in the analytic process to be valid and beautiful.

7 REFERENCES


TRANSITION FROM PRIVATE GARDENS TO PUBLIC SPACE

Applying water management methods of Persian gardens to urban areas

Avazpour, Behnaz
University of New South Wales, UNSW Sydney, b.avazpour@student.unsw.edu.au

Osmond, Paul
University of New South Wales, UNSW Sydney, p.osmond@unsw.edu.au

Corkery, Linda
University of New South Wales, UNSW Sydney, l.corkery@unsw.edu.au

1 ABSTRACT

The urgent need driven by urban development to provide a secure water supply is a challenging task for governments and service suppliers globally (Ahuja, 2016). Governments and professionals are exploring innovative water management approaches, which lead them to study and improve traditional techniques and reconcile these with the changing environments of our rapidly growing cities (Romero et al., 2017). As water scarcity gives rise to growing global socio-ecological impacts, there are lessons to be learned by reviving traditional water management systems in urban spaces (Sharma, et al., 2018). Approaches developed for a specific arid environment, can often translate to successful ideas in other arid locations such as parts of the United States and Australia, as global warming advances. Thus, the main aim of this research is to improve understanding of the role of traditional and local urban and landscape design in rainwater management and re-conceptualise them in the context of contemporary public space in arid and semi-arid cities.

Case study analysis has been used in urban and landscape design disciplines to link practice and theory (Francis, 2001; Steiner, 2014). By a combination of scientific and ‘grey’ literature review and case study analysis, this paper explores and defines strategies to apply water management methods of Persian gardens to urban areas. Two projects have been used to validate the strategies. These case studies were selected based on their particular water management strategies, availability of literature, and climate characteristics.

Most of Iran falls into the semi-arid or desert climate zones (Dinpashoh, Fakheri-Fard, Moghaddam, Jahanbakhsh, & Mirmia, 2004). Consequently, Iranians have always applied innovative techniques to realize opportunities for conservation and responsible utilization of water (Abbaspour, Faramarzi, Ghasemi, & Yang, 2009). The Persian garden is one of the most important elements in Iranian agriculture and landscape (Manuel, et al., 2018). In these gardens, implementing various techniques to collect, distribute, and retain water, has led to water use in various forms such as qanats, diverse types of streams and techniques to collect and evaporate water that creates a unique microclimate and provides comfort to occupants (Fekete & Haidari, 2015a; Yannopoulos et al., 2015). Thus, this paper outlines a basis for water management at the urban landscape planning scale, derived from traditional water management in Persian gardens, that could improve water management infrastructure and provide ecological and social benefits for semi-arid region.
communities. It is important to note that this research has focused on urban and landscape design in the context of its environmental performance and does not address the governance or policy aspects, which are yet to be researched. This paper reviews the techniques and strategies of water management in Persian gardens and their application in urban areas. Strategies to apply these techniques in other countries is the next step of this research.

1.1 Keywords
Water management, Water scarcity, Semi-arid regions, Traditional infrastructure, Persian gardens
2 INTRODUCTION

With population growth expected to double by 2050 (UN 2017), urban areas around the world are facing the tremendous effects of climate change and impending water crises. Urbanization, combined with climate change, has a negative impact on groundwater recharge, water supplies, the qualitative and quantitative state of receiving rivers, and urban climate. Clearly, there is a need for more effective solutions for managing urban water while improving cities’ liveability and safeguarding urban ecosystems (Howe & Mitchell, 2011).

Creative approaches to stormwater management and climate change adaptation may be applicable to diverse communities whether with expansive open spaces and limited capital resources or in dense urban areas, depending on the type of initiative. Moreover, innovative design, although developed in a specific environment, can often translate to successful ideas in other climates and geographies (Qiao, et al., 2018).

Research on the history of water management in the literature of Iran has shown that local and traditional experience and measures that have been taken over the ages can provide inspiration to face future challenges in urban water management (Lofrano & Brown, 2010). For example, the water canals in Isfahan (called madies) are regarded as green corridors in cities and can be considered as one of the main elements in the urban landscape (Kayvan Karimi & Motamed, 2003). These kinds of elements in the history of water management in Iran have the potential to be applied in other dry regions and cities in the world, for example in Australia. This process of transitioning local and traditional techniques to the contemporary era can be found in other parts of the world as they have been tested many decades ago (Romero, et al., 2017).

Iran is a country with a long history of water management strategies. Living on the Iranian plateau means struggling to conserve and preserve water due to geographic and climate conditions. Iran is a combination of mountains and deserts with hot and dry weather in the summer season, cold and dry weather in winter, and low precipitation (5–25 cm a year) (Voss et al., 2013). This affects people’s lifestyles and has required them to use innovative, creative and effective methods to preserve water. The Persian garden, a culturally unique garden design style that responded to the climatic conditions, has played an important role in the history of water management in Iran. These gardens embody practical solutions to help adapt to the extreme climate conditions, especially in the central parts of Iran (Fadaie & Mofidi Shemirani, 2014).

Persian garden design is the result of applying methods derived from different fields of knowledge: water management and engineering, architecture, botany and agriculture (Meskell, 2013). As well as gardens, many historical cities in Iran have applied solutions to manage their water and use it for aesthetic, environmental and functional purposes. These solutions have been modified from site specific water management strategies in private gardens and scaled-up to be applied to cities’ public places (Bakhshi, 2014). These traditional methods of water management may provide lessons for contemporary urban design in similar climate conditions (Brown, et al., 2009). Thus, in this paper, water management in public urban space is considered through examining a combination of traditional approaches in Persian gardens with new strategies to control urban stormwater and wastewater treatment, to deliver this essential resource for life in cities.

3 Water management in Persian gardens

Persian gardens are adaptable to different climatic conditions using the idea of “Chahar Bagh” (four gardens) (Alemi, 1986). The origins of this concept extend back to the times of Cyrus the Great, 6th century BCE. Chahar Bagh divides the garden into four parts and water, as an important element for irrigation and aesthetic enjoyment, passes through all the parts (Alemi, 1986; Fekete & Haidari, 2015a). These gardens usually contrast with their surrounding environment and are achieved by innovative engineering solutions, water management systems and “qanat” as the main source of water. In the central part of Iran, water was conducted from the source in mountains or rivers to the garden by the qanat system, discussed below. Then, by application of different structures and techniques such as basins, streams, creeks, and fountains, these gardens provide mental and physical comfort and at the same time, provide water for irrigation (Fekete & Haidari, 2015a). In some locations, based on having access to water, water was brought to the urban areas and distributed to the gardens via a number of canals. In this way, water could provide comfort in urban climate and also act as a visual and functional element in the urban landscape. The methods for
collecting, distributing, retaining, and storing water in different cities of Iran were based on the climatic conditions and accessibility to water which shaped the cities’ structure (Haghshenas, 2014).

Donald Wilber in “Persian Gardens and Garden Pavilions” mentioned that Persian gardens are considered as Paradise because of their rich water management system and planting pattern in an environment characterized by extremely hot weather and arid deserts (Wilber, 1994). Whenever it was difficult to reach water, “qanats” were used to provide. In this technology, a number of tunnels are excavated to transfer water from its source to arid plains and gardens (Mousavi, et al., 2011). There are also some vertical shafts that provide access to the tunnels and are also used for ventilation. This solution is effective in terms of low evaporation rates during water transportation. Further, it is also cost effective as gravity is the main power used to transfer water and there is no need of any other energy. In addition, there is a low level of degradation of the water and the environment as in this system, the risk of soil erosion and reduction of the aquifer’s capacity is not noticeable (Yannopoulos et al., 2015). The maintained qanats reveal the sustainability of the system based on engineering science and the use of natural conditions (slope, soil, water access) in this system that can be considered in present water management strategies (figure 1). Qanats are designed based on the slope of the ground. As water comes from the mountains and cities are built on lower levels, the slope enables the minimum use of energy to transport water. Also, in central parts of Iran the soil is clay which offers good conditions to retain water and prevents its loss to the subsoil. (Faghih & Sadeghy, 2012; Fisher, 1928; Rostami, Lamit, Khoshnava, Rostami, & Rosley, 2015; Siddiqui, 1986)

Another major aspect of water in Persian gardens is irrigation which is easier to achieve by dividing the garden into main parts in the shape of a square or rectangle, and in each part also there are smaller parts that make water flow based on the slope of the garden between the parts (Fekete and Haidari, 2015). This helps water to flow between the parts and irrigate the plants. By this process, the amount of wasted water would be very low (Fisher, 1928; Manuel et al., 2018; Siddiqui, 1986).

In addition to the main division of the gardens, there are some elements that are added to make use of the water, provide comfort and add beauty (table 1):

- **Jets and fountains:** These fountains work with natural water pressure. In some of them the water is sprayed to make the air cooler while also minimizing the amount used for cooling.
- **Pools:** These elements are used to reserve water for watering plants. Around the pools, there are gutters to collect the wastewater for reuse in the garden.
- **Channels:** These are the most important elements for the garden’s arrangement and irrigation and are usually made of local materials.
- **Waterfalls and vertical water surfaces:** Based on the slope of the ground, some gardens contain vertical surfaces of water. These walls provide a condition that water can be seen, and also make the air cooler (Wilson, 1976).
Table 1. The functional aspect of water features in the Persian gardens. Table by the authors, Images source: Fekete and Haidari, 2015.

<table>
<thead>
<tr>
<th>Water feature</th>
<th>Functional aspect</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet/Fountain</td>
<td>Cooling air</td>
<td></td>
</tr>
<tr>
<td>Pool/Basin</td>
<td>Water reservoir</td>
<td></td>
</tr>
<tr>
<td>Channel/Creek</td>
<td>Irrigation and water transfer</td>
<td></td>
</tr>
<tr>
<td>Cascade/Waterfall</td>
<td>Flowing water</td>
<td></td>
</tr>
</tbody>
</table>

To clarify what has been said, following is an example of a Persian garden - Shahzadeh Mahan, Kerman - located in the arid area which illustrates water management as the most important aspect of its sustainability.

3.1 Persian garden: Shahzadeh Mahan, Kerman

Shahzadeh Garden is a historical Persian garden, which is located 24 km southeast of Kerman, near the small city of Mahan. The way water is used in this rectangular shaped garden, is structured by walls, contrasting with the surrounding dry and hot environment. Water flow is based on the slope that shapes the appearance of the garden. The garden, with its surrounding desert area, is widely regarded as a fine example of a Persian garden that responds to the existing climate conditions (Tajaddini, 2011).

As with many Persian gardens, water is the most important factor in the sustainability of this garden. The source of water originates from the mountains, then is transferred to the garden by the qanat system, which effectively changes the microclimate of the garden. The main stream flows into the garden from the highest level and constitutes the garden’s designed irrigation system. Exposure to the body of water in the garden decreases temperature and increases humidity. Mist created by the water fountain produces an evaporative cooling effect, decreases air temperature and leads to an increased comfort level (figure 2).

The pools in the garden are sources of water especially in the hot seasons (Beckett & Smith, 1953; Tajaddini, 2011).

Thus, water flow is an important factor in the structure of Persian gardens. Division of the garden, its main streams, and construction based on the slope and topography shape the garden. Besides these factors, the water consumption relates to the selection of plants (Porter & Thévenart, 2003). In Persian gardens plants were selected according to the climate condition. Thus, all plants were natives that needed less water and provided greenery and comfort. The use of water in this pattern and elements of Persian gardens makes them unique places in the extreme weather and is the main factor of their sustainability in arid regions (Manuel et al., 2018).
3.2 Transition From Private Gardens To Public Space

In 11th century, private gardens were opened to the public that led to defining a strong relationship between nature and cities. In 16th century, the prescribed pattern for designing a Persian garden was translated and scaled up into the urban form to create a “garden city”. For example, in Isfahan, the pattern of Chahar Bagh was integrated into the main access road entering the city, with the watercourse located in the middle, double rows of planetrees (Platanus) and poplars (Populus) and two pathways facing this avenue (Wilber, 1994).

4 METHODOLOGY: DESIGN FOR WATER

Although the case study analysis method does not always contain accurate scientific results and to some extent is more suitable for examining hypothesis rather than providing new ones (Felson & Pickett, 2005; Steiner, 2014), the urban and landscape design disciplines can take advantage of case study analysis to assess the translation of innovative theories into practice and also generate new assumptions (Felson & Pickett, 2005; Francis, 2001; Palazzo, 2018; Steiner, 2014). In this study, scientific and grey literature, documents and examples have been utilized to specify water management features in Persian gardens, and by study of case study examples, these features are defined.

In this research, water management strategies in Persian gardens are presented in the context of two main cities in Iran: Shiraz and Isfahan. In these two cities, the concept of the Persian garden has informed the design and development of each city based on its climate, geography and water resources. This transformation approach can be considered for urban water management in the present and future especially for similar conditions such as arid and semi-arid cities in the USA and Australia. These case studies are examined against the strategies which emerged in the theory of water management in Persian gardens (Table 2). These projects display best practices and best response to the traditional water management strategies.

4.1 Shiraz; an arid city with gardens

The city of Shiraz is located in the south Zagros Mountains in a semi-arid region of Iran. Because of low latitude and extremely hot summers, the average rainfall is low. Shiraz is well-known for its green gardens that owe their greenness to an optimum use of limited water resources (Sarvestani, et al., 2011). Shiraz is an example of a city expanded on the base of water. What makes this city different from other cities like Isfahan and Ahwaz -that are shaped based on the structure of a permanent river- is its access to the water flows of qanats that skillfully direct water to Shiraz from long distances, enabling the growth of lush green and abundant gardens (Mousavi, et al., 2011).
Different techniques were used in different parts of the path that water flows from the source to the city in order to mitigate the effect of climate on water and prevent any water degradation. Siphon (Shotorgaloo) is a water technology that Iranians have used in different cities. It is made of a U-shaped pipe that works based on the water pressure. The water level is the same in both sides of the pipe. When water enters the entry pipe, it pours out from the other side (Mousavi, et al., 2011) (figure 3). Water storages were considered as reservoirs. Each stream irrigates one part of the city by qanats. Some of these reservoirs have been converted to dams in recent years, which is a modern technique for water conservation and distribution. These reservoirs, wells and qanats shaped the city’s infrastructure systems, managed the water, and add aesthetic and environmental values to the city (Mousavi, et al., 2011). Once the water reaches the garden, a smaller scale of this irrigation system was applied. One of the main gardens of Shiraz that is well-known for its irrigation system is Eram garden which displays the classic pattern of a Persian garden and is irrigated by one of the main streams called the Miri (Sarvestani, et al., 2011).

Table 2. Summary of water management strategies in Persian gardens that are transferred into cities. Table by the authors.

<table>
<thead>
<tr>
<th>Water management strategy</th>
<th>Description</th>
<th>Transferring to the city scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water irrigation</td>
<td>- Use of creeks</td>
<td>- Madies/ Water courses (canals in urban areas) across the city</td>
</tr>
<tr>
<td></td>
<td>- Division in rectangular or round shapes</td>
<td>- Planting in the channels</td>
</tr>
<tr>
<td></td>
<td>- Qanat system based on natural gravity</td>
<td>- Irrigation based on the site’s topography and natural slope</td>
</tr>
<tr>
<td></td>
<td>- Design based on the natural slope</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Use of native plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water conservation and</td>
<td>- Pools as the main source</td>
<td>- Channels as the main source</td>
</tr>
<tr>
<td>storage</td>
<td>- Channels</td>
<td>- Xeriscaping</td>
</tr>
<tr>
<td></td>
<td>- Planting placement based on their need for water</td>
<td></td>
</tr>
<tr>
<td>Water purification</td>
<td>- Use of plants’ roots</td>
<td>- Use of native plants with suitable roots</td>
</tr>
<tr>
<td></td>
<td>- Use of gutters to take particles</td>
<td>- Use of gutters and impermeable pavements as filters</td>
</tr>
<tr>
<td></td>
<td>- Constant flow of water</td>
<td>- Combination of chemicals and plants</td>
</tr>
<tr>
<td></td>
<td>- Use of specific native plants to clean water</td>
<td></td>
</tr>
<tr>
<td>Water for air cooling</td>
<td>- Waterfalls and vertical water surfaces</td>
<td>- The flow of water in streams adjacent to main paths</td>
</tr>
<tr>
<td></td>
<td>- Fountains use a minimum amount of water to cool the air with misting</td>
<td>- Use of different types of water features at city scale such as pools, jets, fountains,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>channels, streams</td>
</tr>
</tbody>
</table>

4.2 Isfahan; Chahar Bagh

Isfahan city is the capital of Isfahan province (32°38’ N, 51°38’ E) located in the lush plain of the Zayandehrud River, at the foothills of the Zagros mountain range. The Zayandehrud River divides Isfahan city into north and south parts. Altitude ranges from 1550m around the River to 2232m in the Sofeh Mountains. According to the Isfahan synoptic station, this city has a semi-arid warm climate (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006). In Isfahan, there is low rainfall during the year. The average temperature is 15.6 °C and the average annual rainfall is just 125 mm (Kottek et al., 2006). Nevertheless, this city is well-known as a garden city. There is a main path in the city called Chahar Bagh which is
delineated by a stream, lines of trees and gardens surrounding this main path (figure 4) (Chardin, de La Croix, & Langlès, 1811).

Figure 3. Plan(above) and section (below) of qanat system, Images source: Mousavi, et al., 2011.

Figure 4. Garden city of Isfahan in 17th century and main avenue of Isfahan (Chahar Bagh), Images source: Chardin, et al, 1811.

The Zayandehrud River used to have significant flow all year long, unlike many of Iran's rivers which are seasonal. The existence of Zayandehrud in Isfahan has depended on the existence of madi (stream) (Chardin, et al., 1811). Originally, madies were created to irrigate the farmlands surrounding the river in the plain of Isfahan since the Safavids period (Hobhouse, 2004). Today their role is completely
changed due to the drying up of the Zayandehrud River and to the expansion of the city with the related land use changes from agricultural into different urban land uses.

The madies in Isfahan are creative approach that go beyond site specific scale and work on the scale of a city or a large region and appear in the form of creation of a special urban element (figure 5). Madies are historical, cultural, and environmental sources. The role of Zayanderud River and the madies in Isahan are very important in terms of agriculture, collecting surface water, and city development (Bakhshi, 2014; Manuel, et al., 2018). Madies were wide streams across the city that carried water in the past. However, by the expansion of the city, the main function of madies has been lost. Thus, nowadays, these elements are considered as greenways in the city bringing liveability to the public areas and conserving the urban’s ecosystems with planting areas and water flows (Kayvan Karimi & Motamed, 2003). Also, as these canals have been built based on the slope of the ground, in flood conditions they are considered to include the major proportion of water. Thus, to use the maximum potential of these engineering canals, a planning strategy must be applied to use the capacity of plants in the madies and consequently, collect, retain and purify the rainwater and surface water and reuse it in urban space. Madies could be considered as the core of a green infrastructure network in the city which allocates greenery, climate comfort, and resiliency to the cities (Ruggles, 2007; Faghih and Sadeghy, 2012).

Figure 5. Madies of Isfahan. Public domain image from Isfahan Council, Images source: www.Isfahan.ir

The role of madies in the city is not limited to water conservation and distribution, but also emphasizing the importance of water in the city as a key element to provide a sense of identity. To sum up, the function of madies in cities is categorized in three main areas (Fadaie & Mofidi Shemirani, 2014; Kayvan Karimi & Motamed, 2003):

- **Madies and urban air purification**: These canals have changed the appearance of the city by adding green space to neighborhoods. Trees and other plants along these paths are a source of improving the quality of the urban climate and air purification. Besides, as water flows in some of madies, water and plants cause a cool microclimate across the city.
- **Madies and Identity of the city**: These features are different compared to the other urban elements in the city. In addition, because of the pleasant environment around madies, they invite people into these open spaces. In this way, public memories and sense of belonging may be shaped by madies.
- **Madies and forming the structure of the city:** These elements are axes to shape the main activities in the city and also affect the design of public buildings and public places. The main structure of Isfahan is shaped based on green and blue infrastructure: 1) The main street (Chahar Bagh) which is based on a linear geometric form and, 2) the madies as organic structures that influence the layout of the alleys and main streets.

5 CONCLUSION

Although in this paper, ‘triple bottom line’ sustainability is not an explicit focus, it should be mentioned that water is one of the most important factors supporting human and ecological life in cities. The increasing demand for water that will result from increasing population growth, as along with decreasing water resources resulting from climate change, will continue to be serious challenges for many nations. Although there are efforts to control and conserve water resources such as improving green areas and irrigation systems, providing a sustainable water management system, and controlling floods, the potential for water crisis is still a major global issue (Palazzo, 2018; Sharma et al., 2018).

It has been proved that over many years, local and traditional water management techniques have had a significant impact on the sustainability of urban areas. However, many of these techniques are in danger of being faced with extinction due to the construction of large-scale infrastructure to support urbanization (Brown, et al., 2009; Wong and Brown, 2009). On the other hand, relying on traditional and vernacular water management techniques which are, by comparison small scale and more site specific, cannot be considered as the only system to manage urban water. Identification and integration of traditional science and knowledge with modern technology would be an effective and efficient way for sustainable urban areas. National and international research organizations need to allocate higher priority to the study and investigation of traditional strategies and try to link them in an applicable way to the water system of modern cities (Palazzo, 2018; Tahmasebi, 2009).

Historically, Iranians have been pioneers in controlling, conserving and reusing water through different sustainable strategies (Faghih & Sadeghy, 2012; Rostami et al., 2015; Ruggles, 2007). There is much to be learned from these traditional methods and they should be considered today as we urgently seek innovative methods for water management that address the challenges of continued urban development. In cities such as Isfahan with a history of water management, these specific natural elements (madies) play an important role in the sustainability of the city in all aspects which could be applied in similar climate conditions in other countries (Kayvan Karimi & Motamed, 2003; Rostami, Lamit, Khoshnava, & Rostami, 2016).

In this paper, different water management techniques that were applied in Persian gardens and cities were reviewed through different historical cases. The main categories of the function of elements in the landscape and how they have been used in specific urban areas were presented. However, applying these and similar strategies to new urban landscapes in different parts of the world should be considered for further research. These techniques were part of providing sustainability in the case study cities and could be combined with modern strategies and techniques in green infrastructure. The sustainable water strategies in Persian garden design, presented in this paper, offer the landscape architecture profession alternative approaches to addressing ways of integrating water management in contemporary urban landscapes (Fadaie & Mofidi Shemirani, 2014). As mentioned above, this research focused on urban and landscape design in the context of their environmental performance, and the governance and policy aspects were outside the scope of this paper. However, to achieve sustainable urban water management, other factors will need to be considered in future research. In addition, providing a link between traditional and modern water management strategies in urban landscape implementation has always been a challenging task for professionals and academics, which will be expanded in the future as the next step of this research.

6 REFERENCES


GREENING WASTELANDS: HISTORICAL LINEAGE AND FUTURE PROSPECTS

De Almeida, Catherine
University of Nebraska-Lincoln; University of Washington, Seattle, WA, cdealmei@uw.edu

Smith, Caitlin
University of Nebraska—Lincoln, Lincoln, NE, caitlin.smith@huskers.unl.edu

1 ABSTRACT
Since the decline of heavy industrialization in the mid- to late-1900s, landscape architects have been working to remediate and revitalize waste landscapes, particularly brownfields. The development of the field toward working on these complex and challenging landscapes has greatly matured. To discuss this evolution, three iconic projects provide a cross-section of the profession’s history in redesigning brownfields: Gas Works Park (1975) designed by Richard Haag, and Byxbee Park (1991) and Crissy Field (2001), both designed by Hargreaves Associates. With differing former uses, each project was selected as representative of a different era and paradigm in landscape architecture, while also having fallen short in achieving their original design intent over time. These three projects also represent a repeating pattern to approaching wastelands as a landscape type—they must be greened in order to be functional.
To argue for more nuanced approaches to waste landscapes that result in distinctively diverse outcomes and directly engage with waste conditions and former uses, Landschaftspark (2002) designed by Latz+Partners and Brick Works (2010) designed by DTAH and Claude Cormier+Associates illustrate the potentials for activating waste conditions, generating highly performative landscapes. These projects demonstrate the importance of integrating multiple uses and bringing visibility to processes of remediation and site histories as aesthetic and performative components of brownfield reclamation. They also reveal opportunities for expanding this lineage. In seeking future prospects to engaging with these sites, landscape lifecycles is proposed as a new design-research framework, which advocates for transforming underutilized spaces by reactivating waste materials.

1.1 Keywords
Brownfield reclamation, waste reuse, environmental injustice, lifecycles, landscape history
2 INTRODUCTION

Waste is culturally constructed as valueless. The word is embedded with negative connotations retained by a long lineage of cultural attitudes toward undesired material excess. This perception has resulted in the inefficient handling, storage, and regulation of potentially valuable waste products, which should be embraced as desirable, cheap, readily available resources with latent benefits for producing new economies, ecologies, and cultural landscapes. The materials and landscapes associated with waste, excess, and the undesired create vulnerability within and surrounding their sites, which are typically relegated to the peripheries of urban environments along with marginalized communities (Engler, 2004, p. 29-30). “Material waste produces spatial waste” (De Almeida, 2018b, p. 17), and these conditions are often associated with terms such as “blight,” “eye-sore,” and “undesirable,” resulting in approaches that move these conditions elsewhere, or attempt to disguise them “under a thin green veneer of grass and asphalt” (Meyer, 2007, p. 62) concealing not only contamination, but also processes of remediation.

The abandonment of former industrial sites produces ruin, and landscapes across the world are strewn with such ruins (Tsing, 2015, p. 6). Brownfields are one type of waste landscape—territories left over from previous industrial activities whose material remnants take the form of contaminants, industrial buildings, and/or infrastructure. These wastelands are in excess supply, with over one million known sites in the United States (U.S.), encompassing the same land area as sixty of its largest cities (U.S. Department of Housing and Urban Development, 2012). At their peak, these sites were viewed as symbols of urban economic power, but are now perceived as examples of decay (De Sousa, 2006, p. 154), having apparently reached the end of their useful life. Even though they appear to be dead, these sites carry the potential to yield “new multispecies and multicultural life” (Tsing, 2015, p. 6), by uncovering their ability to become highly active once again.

Cultural attitudes toward waste have led to its mismanagement, causing widespread vulnerability in and around brownfields. They are generated in many forms and scales ranging from small abandoned gas stations to large areas where manufacturing, chemical storage, military operations, dumping, or other hazardous activities once took place, resulting in a variety of contaminated legacies (De Sousa, 2006, p. 154). These sites create a periphery of vulnerable territories and communities beyond their boundaries, from leaching into adjoining sites to spreading across a neighborhood, nation, or the globe. Communities physically located on or at the periphery of brownfields are often also at the periphery of social and political worlds (Pellow, 2004). As Lindsey Dillon (2014) observes, twentieth century urban wastelands production is inseparable from constitutive processes of race and racism (p. 1209). Remediation processes tend to move more slowly in and near minority communities (Ecker and Keeler, 2012), and development fails to address social and economic needs.

Treated, approached, and managed as waste, brownfields and other waste landscapes are perceived as an undesirable cultural condition. These attitudes are broadly reflected in approaches to brownfield reclamation: contaminated materials are handled and removed using conventional waste management strategies (Dillon, 2014, p. 1208), pushing them to the periphery along with marginalized communities. Such shared cultural [mis]perceptions have become embedded in passive design approaches, driving unconscious aesthetic decisions to fix and hide waste rather than engage with it. Modern shifts toward sustainability and redevelopment quietly promised change in marginal landscapes, reclaiming them as public places, museums, and parks, but subsequently hid their former functions and cultural history. These design strategies are particularly apparent in adaptive reuse and brownfield reclamation projects over the last fifty years. As Anna Tsing (2015) asks, “What emerges in damaged landscapes, beyond the call of industrial promise and ruin?” (p. 18).

In the 1990s, brownfield redevelopment surfaced as an urban growth strategy by attracting private-sector investment and expanding municipal tax bases (De Sousa, 2004). Dillon (2014) further describes brownfield redevelopment as signaling “a new historical conjuncture, in which the twentieth century’s industrial wastelands—environmentally degraded, economically divested, and often racially marked—have emerged as sites of investment, resignification, and value formation” (p. 1206). Waste landscape reclamation has also been used as a comprehensive urban revitalization strategy for “improving the state of urban environments and enhancing the quality of city life” with open space (De Sousa, 2004, p. 579) rooted in Olmstedian principles. As Michael Hough (1995) writes, Frederick Law Olmsted “was part of a generation of American landscape architects and reformers who set out to beautify the American landscape” (p. 129). These traditions continue to be strongly engrained in contemporary landscape architecture practice and are ubiquitously used as the strategy for reclaiming waste landscapes.
According to Engler (2004), there are two typical modern approaches to waste facilities: camouflage and utilitarian. The camouflage approach “paid tribute to the urban aesthetics established in the late nineteenth century and continued the tradition of disguising waste sites,” and the utilitarian approach “reused the waste sites as a public amenity for recreation, for agriculture, and sometimes for private land development. The waste, an integral part of these sites, did not inform the design. Instead, the wastelands were recycled into generic parks that concealed their former phase” (p. 37). Although these approaches have added socio-economic, environmental, and aesthetic value, brownfields still carry the stigma of waste, and are approached as such—their undesirable, dirty legacy must be hidden away, covered up, and made to appear clean and green for private real estate development, recreation, and ecological habitat (Engler 2004; 1995).

Brownfield redevelopment presents new opportunities for considering environmental justice in the context of handling wastes from 20th century industrialization (Dillon, 2014 p. 1218). Alternatively, they may be revitalized by combining landscape processes that repurpose other wastes and promote productivity. Landscape architecture is uniquely positioned to conceptualize the potentials of waste for adding value in the transformation of waste landscapes, especially brownfields: the most prevalent, complex, and ubiquitous landscape condition faced by this profession (De Almeida, 2018b). Landscape architects working on brownfields have largely been focused on private sector projects geared toward greening cities (De Sousa, 2006, p. 156), leaving sites and communities in great need behind. The profession has the capacity to advocate for these communities by rethinking how these sites are approached. Additionally, the wide variety of waste landscape typologies warrant more creative, nuanced approaches and outcomes to their future uses (Figure 1).

Figure 1. Waste landscape reclamation strategies. Conventional methods tend to follow an outcome driven, one-size-fits-all approach to varying types of waste landscape conditions; all diverse waste conditions result in a singular outcome—traditional parks. These landscapes, however, warrant nuanced approaches that result in decentralized outcomes, a landscape lifecycles approach, layering uses that engage with and recognize the diverse conditions these landscapes present. Diagram by authors.

This background provides critical context for the discussion of how waste landscape reclamation practices have evolved in the field of landscape architecture. To expand on this context, this paper first presents three historically significant case studies that illuminate the emergence of a pivotal praxis in the
field toward waste landscapes in the U.S.: Gas Works Park (1975) designed by Richard Haag, and Byxbee Park (1991) and Crissy Field (2001), both designed by Hargreaves Associates. With differing former uses, each project was selected as representative of a different era and paradigm in landscape architecture, while also having fallen short in achieving their original design intent over time. Although these three projects represent a repeating pattern to approaching wastelands as a landscape type—they must be greened to appear cleaned in order to be functional—they have also greatly contributed to an evolution and maturation in design approaches. Each project provides lessons learned for the next one. To argue for a more nuanced approach to waste landscapes that results in distinctively diverse outcomes that engage with waste conditions and former uses, Landschaftspark (2002) designed by Latz+Partners and Brick Works (2010) designed by DTAH and Claude Cormier+Associates are presented as two international case studies. They demonstrate the potentials for actively engaging with waste conditions, generating highly performative landscapes, and illustrate the importance of integrating multiple uses and bringing visibility to processes of remediation and site histories as aesthetic and performative components of brownfield reclamation. In order to do more than clean and green these culturally rich, historically significant sites by converting them into generic parks, these approaches can be pushed further through a landscape lifecycles framework that reactivates waste as a dynamic contributor to local and regional contexts, emphasizing performance and visibility over disguise.

3 GREENING WASTELANDS: THREE HISTORICAL MOMENTS IN LANDSCAPE ARCHITECTURAL HISTORY

3.1 Project 1: Gas Works Park in Seattle, Washington (1975); Richard Haag

Located along the northern shoreline of Lake Union, Gas Works Park is a 20-acre site interwoven with Seattle’s urban fabric. As one of the first projects that effectively provided public access to a formerly industrial site that would have otherwise been left untreated and vacant, this is a highly significant project to the field and to the discussion of reclaiming contaminated landscapes. As a revolutionary project, it achieved excellence for expanding the field of landscape architecture to tackle a new landscape typology—brownfields—introducing possibilities for how site designers might engage with these culturally significant contaminated landscapes. Throughout its development, the site has been historically controversial regarding its form, use, and strategies for addressing contaminants directly beneath the surface. Seattle communities were bewildered when they realized Haag had gone against the favored plan of clearing the site to convert it into “a Victorian-style park,” but have since grown fond of the now Nationally Registered Historic Place (Howard, Thompson, & Waterford, 2013, p. 410). The inclusion and conservation of the gasification towers became a model for successful brownfields—advocating for visibility and admittance to the processes entangled in the site’s industrial past.

Owned and operated by Seattle Light Company (1906–1956), the site was originally a gasification plant that converted coal to gas, and later on, oil to gas. After 1956, it was abandoned and laid in ruin until Richard Haag’s Park Master Plan was completed in 1972. The original plan preserved the old gasification towers as Haag considered them “the most sacred, the most iconic thing on this site,” and were left as a reminder of the site’s former use (Figure 2, left) despite controversy around injuries that had occurred on top of the towers after the plant was shut down (University of Washington Press Blog, 2015). Although Haag originally reimagined the main cracking towers as “climbing equipment, lookout platforms, camera obscura, café, and art gallery” (Satherley, 2016, p. 15), they were evidently fenced off. A large volume of contaminated soil became the iconic 45-foot-high Kite Hill—the first project of its kind to keep contaminants on site rather than move waste offsite to a landfill (Way, 2013, p. 30). Two existing buildings on the eastern portion of the site were refabricated to house the Playbarn, programmed for picnics and child’s play with repurposed equipment. The history of contamination and deliberation at Gas Works Park is well known, and as a pilot project for in situ remediation, challenges associated with industrial waste have emerged.

Haag originally used a combination of leaves, soil, and sawdust as a cover for the contaminants during its reconstruction as a park—a strategy that would be considered hazardous if used today (Diltz, 2015) due to contaminant migration. These contaminants consisted of “solvent-soaked wood chips, slag, lampblack carbon, coal by-products, and tar...polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and elevated concentrations of arsenic, copper, lead, zinc, and other [heavy] metals” (Washington State Department of Ecology, 2003, p. 2-3). In 1997, a “black substance bubbled up near Kite
resulting in the excavation and offsite disposal of 3,000 pounds of tar (Diltz, 2015), failing to meet Haag’s original intent of keeping the site’s waste in place. As contamination challenges have surfaced, capping has been the main remediation strategy. This, however, has been insufficient, as the capping process has been repeated often in order to protect users from contaminants that resurface or leach into surrounding areas. While the strategies for remediating industrial waste materials encountered challenges, the site’s original “sacred towers” have been fenced off with chain-link, only to be viewed from a distance. This fence, however, has been ineffective as visitors cut holes in order to access, climb, and discover the unique qualities of these towers, engaging in a game of defiant rule breaking. These holes are repeatedly patched with layers of chain-link band-aids that visually register users’ desire to interact with these structures, and the park department’s failure to prevent what they perceive as an undesirable use (Figure 2, right). Rather than restricting this engagement from occurring, one could design a catwalk that weaves through the towers, allowing visitors to interact safely with the unique structures (Table 1), a strategy used in Peter Latz’s Landschaftspark, described later in this paper.

Figure 2. Gas Works Park. Main gasification towers with Seattle’s urban fabric in background (left); fence patchwork around towers (right). Photographs by Catherine De Almeida.

Table 1. Gas Works Park Assessment Summary

<table>
<thead>
<tr>
<th>Successes</th>
<th>Shortcomings</th>
</tr>
</thead>
<tbody>
<tr>
<td>• First major brownfield reclamation project – offered insight for future projects.</td>
<td>• Creates a baseline for minimal strategies to reclaim waste landscape typologies.</td>
</tr>
<tr>
<td>• Provides social and cultural benefits through access and preservation.</td>
<td>• Contaminants remain today and continuously resurface.</td>
</tr>
<tr>
<td>• Retaining original industrial structures on site informed future practice.</td>
<td>• The retained industrial structures became viewable ruins, rather than interactive spaces.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• How might this site adapt to future conditions, especially when facing climate change?</td>
<td>• Create safe access to the existing towers with catwalks.</td>
</tr>
<tr>
<td>• Will new structures be built here?</td>
<td>• Experiment with phytoremediation on site to manage contaminants.</td>
</tr>
<tr>
<td>• What new strategies might address the challenges associated with resurfacing contaminants?</td>
<td>• Use site as a research and learning opportunity through transparent story-telling and engagement.</td>
</tr>
</tbody>
</table>

By vastly opening the field of landscape architecture to new site type, Gas Works Park is a brownfield reclamation project that charted a new course for the discipline. As the first post-industrial park of its time, it has become a baseline model for post-industrial landscape design that acknowledges a site’s former use while working toward remediating contaminants for future use and public access. Akin to how the site fell into ruin when industrial operations seized, the project has fallen into a publically accessible ruin that drifts further away from Haag’s original intent, failing to meet his original objectives. In describing entropic qualities of significant projects, Marc Treib (2017) states, “strange in form or material, [projects] may be unappreciated by their audiences, setting in motion public reactions that in time may undermine
their integrity or perhaps their very existence” (p. 1286), a statement that resembles Gas Works Park’s history and current condition. The park is, however, a significant point of departure for developing new frameworks that engage with waste landscapes.

3.2 Project 2: Byxbee Park in Palo Alto, California (1991); Hargreaves Associates

Located along the industrialized western shore of San Francisco Bay, the 45-acre Byxbee Park designed by Hargreaves Associates revolutionized the possibilities for reclaiming landfills as another significant waste landscape typology. Adjacent to a tidal creek and flanked by a sewage treatment plant on the western edge, the site was once covered in up to 60 feet of discarded goods (Rainey, 2009). Constructed sixteen years after Gas Works Park, the site’s greening strategy and use of topographical features is similar, but varies in its reclamation strategies and park culture—an evolution of Haag’s original approach.

Formerly marshland and wildlife habitat (Rubin and Meisenheimer, 1998), the site became an area of industrial processing and dumping, similar to many waterfronts in the early 1900s. Over 150 acres of marshland was purchased for waste disposal in 1904 by the City of Palo Alto, and landfilling began in the 1930s when the city’s incinerator went up in flames (City of Palo Alto, 2018). Dredging and filling activities along with other development, including “a sewage treatment plant, an airport, flood control area, and a golf course” eliminated large areas of marshland habitat (Rubin and Meisenheimer, 1998). Left as a vacant wasteland for years, planners advocated for creating an accessible public park among the city’s refuse. While many were interested in treating the site as a seemingly blank slate, early activists saw the importance of the baylands’ diverse ecology. Community members insisted on converting the landfill into a public park for walking trails, birdwatching, and other recreational activities, putting pressure on the City to take action. After years of landfilling, community leaders developed a plan to reclaim the site as a naturalistic park.

The baylands were dedicated to parkland in 1965, beginning a process for the former landfill of Palo Alto, California to become usable and accessible public open space—Byxbee Park (City of Palo Alto, 2018). In 1991, the park by Hargreaves Associates completed its first phase of construction, granting public access to this space, and ultimately winning an ASLA Honor Award in 1993 (Lee and McKee, 2013). To remediate years of landfilled waste, it was capped with a three-foot-thick soil and clay layer, while off-gassing methane from decaying waste was captured and burned to prevent its emissions into the atmosphere (Treib, 2001). To emphasize this space, a keyhole-shaped layer of gravel suggests, “we are peering into the secrets of the landform whose essential core is a decomposing bed of trash” (Rainey, 2009, p. 176). Mira Engler (2004) highlights that “uncompromising closure standards forced the team to accept a kidney-shaped hill that had formed based on an earlier plan...possibly intended as a golf course” (p. 111). No trees were planted and no irrigation was added in order to prevent the possibility for escaping gases and seeping pollutants (Treib, 2001). These original precautions, however, are no longer in place. The grasses and landforms have become the iconic features of the site, using the previously formed land built by accumulation as a topographic reminder of the waste below. A field of 72 erected poles at the northwest corner (Figure 3) has incidentally become a visible registration of the unanticipated settling of the landfill and park. Crushed oyster shells used as substrate for paths (Rainey, 2009) pay tribute to the ecological and cultural heritage of tidal flats and shellfish harvesting on the site (Lee and McKee, 2013).

The landscape of Byxbee Park ultimately serves as an art-piece to be interpreted by the user. Due to the reclamation strategies used before Hargreaves’ design, and the natural decomposition of materials within the former landfill, the site has fallen into disrepair. In 2013, Byxbee Park’s original mounds were leveled and filled due to major settling complications on the former landfill site (Lee and McKee, 2013), causing the unique topographic and artistic qualities of the park to disappear. Before the remaining landfill was closed, however, the lack of integration between past and present landfills was criticized (Engler, 2004, p. 111). Although common, capping was ineffective, as it requires routine maintenance through the reapplication of soil and the regular monitoring of contaminant levels. This highlights a missed opportunity long-term site maintenance to be a central component for transforming waste landscapes.
Table 2. Byxbee Park Assessment Summary

<table>
<thead>
<tr>
<th>Successes</th>
<th>Shortcomings</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Showcases the artistic potentials of landfills as a waste landscape</td>
<td>• Contamination challenges and landfill settling led to the project’s entropy,</td>
</tr>
<tr>
<td>typology for practice.</td>
<td>leveling significant areas of the site.</td>
</tr>
<tr>
<td>• Landfill mounds used as the foundation for creating iconic topographic</td>
<td>• Single-use (passive recreation) likely also led to the site experiencing</td>
</tr>
<tr>
<td>features, referencing the site’s history.</td>
<td>entropy.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• How might this site adapt to future conditions?</td>
<td>• Create more visual interest with built structures and grade changes.</td>
</tr>
<tr>
<td>• How could the site have been designed to accommodate settling?</td>
<td>• Experiment with other strategies that intentionally and visibly register site processes, such as settling.</td>
</tr>
<tr>
<td>• Will there still be leveling efforts in 10-20 years?</td>
<td>• Develop a longer-term management plan to accommodate future changes and fluctuations to the site as an integral aspect of the design.</td>
</tr>
</tbody>
</table>

Byxbee Park illuminates potential opportunities for engaging with landfills as a waste landscape typology. Uses limited to passive recreation reflect a lack of diverse approaches to designing the site, raising questions of how these landscapes may be approached differently from other wastelands, and the potential to integrate landscape performance and collaborative, multi-use programs. Although the former landfill is an award-winning project and wildlife hub for the Palo Alto community, there are opportunities to increase the usability and adaptability of the site (Table 2).

3.3 Project 3: Crissy Field in San Francisco, California (2001); Hargreaves Associates

Opened in 2001, Crissy Field provides another avenue for understanding a broadening wasteland typology—sites of former military use. The capping and greening of the park is similar to Gas Works and Byxbee Parks, with an added layer of complexity: engaging with coastal conditions through ecological restoration. Ownership changed over a 70-year period, from Spanish, to Mexican, to American control (M’Closkey, 2013, p. 45). Known as El Presidio, this landscape was used for waste dumping, even after the U.S. Army outpost was established (Bevk, 2014). Activity at the outpost increased during the Panama-Pacific International Exposition, during which a racetrack was constructed using fill (Bevk, 2014). Operated by the U.S. Army Air Service, the racetrack became an airfield from 1920 to 1974, (Porter, 2003, p. 42). After decades of trash disposal and aviation activities, the U.S. Department of Defense began cleaning up cannonball debris, tar/skeet disks, and PAH contaminated soil and groundwater in the early 1990s (Porter, 2003, p. 42).
Nearly a decade after Byxbee Park, Hargreaves Associates’ design for El Presidio, Crissy Field, was constructed, echoing an evolution in approaches to waste landscapes. Primary project goals included restoring the shoreline to its original marsh conditions and highlighting forms from previous uses on the site (Porter, 2003) as a strategy for registering its history. Crissy Field’s most expansive feature is the mile-long promenade, connecting West Bluff (a picnic area) and East Beach (a large gathering and parking area) (Reed & the Museum of Modern Art, 2013). An artificial marsh was ambitiously constructed as an integral part of the park, planted with 100,000 indigenous plants consisting of 110 different species. These plantings are distinctly grey-green and silvery to contrast the bright green lawn that covers the majority of the site (Reed & the Museum of Modern Art, 2013). The marsh restoration efforts are admirable, and occurred at a time in which landscape architects were increasingly integrating ecological systems thinking and functions into designs. Although the marsh was too small to be fully functional, biologists have found over 17 fish species and 135 bird species visiting the reconstructed tidal marsh (Presidio of San Francisco). A low seawall beneath the surface of the beach was added to prevent shoreline erosion, allowing for open views without disturbing ocean wave patterns with a more obtrusive structure (Porter, 2003, p. 45) (Figure 3).

Crissy Field engaged with the ecological and hydrological complexity of the shoreline, an important evolutionary shift in landscape architecture. However, the park may also benefit from a multifaceted design approach to the former airfield that not only engages with this history formally, but also programmatically. Although the marsh attracts native wildlife, it does not play an active role in remediating the soil below. To address some contamination challenges on site, a magnesium peroxide compound was injected for encouraging native bacteria to consume the petroleum plume that extends 12 feet underground; this treatment, however, requires continual maintenance and injections over a long period of time (Porter, 2003, p. 42). Although old-growth redwood from over 50 historic World War II-era buildings were recycled, these buildings were dismantled rather than restored, without considering their potential future use (Porter, 2003, p. 43). Additionally, 70 acres of asphalt and concrete were crushed and used as fill for pathways and parking lots, an innovative practice at the time, while over 87,000 tons of contaminated soil were hauled to distant landfills (Reed & the Museum of Modern Art, 2013). Hauling these waste materials “away” implies that contaminated waste landscapes should first become a tabula rasa in order to become something else—hauling them away does not mean they are gone. The incorporation of more mindful, insitu, and site-specific waste management strategies is a missed opportunity for the project to fully engage with its own legacy (Table 3).

### Table 3. Crissy Field Assessment Summary

<table>
<thead>
<tr>
<th>Successes</th>
<th>Shortcomings</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Showcase the potentials for designing historic military sites as a waste landscape typology.</td>
<td>• Used conventional hauling and capping waste management tactics for contaminants.</td>
</tr>
<tr>
<td>• Creates public accessibility to the waterfront as open space.</td>
<td>• Although successful in attracting diverse bird and fish species, marsh is not fully functional due to size constraints.</td>
</tr>
<tr>
<td>• Ecological restoration practices were innovative for the time and informed future practice.</td>
<td>• Site programming for users limited to passive recreation.</td>
</tr>
<tr>
<td>• Reused waste materials from demolition for onsite construction.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• How might this site adapt for future conditions, especially when faced with sea-level rise?</td>
<td>• Create more diverse programming within the site, especially those that relate to previous uses.</td>
</tr>
<tr>
<td>• Will the shoreline maintain its size and form over the next 20 years?</td>
<td>• Experiment with other waste management strategies to achieve visible, mindful site-based practices.</td>
</tr>
<tr>
<td>• How could the project have accommodated more insitu waste management strategies?</td>
<td></td>
</tr>
</tbody>
</table>

Crissy Field presents potential opportunities for reusing historic military bases, more specifically airfields, as a waste landscape typology for landscape architectural practice. The project reused materials on site, and reestablished an eroding shoreline and diverse marsh ecology. However, its use of conventional methods of excavating and hauling soil, capping with new soil, and greening the site to appear as a clean tabula rasa reveal missed opportunities for actively engaging with the performative qualities of waste landscapes. Maintaining a greater number of historic buildings, allowing for extensive phytoremediation in
applicable locations, and creating layers of multifunctional uses could provide more visibility to the history and future possibilities of the site.

3.4 A summary of project critiques

These projects are critically important for the cultural significance and value they provide, and the ways in which they have informed one another and contemporary practice as an evolutionary lineage in transforming waste landscapes. Reclaiming wastelands with in situ remediation and repurposing them for new uses is a significant step toward continuing their lifecycles. As De Sousa (2004) argues, “greening projects should be considered along with other possible uses for brownfields because they tend to fulfill community desires, revitalize neighborhoods, and enhance the economic and aesthetic appeal of inner cities” (p. 598). De Sousa’s statement raises the question: is it always appropriate to default to parks? Greening projects can be combined with other uses. Conventional approaches to brownfield reclamation, using parks and ecological habitat to inject new life into decaying landscapes, limit their future possibilities. This can be pushed further by layering diversified, dynamic, and adaptable site programming that engages with their neighboring communities and users.

4 ENGAGING WASTELANDS: TWO CONTEMPORARY PROJECTS SHIFTING LANDSCAPE ARCHITECTURAL PRACTICE

Marginalized communities need advocates, including landscape architects, who see the potentials for brownfields and other waste landscapes to become active contributors to local economies once again. Together with adding recreational programming and reestablishing ecological functionality, many of these sites have existing infrastructure that can be reused for 21st century economic and cultural programming. How can public accessibility and ecological management be interwoven with active, economically generative programming that engages with its surrounding community?

4.1 Project 1: Landschaftspark in Duisburg, Germany (2002); Latz + Partners

Landschaftspark is one of the first projects to bring visibility to the slow processes of remediation, and create moments for openly engaging with a site’s history. It builds on and differs from its predecessors by allowing direct and indirect interaction with waste materials: slag heaps remain palpable, but untouchable, and industrial walls are fully tactile, even climbable.

After extensive work on the former Thyssen steelworks, Latz + Partners’ design for Duisburg-Nord became publically accessible in 1994 (Rosenberg, 2009, p. 209). Located in Germany’s Ruhr valley region, Landschaftspark represents the decline of pig-iron manufacturing as a pertinent industry, and the economic and physical trail of decay it can leave behind (Hemmings & Kagel, 2010, p. 247). Littered with abandoned factories, mines, and material processing plants, the region is known for its deteriorated aesthetic. Landschaftspark’s 500-acre site consists of “old blast furnaces, elevated rails, slag heaps, and a polluted river” turned landscape park (Raver, 2000). Some of the most prominent features of the site are blast furnaces that extend out from the horizon. Lighting designed by Jonathan Park iconically illuminates the furnaces at night. Landschaftspark is celebrated for its visibility, admittance, and interaction with its past combined with the juxtaposition of new interventions.

Existing sanctioned industrial buildings are used for offices, restaurants, and gallery spaces, or are off-limits to contrast active uses with slow decay (Langhorst, 2014, p. 1119). Key features of the park include a large plaza, “Piazza Metallica” (an adaptable space for events), storage bunkers with hidden gardens, blast furnace structures, catwalks, climbing walls, rock and hedge gardens, and an interactive pond. Described as an experimental park that highlights and engages with the site’s temporal qualities, it enables interactions with waste conditions and accommodates diverse environments that overlap across multiple spaces over multiple time periods (Figure 4). Within the park, climbers “practice rappelling on container walls. Scuba divers descend into the old gasometer. Gardens flourish within the confines of ore bunkers” (Lubow, 2004, p. 47). Latz has created, what he considers to be, a neutral design that allows visitors to interpret the site and interact with the park as they see fit. People are given a sense of history, culture, and even ownership, with accounts of teenage hideouts, graffiti, local gardens, and other intricacies, that have been given a home in this deindustrialized landscape (Langhorst, 2014, p. 1120).
The Emscher area was developed in the 1800s by manufacturing and transporting “coal, steel, chemicals, and energy” (Nnadi, 2000). Latz states, “the old way was to cover up these sites with clay and soil and plant indigenous plants, but that does not do justice to them,” highlighting his design-reclamation strategy as differing from past conventions (Raver, 2000). Industrial ruins are transformed into interactive components, coupled with remediation and restoration strategies. The most hazardous areas of parkland were capped or removed, and “ecological function was restored by relieving the sewage burden on the Emscher canal, or planting vegetation to remEDIATE soil and water” (Hemmings & Kagel, 2010, p. 248). The open-sewer Emscher River running directly through the park has been converted into a collector of pretreated runoff and rainwater (Stilgenbaur, 2005, 9). The site “engages emergent ecologies as an exploratory, open-ended and fluid interaction between human intervention and non-human process,” as contaminated fields are left to weather, inviting the growth of wild plants (Langhorst, 2014, 1126). Pragmatic waste management, material preservation and reinterpretation, viewer interaction, storytelling, and dynamic programming allow Landschaftspark to be a next-generation example for the future possibilities of reclaiming deindustrialized waste landscapes when long-term adaptation is prioritized to meet user needs.

Table 4. Landschaftspark Assessment Summary

<table>
<thead>
<tr>
<th>Successes</th>
<th>Shortcomings</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion of a former raw materials energy plant to a multiuse park with ecological and social benefits.</td>
<td>Approaching hazardous waste on site from the beginning of the project.</td>
<td>Rotating gardens consisting of different plantings throughout the year, managed by interested local population.</td>
</tr>
<tr>
<td>Creates safe public accessibility to a deindustrialized landscape.</td>
<td>Potential to integrate a greater diversity of uses to increase economic benefits.</td>
<td>On-site remediation research and education.</td>
</tr>
<tr>
<td>Adaptable qualities of designed spaces.</td>
<td></td>
<td>Reimplementation of new, sustainable industry/processing to increase diverse uses.</td>
</tr>
</tbody>
</table>

As a high performing waste landscape, the transformation of a former material processing plant to Landschaftspark has given the site unique, unintended characteristics, providing site-specific programs that enhance its visual quality. Unconventional remediation techniques allow remnants of past site activities to be visible—a stark contrast to the previously described projects. Catwalks grant visitors physical access to the industrial ruins, offering an intimate experience with temporal site conditions while ensuring visitor safety. The site’s interaction with water (river, instead of lake, bay, or marshland) remediates the banks, redirects wastewater, and treats rainwater runoff. Perceptible slagheaps and long-term decay highlight waste conditions and remediation processes.
4.2 Project 2: Evergreen Brickworks in Toronto, Canada (2010); DTAH and Claude Courmier + Associates

Evergreen Brick Works in Toronto, Canada is an example of how a new assemblage of multicultural and multispecies life—an open-ended gathering of programs and users—can arise out of death and decay through transformative design. In its former life, the site was known as Don Valley Brick Works, which operated for nearly a century from 1889 to the early 1980s, producing 43 million bricks per year at its peak. When operations ended after depleting the site’s clay and shale resources, it left behind 42 acres of a damaged ecosystem, 16 dilapidated industrial heritage buildings (Irvine, 2012, p. 22), and soils contaminated with heavy metals, asbestos, and PAHs (De Sousa, 2003, p. 189). During this time and in to the early 1990s, excavated fill material from the construction of the Scotia Plaza tower in downtown Toronto was land-filled in the quarry—the beginning of the site’s remediation (Flannery and Smith, 2015, p. 36).

The Toronto-based landscape architecture firm, Hough Stansbury Woodland Limited, developed the Don Valley Brick Works Master Plan in 1990, which sought to restore the quarry as an ecological park by reestablishing the river’s ecological and hydrological function. This emphasis on environmental performance was coupled with passive park-like programs and “provisions for peripheral mixed use commercial and green-industrial densification (North and Waldheim, 2013, p. 394). In anticipation of the effects from redeveloping the site, the provisions for peripheral densification were innovative for the time—the firm was integrating economic performance goals into their plans. The overall vision for the new quarry park was based on “its role as a natural focus for interpretation and education of the biophysical, cultural, and industrial history of the Don Valley, its future restoration to a state of health, and its ongoing influence in the affairs of the city as a whole” (Hough Stansbury Woodland Limited, 1990, p. 34). The restoration work was completed in 1995 by the City of Toronto and the Toronto and Region Conservation Authority, which created a series of five connected wetland ponds that daylighted Mud Creek and slowed its flow, improved water quality, and provided habitats for fish, reptiles, and birds. Now known as the Weston Quarry Garden, its 28 acres consists of native trees, shrubs, and a wildflower meadowland traversed by walking trails, bridges, and boardwalks, and punctuated with ponds and channels that connect the creek back to the Don River, alleviating flooding in the valley (Flannery and Smith, 2015, p. 36; Lobko, 2011, p. 405). Two of the 16 buildings were restored, but the contaminated industrial pad and buildings were fenced off, and inaccessible to the public, remaining abandoned for the next decade (Evergreen, 2008, p. 13).

In 2002, Evergreen, a Canadian national non-profit organization whose core mission is to bring nature back to cities, began plans to revitalize the industrial pad and buildings of the former Don Valley Brick Works (Lobko, 2011, p. 405). They assembled a diverse multi-disciplinary design team made up of three architectural firms, two landscape architectural firms, engineers, hydrologists, ecologists, and planners (Lobko 2011, p. 406). This team, led by the architectural and urban design firm du Toit Allsopp Hillier (DTAH) and landscape architecture firm Claude Cormier + Associates, developed a master plan in 2006 focused on fostering diverse experiences connected to nature (North and Waldheim, 2013, p. 401). Their design strategy was based on flows through the valley, and these trajectories of motion extended “to inform layers of design including water, cars, walkers, electricity, trains, and wildlife” (Flannery and Smith, 2015, 36). The proposed master plan became Canada’s first large-scale environmental discovery center “integrating cultural and natural heritage, and ecological and social services” with many on-site features (Lister, 2010, p. 531). Opened in the fall of 2010, four themes underpin the project: Innovation & Discovery; Food & Community; Natural & Cultural Heritage; and Gardening & Greening.

The project features wide-ranging programs and adaptive uses of over 110,000 square feet within existing structures, consisting of a native plant nursery, a demonstration kitchen, children’s gardens and camps, family and youth leadership, youth-at-risk programming, a year-round local farmer’s market, and an organic restaurant (Lister, 2010, p. 531). Cultural, industrial, and natural heritage are all celebrated at the site through the juxtaposition of managed gardens and wild habitats, arts and cultural activities in the old industrial buildings, and the deployment of many different ecologies across this complex urban landscape (Lister, 2010, p. 532) (Figure 4). To help achieve this vision and mixture, a new LEED Platinum rated 5-story building was constructed to house the Centre for Green Cities (Flannery and Smith, 2015, p. 38).
Table 5. Evergreen Brickworks Assessment Summary

<table>
<thead>
<tr>
<th>Successes</th>
<th>Shortcomings</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Former quarry restored as wetland, reconnecting the larger hydrological network.</td>
<td>• Moved lead-contaminated soils offsite.</td>
</tr>
<tr>
<td>• Existing structures as adaptable public space.</td>
<td>• Demolished portions of existing structures moved offsite to landfill.</td>
</tr>
<tr>
<td>• Addition of new building for Centre for Green Cities demonstrates the integration of greater site uses and the future with the past.</td>
<td>• Programs could be more integrated with one another.</td>
</tr>
<tr>
<td>• Achieves environmental, economic, and social benefits with educational and cultural programs.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• How can the project incorporate more active and diverse uses?</td>
<td>• Integrate light industrial/manufacturing uses to increase engagement with past and future uses.</td>
</tr>
<tr>
<td>• How might the project adapt to future conditions?</td>
<td>• Waste materials generated from varying programs can feed into one another.</td>
</tr>
<tr>
<td>• Will the site’s adaptability and diversity increase or decrease over time?</td>
<td>• Use site as an educational platform for deindustrialized wastelands.</td>
</tr>
</tbody>
</table>

Evergreen Brick Works transformed a former brick manufacturing industrial complex and quarry into a cultural center for community engagement and development. The existing industrial structures are adaptively reused for multiple purposes, creating a place for new and old multispecies and multicultural programs and life to mix and interact, engaging with the economy, ecology, and culture of its context. The project allows for flexible uses catering to the larger community, resulting in an active, adaptable scheme that transforms over time (Lister, 2007, p. 52). This generates cultural capital, which complements and enriches recreational uses associated with the ecological functions of wetlands and trails within the former quarry, connecting to a larger network. Toronto is a multi-cultural city whose residents come from many different backgrounds, and Brickworks has become a new cultural center and destination attracting local residents and international visitors. The variety of community-oriented programs on-site adds a layer of complexity to the overall project, where the community is engaged in an intellectual economy integrated with remediation, recreation, ecological functions, and habitat. The layering of uses creates a dynamic relationship between different programs that feed off one another while negotiating the same space, ultimately strengthening the function of each program.

4.3 A summary of project critiques

As projects that represent a maturation and progression of the ability for landscape architecture to address waste landscapes in increasingly complex and effective ways, Landschaftspark and Evergreen Brickworks demonstrate how passive recreational uses can be combined with active cultural programming, performative ecological habitat, and community engagement. The approaches, tactics, techniques, private-public partnerships, and interdisciplinary design teams used in the redevelopment and operation of Evergreen Brick Works have the potential to be applied to similar deindustrialized waste sites. As the profession continues to evolve, these approaches may continue to be questioned and pushed even further. For example, layering multiple uses that share the same space and utilize one another’s waste streams can increase the possibilities for developing diverse, overlapping multispecies spaces and activities. This diversity, in turn, increases the efficiency, resiliency, and adaptability of the system as a whole. Conceiving of active industries with such approaches could potentially prevent the generation of deindustrialized sites by using waste products as resources, integrating mutually beneficial programs, and anticipating economic, cultural, and environmental change.
TOWARD A LANDSCAPE LIFECYCLES APPROACH

Reframing waste sites and materials as desirable, high value opportunities for extending lifecycles can offer the opportunity to reshape culturally significant waste places. In order to restructure cultural attitudes towards waste, the notion that there is an end-of-life for materials and landscapes must be rejected. Rather than viewing ecology, economy, and culture as separate, linear systems, a landscape lifecycles approach understands them as integrative and cyclical (Figure 5): they can be interwoven through the exchange of waste materials to create new hybrid landscapes with the capacity to evolve over time. Combating waste by generating new economic streams built on and propelled by waste resources can drive environmental and economic justice. As an ecologically grounded landscape-based design approach, landscape lifecycles offers a comprehensive perspective of technological and environmental systems; one that does not see them as mutually exclusive or operating in isolation of one another, but recognizes that such systems are boundless and fluid.

As a design research framework, landscape lifecycles aims to push the design disciplines to tackle these waste landscapes with integrative approaches, strategies, and techniques that reactivate waste as a dynamic contributor to local and regional contexts. It is a method for integrating multiple diverse programs rooted in economic, ecological, and social performance to form hybrid assemblages in the transformation of perceived physical and spatial wastes. Broadening the scope beyond industrial land uses, site-based programmatic relationships are forged through the exchange of internally and externally sourced material byproducts that create new waste economies and ecologies, capitalizing on waste’s generating capacity. This method aspires to engender new culturally significant landscapes of multiplicity with waste, providing venues for multispecies users negatively affected by waste landscapes to participate in their transformation. Landscape lifecycles disputes conventional modes of reclaiming waste landscapes as generic passive parks by reframing waste as a resource with material, spatial, experiential, and aesthetic dimensions, which has the capacity to generate highly performative, diverse, and active landscapes as cultural destinations (De Almeida, 2018a; 2018b).

CONCLUSION

Landscape architecture has been constrained by the cultural construction of waste as undesirable. The iconic projects described earlier provide an evolutionary lineage of increased sophistication in the ability for the profession of landscape architecture to transform brownfields and other waste landscapes. The study of these projects also reveal a set of open questions that prompt a discussion of how the design of these landscapes require longer-term planning and design, while building in the ability for such projects to be diverse, resilient, and adaptable. This exploration illuminates that there is no single solution for approaching any particular type of waste site due to their diverse origins and conditions. Rejecting the notion of undesirable waste reveals there are infinite possibilities for reimagining how brownfields can be revitalized. To continue to push this evolutionary lineage, a landscape lifecycles approach proposes to generate new,
hybrid landscapes that interweave ecology, economy, and culture within the same landscape while engaging with a site’s broader community. These programs benefit one another through the exchange of waste materials, spatializing industrial ecology and integrating traditional and radical landscape architectural methods. In this approach, the end-of-life of materials and landscapes does not exist—these perceived wastes contain latent power to produce value, transforming their legacies by continuing their lifecycles.

7 REFERENCES


Lister, N. M. (2007). Sustainable Large Parks: Ecological Design or Designer Ecology? In J. Czerniak and
G. Hargreaves (Eds.), *Large Parks* (pp. 35-57). New York: Princeton Architectural Press.


CELA MEDIA STATEMENT

Dear CELA Authors:
Please consider include in this space a research summary in 100 words or less that would best describe your topic, its principal results and/or impacts, written in clear language that would be of interest to public media outlets. In addition to the research summary, you may provide an *optional* graphic abstract that further explains the topic.

**Title of Paper or Research:**

**Author:**

**Institution or Professional Affiliation:**

**Authors please select one of the following:** I DO _____ DO NOT_____X_____ want to prepare a media statement for general release from the 2018 CELA Conference. (If you choose DO NOT, you do not need to prepare a media statement).

**Media Statement** (100 words max.):

**(Optional) Graphic Abstract:** please insert the illustration below. Authors: please seek copyright permission if copyrighted materials are used.

Fox, Kris
University of Calgary, mk.fox1@ucalgary.ca

1 ABSTRACT
This study examines the development and evolution of the landscape construction column as a component of Landscape Architecture Magazine (LAM) from 1978 to 2017. It is the first longitudinal study of technical columns focused on materials, technologies and construction methodologies and their contributions to trends within the profession. Several questions will be addressed: How have the columns changed and evolved? Has their frequency and content related to the "materials explosion" that has swept through the building industries over the last two decades? Finally, how has LAM documented this evolution to help establish the practical approaches associated with these new materials and technologies? To answer these questions, column runs have been grouped into “eras” based on such factors as subject matter (materials, construction or technology / software), and approach (traditional vs. sustainable materials and/or construction methods). The ‘eras’ and their time-frames are “Traditional Materials and Construction” (1978 – 1991); “Traditional Materials and Explosion” (1992 – 1995); “Non-Material” (1996 – 1998); “Sustainably Influenced Materials Explosion” (1999 – 2004); “Ecology & Sustainability” (2005 – 2010); and “Assumed Knowledge” (2011 – 2017). The study concludes with a summary of the impact of the technology columns. Perhaps, most importantly, this article offers a critique on how Landscape Architecture Magazine can look to its past to address how it might position itself moving forward with the coverage of landscape materials.

1.1 Keywords value
Landscape Architecture Magazine, landscape construction materials, sustainable materials, sustainable construction, landscape architecture profession

The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the Council of Educators in Landscape Architecture (CELA), and its printing and distribution does not constitute an endorsement of views which may be expressed. Citation of this work should state that it is from a CELA conference paper. EXAMPLE: Author’s Last Name, Initials. 2018. Title of Paper. Blacksburg, Virginia: CELA. For information about securing permission to reprint or reproduce this paper, please contact CELA at staff@thecela.org
2 INTRODUCTION

For over one hundred years, Landscape Architecture Magazine (LAM) has been the most widely circulated trade magazine in our profession, during which time it has served as a conduit for current events and trends within the profession. It is "the oldest, largest, and most continuous repository of landscape architectural practice, research, philosophy, and teaching anywhere." (Ferguson, 1999, 86) Until the late 1970s, the magazine consisted mainly of feature articles, letters to the editor and book reviews. As the level of complexity of our profession increased, the magazine developed technically themed columns, the first of which was “Technik” debuting in January 1978. This was followed by “Construction” in November 1980 under the column editorship of Linda Jewell. In the years since “Construction”, numerous technical column titles have come and gone. Articles on materials and construction evolved over the years. Several sustainable elements were mentioned for the first time in column articles and have become parts of our lexicon, such as green roofs, bioswales, constructed wetlands, landfill restoration and stream restoration.

This paper analyzes LAM’s contribution to the evolution and introduction of both familiar and new construction materials and technologies that have impacted the profession since the late 1970s. While it may seem predictable that the types of materials and construction processes change from more traditional to sustainable in focus, it did not happen as smoothly and consistently as one would expect, as some periods saw the publishing of numerous material columns while others saw very few. In order to best reflect the trends and patterns post-analysis, the technology column runs are redefined into ‘eras’ through the focus of their content, illustrating the impacts and trends of construction materials and how the coverage of these materials played out in LAM over the 40 year period: 1978 to 2017.

2.1 Significance

As a practitioner in a small firm in the early 2000s, it was difficult to keep up with the sheer number of new materials being introduced and frequently just as difficult to convince clients to use materials with little to no track record. Part of why I transitioned to academia was to work more closely with materials and to better understand the opportunities that were being brought to landscape architecture by the proliferation of new products. This explosion in materials was one of three major factors that have reshaped the profession in that last 15-20 years; the others being advances in computer technology and the sustainability movement.

The 2000s saw a proliferation of publications on new construction materials and methods, espousing the importance to designers of working within this new environment. Addressing this point, in the introduction to Transmaterial, Blaine Brownell states that “One simple view is that while materials science has existed since the stone age, it is simply advancing at an accelerated pace like other technologies, and this pace has finally become conspicuous.” (Brownell, 2005, 7) This is especially true within architecture, which produced numerous titles over the course of the decade including the Transmaterial Series (Brownell, 2006), Materials For Design (Bell and Rand, 2006), Refabricating Architecture (Kieran and Timberlake, 2004), Prefab Prototypes (Anderson and Anderson, 2007) and many more. At the same time, publications focused on landscape architectural materials emerged, such as Materials for Sustainable Sites (Calkins, 2009), The Sustainable Sites Handbook (Calkins, 2012) and Living Systems (Margolis and Robinson, 2007). However, within the covers of LAM, the number of articles covering materials decreased over the past decade, almost disappearing from the mid 2000s through the early 2010s. Recently there has been a slight upward trend, with the number of articles doubling in 2017.

During the peak of materials coverage in LAM, which ran from 1999-2004, technical articles provided essential information on new materials. The varying numbers of technology articles over time shows that LAM hasn’t always accurately reflected this trend of the ever expanding materials explosion. Other published resources (some of which are listed above) in landscape architecture, architecture and industrial design have begun to show that such tracking has become a subject in and of itself. Moving forward, can Landscape Architecture Magazine be the place where practitioners can go to educate themselves on the trends in the increasingly more technologically demanding environment of landscape architecture?
2.2 Historical Overview of Technology Columns

While many practitioners and educators in landscape architecture remember “Construction” as the first materials column, it was preceded by “Technik”, which first appeared in January 1978. Though it only appeared twelve times, it laid the ground rules for the level of detail in technology columns that were to follow. But, it was in November 1980 when the technical column really took off.

That month, Grady Clay, the Editor of Landscape Architecture Magazine, incorporated subject-based columns into the magazine. Amongst these columns was “Construction”, which revolved around materials, detailing and construction. It served to teach us about new materials and construction techniques as well as to remind practitioners of materials which spoke to the legacy of our profession. Under the leadership of column editor Linda Jewell, “Construction” became a staple of the magazine for nearly a decade appearing on a regular basis, though not in every issue, until July/August 1987, (and twice under “Technique & Practice” in Dec 1988 and May 1989).

The late 1980s saw LAM’s expansion from six issues per year in 1987, to eight in 1988, ten in 1989 and finally monthly in 1990. This period, primarily under Editor-In-Chief James Truelove, also witnessed a major reformatting of LAM. Beginning in Dec 1988, a new section entitled “Technique & Practice” was created. It served as an umbrella under which a variety of topics related to materials, construction, computers and the practice of landscape architecture were housed. In addition, a smaller one-page column on new landscape materials and products called “Product News” was started. These columns ran until Editor Truelove stepped down in January 1996.
Spearheaded by Editor-In-Chief Anne Elizabeth Powell, LAM underwent a content reformat in February 1996. One of the changes was the increase in the number of columns, dubbed ‘departments’ that appeared monthly. Unlike the single “Technique & Practice” column, there were now separate columns. This incarnation of LAM transitioned to Editor Steadman in 1999 and then to J. William Thompson in 2000. Most columns that focused on materials occurred in “Technology”, “Details” and “Ecology”. Over forty column headings were created during the 14-year run of this format to cover a diversity of topics. In the back of the issues, “New Products”, which ran from Jan 1999 to Feb 2001, and “Product Profiles”, which ran from March 2001 to Dec 2010, picked up where Product News left off in October 1995. After serving as editor for nearly a decade, J. William Thompson stepped down in October 2009.

The most recent major reformat, and current version of LAM, began in January 2011 under Editor-In-Chief Bradford McKee. Several new departments were created to reflect the changing nature of the discipline. The majority of materials-based columns occurred in “Close-Up”, “Materials”, “Green Roofs” and “Water”. Finally, “Goods” became the fourth iteration of a column revolving around new landscape materials and products.

3 METHODS
To track the evolution of materials focused technology column articles in Landscape Architecture Magazine, an inventory of the articles from the first appearance of “Technik” in January 1978 to June 2017 was created. For this study, a column is defined as any article that appeared under a subject category heading, occurred on a monthly or semi-regular basis and was not a ‘feature article’. A ‘material’ is defined as any landscape construction material that’s used for site construction or infrastructure. This is self-evident with hard landscape construction materials, but can include vegetation such as sedums, if they are described as the insulation layer to the sandwich assembly of a roof garden. From that, a ‘materials’ column article has been defined as those articles where the main focus is to provide a description, outline potential uses for and illustrate construction processes with a particular material, such as colored concrete, or assembled landscape elements, such as septic systems. Several readings of the column articles were required to isolate those with a significant amount of information on materials.

The period from February 1996 to December 2010 was the most complicated to sort through as over forty column titles were created, which LAM referred to as “departments”. For this study, the number of columns was narrowed down to the three with the highest proportion of articles on materials: “Ecology”, “Technology” and “Details”. Though not in significant numbers, articles focused on materials occasionally appeared in other columns, such as Landscapes of Home, Landscapes of Escape, an “Education” column from February 2009.

The articles were divided into two categories, “In-Depth” and “Product”. The criteria were based on similarities of formatting, content, and the level of descriptive detail. The In-Depth columns always listed an author, many of whom were frequent contributors, making these columns more impactful when present in an issue. They are as follows: “Technik”, “Construction”, “Technique & Practice”, “Technology”, “Ecology”, “Details”, “Close-Up”, “Materials”, “Green Roofs” and “Water”. Articles that provided brief profiles of landscape construction products were put into the ‘Product’ category. They are as follows: “Product News”, “New Products”, “Product Profiles” and “Goods”. The column runs and types are summarized in Figure 1.

The final step was to categorize the articles by how LAM presented the data: “traditional” or “sustainable”. Four variables were used as follows:
1. Traditional Materials
2. Sustainable Materials
3. Traditional construction process
4. Sustainable construction process
If a material or a construction process was referred to as “sustainable”, it was defined as such; otherwise it was defined as “traditional”. Both traditional and sustainable materials are capable of illustrating advances in technology over time. A traditional material or construction process can be environmentally sensitive and have less impact than alternative materials or construction processes, but in order to be considered sustainable, they must speak to the ethos of sustainability.

The definition of sustainability that was used comes from the one presented by J. William Thompson and Kim Sorvig in *Sustainable Landscape Construction* (Thompson and Sorvig, 2000, 2008, 2018). The authors pointed out that sustainability is difficult to define, which is emphasized by the fact that in the second edition of their book the definition was changed to match the article published by CELA in 1988, which defines sustainable landscapes as those which

“contribute to human well-being and at the same time are in harmony with the natural environment. They do not deplete or damage other ecosystem. While human activity will have altered native patterns, a sustainable landscape will work with native conditions in its structure and functions. Valuable resources – water, nutrients, soil et cetera – and energy will be conserved, diversity of species will be maintained or increased” (CELA, 1988).

4 FINDINGS

The findings for the ‘Product’ and ‘In-Depth’ columns will be addressed separately as there are major differences between them. The most notable is that virtually all ‘Product’ columns feature materials and have a more consistent month-to-month presence than the ‘In-Depth’ columns. As such all proportional calculations and comparisons were separated by these categories. For overall numbers, each category was counted separately and the two categories were combined to determine the overall trend in the presence of materials column articles over the past 40 years.

4.1 “In-Depth” Columns: Detailed Descriptions

In January of 1978, Grady Clay introduced “Technik”, the first technology column. Only twelve articles appeared between January 1978 and March/April 1984. They provided a general heading under which a variety of technical articles could appear. Under this umbrella, articles ranged from bus shelter design to computer software to site engineering. The majority of articles were on such topics as slope stabilization, erosion control, and re-vegetation.

The next technology column to appear was entitled “Construction”, edited by Linda Jewell. The column and its editor were formally introduced in the “People” section of the November 1980 issue. Jewell authored 26 of the 36 articles written during the column’s run. Subject matter revolved around what today would be considered “traditional” landscape materials and construction, which, when grouped together, are similar to introductory texts on the subject. Overall, “Construction” featured the highest proportion of materials articles of any column run.

“Construction” articles were typically three to four pages in length and covered a single material such as granite curbing or integral color for concrete paving. In a sense, these articles were short crash courses on the material profiled. The articles gave a brief introduction to the material covering its available options, its qualitative and quantitative properties, best applications, and potential costs. Construction details and detailed sketches were common, photographs were not.

Of the 36 articles, 21 focused on landscape materials, nine focused on construction processes, and six focused on other topics, including a historical retrospective on A. D. Taylor who penned numerous articles on materials and construction from 1922-1936. Examples of Construction column articles that focused on a material were Bluestone and Slate Flagging from Nov 1981, Colored Concrete Paving from January/February 1984 and Ornamental Metal – Wrought Iron from March/April 1987. Examples of Construction column articles that focused on a construction process were Perforated Brick Walls from May/June 1983 and Wood Crib Retaining Walls from November/December 1984.
The next column to feature a large proportion of materials articles was “Technique and Practice”, which ran from December 1988 – January 1996. Similar to “Technik”, this column contained a diverse range of articles, in effect combining “Construction”, “Computers” and “Technik” from previous issues of the magazine. Roughly 50% of articles focused on materials, but topics were as diverse as digital technologies, insurance, restoration, practice and education. Occasionally materials were discussed within these, but if they were, it was from a design perspective rather than a material perspective. The use of photographs, and to a lesser extent sketches was similar to the earlier “Construction” articles.

Notable examples of “Technique and Practice” column articles that focused on traditional materials were Green Walls, about vegetating highway barriers in August 1991, Brave New Materials, about new and emerging construction material in July 1993, Colored Concrete in January 1994 and Plastic Lumber in January 1995. Examples of column articles that focused on traditional construction processes were Playground Surfaces in May 1994 and Earth-Building in Landscape Architecture in February 1995. Articles that focused on sustainable materials and construction processes had only a small presence. Examples were Wood Wise, in January 1992 and Comparing Grass Pavers in May 1995.

The columns to follow were entitled “Technology”, “Ecology”, and “Details”. These ran from February 1996 to December 2010 and from January 1999 to December 2010, respectively. Though 1996 to 1998 was a relatively quiet period, the change in editors brought about a resurgent period of materials column articles from 1999 to 2004. However, there was a steep decline in materials articles between 2005 and 2010.

A typical material-focused “Technology” article profiled a single material or construction process, such as salvaged wood or straw-bale construction. Many of these articles are similar to the material profile articles in “Construction”; however, they are more qualitative and are more likely to tie the subject to a site or sites. “Other articles contained information on digital technology for mapping and representation. Software-based columns rarely related to materials. Typical and notable examples of “Technology” column articles that focused on traditional materials were Back to Brick from December 1996, Tile Tales from February 1997, Grass Roofs Movement, which explained what green roofs are, from May 1998, Meadows Above, which further defined green roofs, from September 2000, and Problem Solving in Stormwater Bioretention Systems from May 2006. Examples of column articles that focused on traditional construction processes were Stone Veneer Site Walls in Feb 2001 and The Makings of a Skatepark in April 2004.

Typical material-focused “Ecology” articles look at how a common material or element can be made more sustainable through new specifications or alternatives. In general, these articles are very technical and provide a large number of quantitative and qualitative specifications, particularly in articles by Meg Calkins and Kim Sorvig. They typically introduce a material, describe the contemporary condition and its pros and cons and then spend the majority of the article looking at how to build or specify it in a more sustainable way. Notable examples of “Ecology” column articles are Soils Under Pressure, about structural soils, in June 2001, Light on Their Feet, about low-impact metal piering systems over water, in November 2001, and Cooling the Blacktop, in February 2007.

A typical “Details” article examined a single element from an existing project and either profiled the element or discusses how it was detailed. The subject could be a lighting product used in a project or a built element, such as a wall. Typically, these descriptions were qualitative, although some specifications may be included. Interviews with designers involved with the project are common. The number of material focused articles decreased during the lifespan of the column with the majority of the material-focused articles appearing in the first half of its tenure. Examples of “Details” column articles are Specifying a Greener Concrete in February 2000, A New Twist on Trellis Design in June 2000, and Conspicuous Reconsumption, about recycled concrete, in April 2004.

“Green Roofs” was introduced as a column in October 2008. Typically, its articles consisted of a case study of one or more green roofs. Usually the studies touched on the decision-making process that led to the installation, the plants used, soil depth and mix, issues, and lessons for future projects. Some
articles only described the project, but others included technical information and construction details. Notable examples are A Spot of Green in Steel City in September 2008, and The Tipping Point in January 2010.

The current incarnation of *LAM* began in January 2011 with three new columns, “Materials”, “Close-Up” and “Water”; “Green Roofs” has continued. However, from January 2011 to June 2014, there were only seven articles focused on materials distributed among these four columns. With such small sample sizes, it is not possible to isolate a “typical” material-focused article. “Materials” has only appeared three times, with two of the articles focused on a specific class of product and provided a reason why landscape architects are now interested in the product. Photos of these products were included and pros and cons of different product types were described broadly. “Close-Up” also had only two materials-focused articles; both of which were on either the detailing or construction process behind a project or product. Both provided photos of the finished work and some quantitative details through CAD drawings and text. To date, “Water” has only one materials-focused article, which spoke to new standard storm water plans for developments in the Los Angeles area.

4.2 Trends With ‘In-Depth’ Column Articles

During the past 40 years, several columns have featured materials as the focus of an individual article whether it was on a specific material or a construction technique. Some columns, like “Construction”, focused almost exclusively on the subject of materials (30 of 36 total articles), while others varied from 7-50%, such as “Technique and Practice” (52 of 107 articles), “Details” (31 of 84 articles), and “Ecology” (10 of 140 articles). The column articles were then separated into two groups based on their specific focus; a materials study vs. construction processes, with materials being the main subject. These two groups were then subdivided based on presentation, ‘traditional’ versus ‘sustainable’.

Based on the increase in the availability of landscape construction materials becoming available over time, one might expect to see an upward trend over time in the number of articles per year that focus on materials. Instead, there are two distinct peaks, one in 1994 and the other in 2000. Since that time, there has been a decline in the frequency of column articles that focus on materials. As Todd Steadman’s editorship period is quite short and mimics that of the first portion of Thompson’s editorship, the two are being combined into the overall period of 1999-2010. The most curious decline is within the Steadman / Thompson editorship period which can be broken up into two parts, one with heavy coverage of landscape materials from 1999-2004, which averaged 9.0 articles per year, and the second being a period of minimal coverage from 2005-2010, which averaged 2.0 articles per year. Though most of the patterns in coverage can be attributed to editorship periods, one can also see the continuity of materials coverage that was maintained in the transition from Steadman to Thompson from 1999 to 2000. The number of total articles and articles per year was the lowest under the current editor, Bradford McKee, during the period 2011 – mid-2014. Since that time, there has been some indication that this pattern might be changing as the average number of articles between mid-2014 and 2016 was 3.3, with six articles published during 2017.
4.3 Materials Versus Digital Technology Coverage in ‘In-Depth’ Columns.

From 1988-2010, articles that focused on digital technology appeared in the same columns as articles on materials. The columns were “Technique & Practice” (1988-1995) and “Technology” (1996-2010). Before December 1988, digital technology was covered in the column “Computers”, and starting in January 2011 digital technology is covered in “Workstation”. Between 50-80% of the column articles during the periods from 1996-1998 and 2005-2009 were on digital technologies. In retrospect, these periods can be labeled as more ‘digitally focused eras’. In light of computer advances in both hardware and the increasing utilization of digital tools in landscape architecture, one can see how this subject matter could take precedence over coverage of landscape construction materials.

4.4 ‘Product’ Columns: Detailed Descriptions

Throughout the years, the ‘Product’ columns have had the same function and have exhibited similar formatting and levels of detail. Therefore, all ‘Product’ columns have been viewed as a single column type that changed names with changes in editorship.

The first of these, “Product News”, ran from 1988 to 1995, and initially reported on a variety of products that were not necessarily related to one another on a single page. For example, April 1990 covers a variety of landscape construction products; pavers, concrete stamps, site furnishing and modular trellises. September 1992 featured seeded turf fabric, site furnishings, site lighting, umbrellas and modular face brick. In January 1994, the “Product News” columns began to organize products via a unifying theme, and in October 1994, a subtitle named a theme for the page. This first officially themed ‘Product’ column is titled “Fair Game: New Playground Furniture and Surfacing”. The last “Product News” column appeared in October 1995, becoming the last ‘Product’ column to appear in LAM until January 1999 when the first “New Products” column appeared under Publisher Todd Steadman (J. William Thompson Managing Editor).

“New Products”, which ran from January 1999 to February 2001 featured a variety of products in a one to two page spread and used the ‘grab bag’ approach of its predecessor. Occasionally it would feature one to two new materials, such as A-Jacks concrete streambank stabilization units in February 2000, or ornamental metal work and bike racks in September 2000.

In March 2001, “New Products” was renamed “Product Profiles”, which themed the products each month. The theme was announced via a subheading and went further than the earlier themed “Product News” by including a few sentences on the theme. Some representative examples over the column run are as follows: June 2001 featured landscape ornamentation and furniture, April 2004 featured site furnishings for historic restorations, May 2006 featured a selection of green roof products, February 2009 featured stormwater management products and October 2010 featured site ‘style enhancers’. It should be noted that many of the Product Profiles columns from 2010 were given a sustainable theme, which is evidenced by the spike in articles that year. Another notable sustainably themed Product Profiles was Going Green from Jan 2001, which listed the top 10 green building products from the GreenSpec Directory.

The current Product column is “Goods”, which started in January 2011, and is the only one that credits an author, Lisa Speckhardt, in the article. Each article presents a set of products, all centered on a single theme, such as fencing or ground materials. These columns typically provide a photo and brief description of each product and the manufacturer’s website and more closely resemble an advertisement rather than a column that is meant to educate its audience. This is due to the brevity of the descriptions versus earlier incarnations of Product columns. While the magazine has employed a wide range of authors, it should be noted that Speckhardt does not have a background in landscape architecture, which could call into question whether this was the best person to write about products to practitioners.

4.5 Trends With ‘Product’ Column Articles
One the one hand, ‘Product’ columns have, in a sense, the purest focus on materials, on the other, their contents can blur the line between what is a column and what is merely a product advertisement. This is especially true of the “Goods” column, whose contributions to the profession can be called into question. While they may only offer short descriptions of a material or commercial product, 97% of the articles published between 1988-2017 described a landscape construction material. Of these, ‘traditional’ materials were present in 81% versus 19% for ‘sustainable’ materials.

![Figure 3. ‘Product’ column content by subject matter to the left; ‘Product’ columns by material category to the right, not including software (2018). Diagram by author.](image)

From December 1988 to October 1995, ‘Product’ column articles were present in about half of the issues in any given year and were focused almost exclusively on traditional materials. From November 1995 to December 1998, ‘Product columns’ did not appear. However, since January 1999, the ‘Product’ column articles have generally been present throughout each year with the exception of some ASLA Awards issues. Two distinct trends have occurred since January 1999. The first is the upward trend in the frequency of sustainable material articles from 1999-2010 (the average jumped from 2.0 to 8.0 articles per year), and the second is the severe drop in the frequency of such articles since the beginning of “Goods” in January of 2011 (where it dropped from ten articles in 2010 to one in 2011).

4.6 Reframing Technology Columns: the Different Content Eras of Landscape Architecture Magazine

When looking at the trends presented by the various technology columns that focused on landscape materials and construction processes over the past 40 years, one can begin to map out an irregularity in coverage that more or less follows terms of editorship. From the rise and fall of traditional materials and construction to the resurgence of materials coupled with sustainability to the decline of materials altogether, each significant period of development within LAM can be given a name.

Traditional Materials and Construction, 1978 – 1991: This era is defined via the coverage of a diverse spectrum of materials, from refinements of such age old materials as stone to such new composites as plastic lumber. Every issue of LAM contained an article to familiarize the reader about a new material or construction method. Over the course of this period, the materials and construction processes in column articles fell mostly into the ‘traditional materials’ category.

The Non-Material Era, 1996 – 1998: during this period, the magazine turned its attention to digital technology and other subject matter. Feature articles contained fewer mentions of new materials within the technology columns.

Sustainably Influenced Materials Explosion Era, 1999 – 2004: With the reintroduction of a landscape architect at the helm of the magazine, materials and construction processes surged back into the consciousness of the profession. J. William Thompson also brought an emphasis on materials that espoused a sustainability ethos, which was echoed in Sustainable Landscape Construction that he authored with Kim Sorvig. The other hallmark of this era was that it was balanced between sustainable and traditional materials.

Ecology and Sustainability Era, 2005 – 2010: Many of the materials and construction processes introduced in the previous era were maturing, with articles adding new dimensions such as monitoring performance and regional specifics. This trend is easiest to follow with green roofs, which is the hot button materials topic of this era. But, the overall trend was that concerns about materials and construction processes, sustainable or otherwise, were now on the decline. Similar to the Non-Materials Era, the focus of technology columns turned to digital technologies and other issues.

Assumed Knowledge Era, 2011 – 2017: Column articles related to materials dwindled during the first few years under the current editorship. During this period the magazine underwent a major formatting transformation, placing emphasis on developing other aspects of the magazine. Toward the end of this ‘era’ the article count began to slowly rise to three articles per year from 2014-2016 and ending with six articles in 2017, the most in a single year since 2004.

Figure 4. ‘In-Depth’ column articles per year by ‘Era’ (2018). Diagram by author.

5 CONCLUSION

All told, Landscape Architecture Magazine has created a substantial legacy of technology columns. Since their inception in January 1978, technology columns focusing on materials and construction have been one of the largest regular contributors to the discourse of these subjects to the professional and academic landscape architecture communities. Reviewing and reflecting upon the content of the largest publication in our profession is necessary if the discourse within landscape architecture is to evolve. Through such reflections we can look at what have we gained and what have we lost with regards to the coverage of landscape construction materials and construction processes and how this subject matter is to be covered by LAM moving forward.

5.1 Trends in Materials Coverage Within LAM.
The issue raised by this paper is whether LAM has reflected the proliferation of available construction materials within its column articles. With the exception of two distinct spikes, the average number of column articles per year in LAM has not always correlated with the explosion of available construction materials as noted by Brownell in Transmaterial and as illustrated by Kieran and Timberlake through the product offerings of DuPont (see figure 5). When compared to this “Explosion of New Materials” chart (which is one of the few diagrams depicting this trend), the trends in the offerings of technology columns in LAM can be best labeled as irregular. However, spikes in the number of ‘In-Depth’ materials columns from 1992-1995 and from 1999-2004, suggest that there has been interest in this subject matter and the recent upward trend in 2017 may suggest that the future is once again bright, perhaps spurred on by the interest in landscape performance.
Figure 5. Graphic approximation of the coverage of materials in LAM over the past 40 years versus the trend in quantity of available materials, in this case using the products of the DuPont company (2018). Diagram on top by author. Diagram on bottom republished with permission of McGraw-Hill, from Refabricating Architecture: How Manufacturing Methodologies Are Poised to Transform Building Construction, Kieran and Timberlake, 2004; permission conveyed through Copyright Clearance Center, Inc.

Though this gives us the “what”, the “why” is harder to come by as the editors didn’t explicitly address the creation of or changes to all the columns and asking about this of them now may not reflect...
their original rationale or biases. While each editor may have a bias toward what material was presented in the magazine, one cannot attribute that to whether or not a particular editor has a background in landscape architecture or from another field. This is evidenced by the two biggest spikes in materials columns being under James Truelove, who came to LAM from another field, and J. William Thompson, a landscape architect. The current editor, Bradford McKee, also comes from a field other than landscape architecture; as his tenure is still underway, we cannot yet assess his legacy other than to note that the annual number of columns is trending slightly upward.

5.2 Landscape Architecture Magazine versus Online Resources.

If materials are not being covered by LAM, a question is: where do practitioners and students go to learn about materials in landscape architecture? Perhaps most materials research is being done online. Further surveys of practitioners and academics will be necessary to document the sources used and if these sources meet their needs. The recent online platform for performative landscapes by the Landscape Architecture Foundation could help with the development of an online column that could highlight materials that help with aspects of landscape performance.

In looking at the directions LAM can go with its coverage of materials in column articles, perhaps the answer lies as much in its past as it does in its future. As Bruce Ferguson stated in his article chronicling the history of the magazine, “each successive generation tends to believe that it is starting the world anew without precedent or hindrance. But full professional competence requires respect for how much work has preceded ours, the mistakes landscape architects have made, and how far we have come.” (Ferguson, 1999, 113) As the sustainable movement matures and the materials explosion continues, the hope is that Landscape Architecture Magazine can present a holistic approach to materials, detail design and construction processes that speak to the technical legacy of the magazine. If performance, maintenance and cost drive the future of the profession, dedicating more time to the knowledge of materials, methods and construction may be the key to helping us navigate the future.
6 REFERENCES


Council of Educators in Landscape Architecture (CELA).  1988.  “Sustainable Landscapes – Call For Papers”.  Pomona: Department of Landscape Architecture, California State Polytechnic University.


THE CHANGING ROLE OF BOTANIC GARDENS
IN THE CONSTRUCTION OF THE NATURAL ORDER

PÉREZ-RAMOS, PABLO
Harvard University Graduate School of Design, pperezramos@gsd.harvard.edu

1. ABSTRACT

Botanic gardens constitute an excellent medium to render legible different conceptions of environment. Since the earliest examples of gardens aimed to increase the scientific understanding of plants, botanic gardens have always exceeded their research purpose of plant collection and classification. Aside from codifying plant life, they have expressed the different aesthetic and cultural aspirations of each time and place. In recent times, an emphasis has been put on the capacity of botanic gardens to educate the general public about current environmental issues and the different values around which the relationship between humans and plants has been constructed over history. In the current context of environmental disruption, less attention is given, however, to the extraordinary potential of contemporary botanic gardens to contribute to the construction of new forms of natural order.

Through a quick overview of some of the different systems of classification in the natural sciences and its concomitant principles of organization in landscape gardening, this essay will highlight a few historic examples to show how botanic gardens have worked towards a synthesis of prevalent scientific codes of botany and aesthetic canons of landscape architecture. It will then focus on the discussion of a contemporary case, the Bordeaux botanic garden, designed by the French landscape architect Catherine Mosbach, as a way to recapitulate and expand some of the key issues in the history of botanic gardens. This essay ultimately seeks to highlight the potential of botanic gardens, specifically, and landscape architecture, in general, to internalize, render legible, and thus advance different constructions of the natural order and of the position of the human within.

1.1 Keywords

botanic gardens, botany, natural order, construction, representation
2. **ART AND SCIENCE IN THE INCEPTION OF A LANDSCAPE ARCHITECTURE TYPE**

Modern botanic gardens, as they proliferated across Europe in the sixteenth and seventeenth centuries, had their precedents in the *herbularia*—also called medicinal gardens—frequently found in medieval monasteries. In these *herbularia*, often planted in simple and regular schemas of separate and rectangular *arae* (planting beds), monks would grow those herbs that could not be otherwise found in nearby woodlands or grasslands and that they considered useful for their medicinal properties. Because the aim of these gardens was not specifically the expansion of botanic knowledge, the resulting catalogs may not be considered strictly scientific. With the extraordinary growth in the number of universities in the sixteenth century, however, the formal study of medicine instigated the creation of more complex collections of plants expressly intended for scientific examination. It was in the context of these modern universities that the first botanic gardens began to appear. Unlike their medieval predecessors, these *horti botanici*

---

**Figure 1.** Intricacy and hierarchy in the plan of the botanic garden of Padua. Girolamo Porro, *Plan of L’Horto de i Semplici di Padova*, 1591.
were invested in a disinterested quest for knowledge, in the understanding of plants beyond their medicinal properties, in their allure as objects of study in and of themselves, whose physiological structure and relative position within a larger organizational framework merited examination (Tomasi, 2005a).

Although this new form of knowledge was the fundamental aim of early botanic gardens, their spatial organization was not exclusively or even primarily informed by the scientific understanding of plants. Aesthetic preferences in contemporary non-scientific gardens and other cultural aspirations of the time were more influential in the early formal explorations of botanic gardens than the specific scientific principles from the still emerging field of botany (Tomasi, 1983). Most pioneering examples of the sixteenth century, such as the University of Pisa (1543), Padua (1545), Bologna (1568), or Leiden (1587), and even some seventeenth century iconic gardens, like Oxford University’s (1621) or the Jardin du Roi in Paris (1640), consisted of the compositional canons of the medieval hortus conclusus, where two walking paths subdivided the cloister into four quarters, with the Fountain of Life—or God—at the center. In the more humanistic tradition of the Renaissance, this quadripartite quadrangle was used to signify the four elements of the cosmos—earth, water, fire and air—and the four cardinal points. With the arrival of the Europeans to the Western Hemisphere in the 1490s, the new American continent came to complete—along with Europe, Africa, and Asia—a fourfold subdivision of the world that offered a straightforward and long-awaited correspondence between the cosmological and the geographic (Prest, 1981). Exhaustive intricacy, as an expression of the larger Renaissance quest for the mastery and control of geometry, was the rule in the arrangement of the planting beds. The scheme of the botanic garden of the University of Padua (figure 1), still preserved today, inscribes a square inside a circle, in an exercise that has been described as a translation of Leonardo da Vinci’s Vitruvian Man into the field of garden design (Tomasi, 2005a). The botanic garden was, as much as any other form of Renaissance garden, a microcosm, a synecdoche that allowed one to contemplate a well-ordered and human-centered model of the world in one single space (Battisti, 1971).

The first Spanish transatlantic voyages and the Portuguese establishment of a sea route to India in the late fifteenth century gave way, later in the seventeenth and eighteenth centuries, to the great age of explorations by European naturalists, which offered a new vision of nature unprecedentedly large in scale and complexity (O’Malley, 1992). As many new species from distant continents began to arrive in Europe, early botanists were charged with the task of elucidating the increasing variety of plants. They needed more rigorous organizational frameworks, and new classification systems began to emerge and describe different species, as well as to facilitate easy and effective study of plants constituted the definitive inauguration of the botanic garden as a landscape encyclopedia.

In 1735, during this dynamic stage of development, the Swedish botanist Carl Linnaeus published System Natura, which was the first widely accepted classification system in botanical studies and the inauguration of the binomial nomenclature that has ever since been used in naming species of living organisms. Linnaeus’ classification system organized the world of plants in discrete classes by solely following numerical criteria derived from the morphology of the flower. Its global acceptance and success resided in its fundamental simplicity, regularity, and effectiveness. These were attributes Linnaeus had found in the spatial arrangement of the botanic garden at the University of Leiden (figure 2) when he arrived in the Dutch Republic to study medicine. Founded in 1587, Leiden’s botanic garden had marked a clear move away from the aesthetic intricacy and hierarchical symbolism of its earlier Italian counterparts and had drawn connections, instead, with the more utilitarian rationale of the herbularius. Its system of long, straight, and narrow planting beds, arranged in accordance to the uniformity of the agricultural grid, was designed to offer flexibility in the rearrangement of the different species, as well as to facilitate easy and equal access for the cultivation, care, and study of the catalog. By dealing with pulvilli (flower beds) as if they were technical sheets in a scientific publication, Leiden had turned the garden into a living encyclopedia.

The regularity, openness, and permeability of Leiden’s framework sparked—more than any other design characteristic—the academic inception of the botanic garden (Prest, 1981). The separation from the canons of non-scientific garden design and the emphasis on the strictly practical ends of agronomy for the effective study of plants constituted the definitive inauguration of the botanic garden as a landscape...
architecture type. It was then that the botanic garden began to play a determinant role in the development of the science of botany. Botanic gardens were not just places for the collection and exhibition of species anymore, nor did they simply record plant classification systems; they started to actively participate in the evolution of the science of botany. The simple, separate, and regular configuration of Leiden’s space not only represented but also enabled a very specific line of thinking in botany, one that emphasized ideas of discreetness and regularity in the natural order, and which had culminated in the Linnaean *Systema Naturae*.

Where Linnaeus’ contemporaries saw much needed simplicity and effective regularity, taxonomists at the turn of the nineteenth century instead found unacceptable *artificiality*—to use the idiom of the time (Stevens, 1994). Many began to consider that using the arithmetic of the reproductive system as the primary criteria led to an arbitrary construction and capricious categorization of the world of plants and, therefore, to unobjective science. The French botanist Antoine Laurent de Jussieu was among the first to contest the fundamental discretization that Linnaeus’ system imposed upon an order of nature that he considered empirically continuous. In 1789, Jussieu published an alternative *natural* method of classification that

![Figure 2. Influence of the regularity and utilitarian principles of agronomy in the arrangement of aerae and pulvilli in the botanic garden at Leiden. Pieter Pauw, Hortus publicus academiae Lugdunum-Batavae, 1601.](image-url)
conceived general morphological affinity as the leading criteria in linking together different species and locating their relative positions in the continuous series of nature (Foucault, 1970). The Swiss botanist Augustin Pyramus de Candolle also worked within the premise of continuity in the construction of a natural order (Stevens, 1994) and began to expand the typological catalogue of the modern botanic garden through a new spatial language of specimens lined up in accordance to morphological similarities, which the British landscape architect John Claudius Loudon would quote and enshrine decades later in his sinusoidal plan for the Derby Arboretum.

This shift from discreteness to continuity between different species was part of a larger conversation in biology about the ultimate metaphysic constitution of nature itself, that would eventually facilitate the rise of Darwin’s theory of evolution and Haeckel’s ecology by the mid nineteenth century (Hull, 1967; Haeckel, 1866). As botany moved away from the fundamental discreteness of artificial systems and closer to the continuity of natural methods, so did the spatial organization of botanic gardens. Specimens were not arranged anymore by principles of separation and regularity but, rather, by morphological grouping and continuity. This correlation between system and garden, however, was not asymmetric: botanic gardens were not just spatial representations of the images of nature put forward by the science of botany. In shifting towards an emphasis on notions of continuity, botanic gardens were also registering the general turn that landscape architecture theory and practice went through during the eighteenth century. The rigid and symmetric Euclidean geometry that dominated the seventeenth century jardin à la française gave way first to the looser, softer, and predominantly curvilinear forms of the pastoral English landscape gardening, and later, by the turn of the nineteenth century, to the intricate and variegated aesthetics of the picturesque. Through the internalization and synthesis of both the codes of the natural sciences and the aesthetic canons of landscape architecture, modern botanic gardens exceeded their role as indexes of botanic ideas of nature and became, as well, active agents in the imagination, visualization, and construction of new forms of natural order.

3. THE EXPANDED PROGRAM OF THE BOTANIC GARDEN TODAY: CATHERINE MOSBACH AND THE CASE OF BORDEAUX

I shall focus now on a contemporary botanic garden, the one designed by the French landscape architect Catherine Mosbach for the city of Bordeaux, in southern France. Although questions of plant taxonomy still remain at the core of botany and continue to be important in the establishment of a botanic garden research program, today there is also a growing interest in the general public’s engagement (Conan and Kress, 2007). I want to use the case of Bordeaux to discuss how, in recent times, more emphasis has been put on the capacity of botanic gardens to raise awareness about current environmental issues, and to educate the public about the different values that have informed the relationship humans have established with plants over time. I shall also argue that Bordeaux constitutes a contemporary and extremely eloquent example of the capacity of landscape architecture to internalize, render visible, and help advance conversations about the natural order, which in the twenty-first century mainly take place in the cultural context of global disruption brought about by the relationship of humans with the environment over the past two centuries.

3.1 Introduction to Bordeaux Botanic Garden

The botanic garden at Bordeaux is part of a larger municipal project to redevelop the right bank of the Garonne river. Contrary to the more consolidated left side of the river, the right bank has been undergoing a process of postindustrial reconversion since the late twentieth century, in which the botanic garden is called to play the role of a new urban centrality. The design exploits the long urban interface of the plot—six hundred meters long in the east-west direction, and one hundred meters wide—to provide easy access to local residents and visitors, taking its elongated form as an opportunity to unfold a sequential logic of botanic galleries perpendicular to the water course (Mosbach, 2003).

The exhibition’s point of departure is the area closest to the Garonne river, the so-called jardin aquatique, where a mosaic of pools grows various kinds of aquatic plants. The sequence continues with the galerie des milieux, or “gallery of environments,” which shows a variety of natural landscapes found across the southwestern basin of the Aquitaine, where the city of Bordeaux sits. The next main gallery is the champs de culture, or “fields of culture,” where visitors get acquainted with the different uses and values humans have assigned to cultivated plants over history. The sequence ends in the area that is furthest from
the river, where a collection of xerophytes that do not currently grow in the Bordeaux region are cultivated in a greenhouse. There is also an arboretum, distributed across the whole space of the garden, and other minor events situated on the flanks of this central sequence, such as the vertical gardens—a collection of vines and climbing plants—and the allée of pioneers, an old denuded oak fence, 450 meters long, which is progressively colonized by lichens, ferns, and sedums (Jardin Botanique Bordeaux, n.d.).

The main educational discourse of the garden, however, is the one offered by the four central galleries—the aquatic garden, the gallery of environments, the fields of culture, and the greenhouse—which represent, as a whole, a complete natural history of plants. Beginning with the exhibition of some of the earliest plant life forms, such as hydrophytes and helophytes, the timeline continues with some of the natural formations that result from the plant colonization of the land, progressing into the cultural domestication of plants by humans, and then concluding with a glimpse of the potential “mediterranization” of the Aquitaine region, as an epiphenomenon of global warming.

The design of two specific galleries of the garden—the champs de culture or fields of culture, and the galerie des milieux or the gallery of environments (Figure 3)—constitute a particularly good example of the ongoing potential of botanic gardens, in particular, and of landscape architecture, in general, to contribute to the construction of different forms of natural order, as well as of the position of the human within. Through the fields of culture, on the one hand, the garden represents the different cultural values assigned to plants across different geographic locations and historic periods, and the gallery of environments, on the other, reproduces different natural landscape conditions of the Bordeaux region in a series of “promontories” where management is kept at a minimum, so that plants on top develop with virtually no human intervention.

3.2 The Agronomic Discreteness of the Fields of Culture

In the fields of culture, the educational agenda for the garden unfolds in what Mosbach (2003) refers to as an ethnobotanic project: a representation of the different social roles played by plants over different cultures and centuries of agriculture. In the design scheme, the fields of culture follow a regular organizational framework made of long, straight, and narrow pulvilli or planting beds (Figure 4). If, as we have seen, Leiden constituted the introduction in the late sixteenth century of a branch of botanic gardening that moved away from symbolic formalism and into agronomic pragmatism, Bordeaux’s fields of culture constitute a contemporary and radical expression of that same lineage. They are “cultivated” with the traditional agronomic technique of ridges and furrows, yielding maximum ease of management of the collection while unapologetically aspiring to the aesthetics of agronomic landscapes. Despite the small size of each unit—widths between 7 and 4 meters and lengths between 20 and 12 meters—the fields of culture produce the optical effect of a much larger agricultural landscape, achieved through the formal redundancy of the elongated shapes of the planting beds, their sequential organization, and the linearity of the furrows. As in real agricultural fields, these plots serve as a permanent canvas for the growth of crops that are seasonal and temporary. Since crops are in transition, each planting bed is provided with an adjacent and independent water reservoir, allowing for irrigation and soil moisture control for the growth of a maximum variety of species.

In step with the garden’s ethnobotanic plan, the collection does not follow taxonomic criteria or morphological resemblance between different species, but is rather organized according to the economic and social values that plants have been assigned over time. For example, among other categories and subcategories, the collection presents edible plants (oils, mints, berries, vines, grapes, leafy vegetables,
cereals, sugar plants, plants for the production of alcoholic beverages), ornamental plants (flowered legumes, aromatic plants, or simple assortments of flowers), medicinal plants (allergenic plants, conifers, essential oils), toxic plants, plants that are useful in various ways (dyeing plants, textile plants, basketry plants, and agrofuels), and other stand-alone chapters, such as plants that move rapidly, horsetails and fossil rocks, pioneer species, bulbs, bamboos, and so on. Each of the planting beds is monographically dedicated to a different subcategory and, therefore, the garden offers spaces that display, for example, a collection of textiles, such as mulberry (*morus alba*), cotton (*gossypium hirsutum*), or teasels (*dipsacus*)—anciently used as a comb for raising the nap on fabrics, particularly wool—or plants for production of alcoholic beverages, such as wormwood (*artemisia absinthium*), sugarcane (*saccharum officinarum*) or hop (*hummulus lupulus*) (Jardin Botanique Bordeaux, n.d.).

This economic categorization of plants coexists with a sensorial one. The catalog is also organized in a way that privileges the one of the five senses that is most attuned to the appreciation of the different species. For example, the garden groups plants that are better sensed by touch and smell, such as mints, lemongrasses, and other aromatics; by ear, such as bamboos and plants that attract and feed birds; or by sight, such as ornamentals, plants that move rapidly, or dyeing plants. A system of small landscape rooms, with sitting benches under the shade of the trees of the garden’s arboretum, flanks the fields to enhance the sensorial aspect of these crops.

In pursuing this multifold reading of the collection, Mosbach (2003) stresses the idea of modularity. Modules allow to emphasize the discrete individuality of each unit without implying fragmentation: each unit is presented and evolves independently, but is also understood as part of a larger whole, and as such is seen in continuity with the forms and rhythms of other units in the garden. Through modularity, one can focus on the content of a particular moment in the garden and, at the same time, integrate it into the larger whole: a whole that is not only the larger botanic organizational framework to which all species belong, but also that of the agronomic landscape that lies beyond the physical limits of the garden and its immediate urban context.

### 3.3 The Ecological Continuity of the Gallery of Environments

In the gallery of environments, eleven natural landscapes typical of the Aquitaine basin are reconstituted above ground as promontories that emerge on their geological base (Figure 5). The five environments to the north represent the landscapes of the right bank of the Garonne—the wet
meadowlands, the pubescent oak forests, the dry meadows, the limestone green fields, and the limestone hills—and the six to the south represent the left bank of the river—the dunes, the dune fixation forests, the dune hinterland forests, the ponds, the dry moors, and the wet moors (Jardin Botanique Bordeaux, n.d.). The reconstruction of these landscapes is produced by using natural substrates, derived from a series of surveillance campaigns carried out in these different environmental categories. The exposure of the substrates offers, on the one hand, an understanding of the geomorphology and the stratigraphy of the region (Mosbach, 2012), and, on the other—and more importantly, in the context of a botanic program—an understanding of the interrelationships that exist between plants, soils, and subsoils: an understanding of how the composition of the abiotic components of the physical environment determine, to a great extent, the vegetal formations that are perceived on the face of the land.

Part of the scientific program of the garden, these environments are intended for researchers to study the development of ecological processes. They are subject to continuous scientific monitoring and periodic botanic inventories, but the overall management regime is kept at a minimum, so that the plant communities that develop on top do so along successional processes with no major human intervention. With strong resonances with Derborence Island, the inaccessible and unmaintained structure that Gilles Clement completed in 1995 at his Henri Matisse Park in Lille, Mosbach’s environmental promontories produce a powerful visual effect on the urban landscape of Bordeaux, as if fragments of the Aquitaine region had been actually cut out and deposited on the garden’s gravel.

Each of these plinths unfolds independently: each constitutes an individuality, an island with its own internal processes. Following, however, the notion of modularity, this individuality is not at odds with the possibility of reading these landscapes in continuity with each other. In fact, Mosbach (2003) organizes these discrete landscapes to expose these continuities. The five galleries to the right of the Garonne are arranged according to a twofold progression: via geological time, from the Secondary period of the limestone hills to the Quaternary wet meadows, on the one hand, and via the evolution of the vegetal formations, from the absence of soil to the richest soil. The structural logic of the six galleries to the left of the river—all formed during the Quaternary period—is a topographic progression that moves inland from the ocean, a section where the gradual disappearance of the sea sand of the dunes gives way to the moors. The different geologic sections share also tones and color palettes that also enhance visual continuity and the unity of the composition.

Figure 5. Diagram of the planting scheme of one of Bordeaux’s galleries of environment, with different species represented by different numbers, and image of current state of the successional landscape on top of one of the promontories. Diagram courtesy of Catherine Mosbach; accompanying detail photograph by author.
4. CONCLUSION

Today, concern for the environment has come to shape our worldview. Resource scarcity and climate change entered the public consciousness at the end of the twentieth century and are today at the forefront of our interpretation of the relationship humans have established with the environment and with the plant world. The proposition of the Anthropocene and the emerging discourses around the notion of the posthuman signal the current reevaluation of the asymmetric nature of our relationship with the environment.

The *champs de culture* and the *galerie des milieux* in Bordeaux mimic the physical and operative constitutions of both cultural landscapes and successional landscapes. They turn the garden, in so doing, into a synecdoche of our most prevalent ideas of environment. Mosbach’s design is not, therefore, a closed system, arranged in accordance to relationships internally established within the world of plants. It looks at plants, instead, through their external relationships, through the relationships that they establish with the world of humans, as well as with both the biotic and abiotic components that constitute their physical medium. It is, in this sense, an *ecological* botanic garden, ecological insofar as it highlights plants not as natural objects or phenomena in themselves—as early botanic gardens would do—but through the evolutionary processes and the active interrelationships that exist between them and other environmental agents. It may be regarded as a cabinet of curiosities, where the natural history items of the exhibition are, in this case, expressions of an order that is not *natural* anymore but, instead, the result of the tensions that exist between worldviews of human appropriation and control and worldviews that counterbalance the hegemony of the *anthropos* relative to other forms of life. Seen under this light, Bordeaux realizes the great potential of today’s botanic gardens in particular and of landscape architecture in general to augment the awareness and legibility of our ongoing construction of the idea of environment.
5. REFERENCES


THE GAMBACORTA OR TOWN MARSH IN NEW CASTLE, DELAWARE: AN INVESTIGATION INTO ITS TRANSFORMATION OVER TIME

Wik, Anna
University of Delaware annawik@udel.edu

1 ABSTRACT
This project explores the shifting relationship of humans to marshland over time in Delaware. It links the development of the city of New Castle, Delaware to the Gambacorta/ Town Marsh, which includes the urban, industrial site of the historic Tasker Iron Works and neighborhood of Dobbinsville. Proximity and access to marshland have profoundly influenced settlement and land use patterns in New Castle, and human development and attitudes towards nature have in turn affected the marsh. While current attitudes recognize that, as a functional ecological system, tidal marshland provides a myriad of ecosystem services, such as habitat provision, storm surge protection, and carbon sequestration, humans have not always looked so favorably upon the marsh. By its very nature, marshland acts as a barrier, and does not lend itself to ease of development; humans are required to put in significant effort to manage this landscape and marshland has dictated land use patterns. Through interdependent relationships, based on input and extraction, and diking, banking or filling, agricultural and industrial practices in Delaware have harnessed and transformed this abundant natural resource.

Historical research using methods from the scholarship of vernacular architecture guides this investigation. As a historical repository for industrial waste, the marsh represents environmental injustice and segregates neighborhoods of the town. While methods of management and notions of stewardship have reformed over time, the current trend of marsh restoration and environmental sensitivity, especially in the face of resiliency concerns, supports this study and its applicability to future approaches to conservation and development. This study is applicable to future approaches to conservation and development as it defines the cultural significance and sense of place inherent to the marsh landscape, which is disappearing as a result of development and gray approaches to resilience engineering.

1.1 Keywords
Marsh; Coastal Resilience; Vernacular; Environmental Justice; Townscape

The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the Council of Educators in Landscape Architecture (CELA), and its printing and distribution does not constitute an endorsement of views which may be expressed. Citation of this work should state that it is from a CELA conference paper. EXAMPLE: Author’s Last Name, Initials. 2018. Title of Paper. Blacksburg, Virginia: CELA. For information about securing permission to reprint or reproduce this paper, please contact CELA at staff@thecela.org
2 INTRODUCTION

As a child I walked regularly along the old dike that marked the adjacency of the Delaware River and the Gambacorta Marsh. At that time in the 1980’s, this was liminal space, an unpaved gravel path with shade trees and a rubble bank leading down to the smooth sand and driftwood on the river side and *Phragmites* and cattails (*Typha sp.*) as far as the eye could see on the marsh side. The dike was the connector from the main part of Old New Castle, with its cobbled streets and stately Georgian homes, through the no-man’s land that was the marsh, with trails that led to piles of old furnishings, car parts, paint cans, and discarded plastic, to the little enclave of Dobbinsville. In truth Dobbinsville was just another neighborhood of the town of New Castle, like Shawtown or Jefferson Farms, but in experience a completely different type of settlement, with rundown row homes and whispered stories of drug use, violence, and attack dogs. These stories did not make it a place to be feared but gave it a mystique that was attractive and exciting to me as a child. I went to school with children from Dobbinsville, and we were friends, and their life experience was different from mine, and stoked my curiosity.

The trail along the dike was accessed at the far end of the paved Battery Park trail, near the sailing club. It was a pleasurable spot to spend a summer morning, clamoring over the rubble hoping to avoid the rats that were rumored to make nests among the rocks. As a child and teenager, I sought out these types of spaces, separated from the eyes of the neighbors in my small town, exploring the wilds and ‘woods’ which were really a successional tree stand grown up in the unmanaged aftermath of an industrialized landscape.

The trail began to be paved in the early 1990’s. Most of the shade trees remained, and some benches and viewing platforms were installed. My father fashioned sticks for the older women who would walk the trail early in the morning, to fend off any wild dogs that could disrupt their exercise.

As teens, at low tide, we would climb out along the concrete pipes and remnant pilings of the old wooden docks where we would chain smoke Marlboros or clove cigarettes, the lights of the refineries of Delaware City and New Jersey flickering like Oz in the distance at twilight.

By 2000, the trail was paved all the way to Delaware City.

In my twenties and early thirties, when home for the holidays, I would walk along the trail with my dogs and mother and sister. We would find the best beach glass along this beach and had a point system. For each piece of green, brown, and white glass we got one point, blue glass was three points, and the rarest, red, was five points. The natural inlet that made New Castle a favorable place to settle collected and deposited rounded and aged glass from Philadelphia, Wilmington, New Jersey. This was a landscape that inspired curiosity about the past and the ecological and cultural systems at work.

In 2013, in the aftermath of Hurricane Sandy, an extensive reengineering project was conducted, and the entire dike was raised an average of 1.7 feet. Most of the riverside vegetation was removed and new rip rap was installed. While these improvements have been excellent as far as the resilience of the dike is concerned, the phenomenal experience of the trail has been completely transformed. No longer a wilds or a ‘woods’, the driftwood and beach glass is gone, there is no access to the sandy beach or pilings or concrete pipes.

Today, many people enjoy the dike recreationally, and the view of the marsh and river is wide open and stunning any given day. However, for me, there is a sadness at the removal of the perceived ‘wildness’, and the diversity of experience that could be had along this historically important site. While the intensifying storms and sea level rise make it imperative to bolster our protections against nature, I believe there is an equal imperative to retain the mystery and enchantment of our wild edges and liminal spaces. In the absence of the ability to prevent trees from being removed or the dearth of beach glass lodging in the sand, we must find ways to tell stories of the fantastic changes that have been wrought over time in our cultural landscapes.

2.1 Themes

A marsh is “an area of low-lying land that is flooded in wet seasons or at high tide, and typically remains waterlogged at all times” (Oxford Dictionary). Proximity and access to marshland have profoundly influenced settlement and land use patterns in the over 350 year old city of New Castle, Delaware and human development and attitudes towards nature have in turn affected the marsh. The field of vernacular architecture studies provides several methodologies or themes that guide this investigation, which examines the evolving relationship between people and a marsh. Accounts over the years provide insight into several
different methods humans have used to control and manage the Gambacorta marsh. The themes of agriculture and industry played an important role in the early development and subsequent transformations of the Gambacorta Marsh. The lens of class provides another view, as the marsh functionally segregates distinct areas of the town of New Castle from one another. As a historical repository for industrial waste, the marsh represents issues of environmental injustice. Finally, the overriding theme of landscape and townscape coalesces all of these investigations into a clear picture of how the town of New Castle shaped and was shaped by the Gambacorta Marsh.

There is a growing necessity to understand the changing nature of the tidal wetlands along the eastern seaboard, which buffer intensifying storms, provide ecological patches for wildlife, and inhibit mass development, as well as offer recreational and aesthetic value to our communities. Methods, including examination and comparison of primary resources, such historic maps, as well as review of secondary source materials such as HABS and National Register Nominations, provide insight into elements of the built environment surrounding and within the marsh that are no longer extant. Comparison of aerials documents the transformation of this landscape. Oral history in the form of interviews with town elders helps unearth previous research. Ultimately, the goal of this project is to lay historical groundwork to understand more fully the socio-cultural impacts of the marsh and the implications of these for modern efforts to establish coastal resilience.

Humans are drawn to the marsh and will continue to be. As we develop new technologies for protecting our coastlines, how do we interpret this important functional ecosystem and tell of its continuous impact on the community? My individual interests include development patterns related to industry and agriculture, environmental justice concerns, and coastal resilience. Assessing the marsh in the context of these specific lines of inquiry provides insight into historical impacts to the marsh and their future implications.

How does this landscape take on meaning? What makes it more than the individual materials that comprises it? This project uncovers an underlying connection between the meaning, lineage, and sociocultural aspects associated with the development of the marsh. It aims to understand this distinct cultural landscape and associated built environment less from the standpoint of how this collection of objects in space came together physically, or with what materials. Instead the focus is on uncovering the why of this place, space, and collection of objects, which is considered common, ordinary, widespread but not mundane.

2.2 Chronology

By way of orientation, the changing role of the marsh can be viewed in chronological order. In the historical view, from pre-European settlement of New Castle by the Lenape to roughly 1800, the marsh was a provider, giving access to resources such as salt hay, forage for animals, and pelts. While these functions can be interpreted to relate to our 21st century understanding of eco-system services of provision and regulation, it was also during this early period that the marsh was first documented to require ‘taming,’ as without intervention it proved unruly and non-compliant with the agricultural needs of humans. By the mid-19th century, the marsh was viewed as undesirable, leftover, or remnant land, and an ideal site for industrial development and the residual debris of the manufacturing process. In the 1930’s the changing economic base of the city of New Castle opened up the riverfront to recreation, but only within the last thirty to fifty years, since the development of the ecology movement in the 1970’s, has the marsh been recognized as a site to be protected and enjoyed. Even more recently, issues of resilience in the face of climate change and sea level rise have revitalized the interest in and desire for understanding of the numerous functions healthy marsh ecosystems can provide. In addition, increased flooding due to storm surge and sea level rise has required the bolstering of historic dike for storm surge protection.

3 METHODS

3.1 Vernacular Architecture, Defined

This investigation uses the field of vernacular architecture studies to delve into the various aspects that define the Gambacorta Marsh. Vernacular architecture is a hybrid area of scholarship, which resides at the junction of architectural history, cultural geography, anthropology, archaeology, historic preservation,
folklore scholarship, and material culture. Vernacular architecture can refer to both a method of study and an object of study (Wells, 1986, p. 4), in the case of this marsh, the assemblage of entities and patterns that comprise the built (or human impacted) environment. Like the field of material culture, vernacular architecture studies have shifted (or waver) from the ‘object focused,’ in which the documentation, classification, and deconstruction of these elements are the outcome, to the ‘object driven’ mode of research, which posits that the built environment can only be understood in relation to the people that make and use it. The notion that the exploration of the physical form or other source material can allow researchers to understand a culture’s intangible values and beliefs is attractive. However, without the application of objective methodologies in the form of rigorous scientific thinking (Wells, 1986, p. 3) there is the danger of applying romantic theories, ‘filling in the blanks,’ or aestheticizing the object (Upton, 2007, p. 9). This is of concern as many of these objects have ‘complicated histories’ that deserve to be examined, as they can provide researchers important clues to our past and how human settlement patterns and building styles may affect the future.

Landscape architecture scholars and practitioners describe the act of ‘reading the landscape,’ by which they mean to analyze a given site in a holistic manner, taking into account the cultural, physical, geological, hydrological, vegetative, and other systems which can act on a landscape. However, as cultural landscape scholar D.W. Meinig describes in his essay The Beholding Eye: Ten Versions of the Same Scene, “such facts (can) take on meaning only by association… We are concerned not with the elements but with the essence; with the organizing ideas we use to make sense out of what we see” (Meinig, 1979, 34). In this study I use the methods of vernacular architecture to examine the elements that comprise the built environment of this site, including dikes, the development of the neighborhood of Dobbinsville, associated circulatory paths and roads, remnant loading docks, airplane shorings, and train tracks. Vernacular architecture studies are an attempt to tease out the less obvious, but sometimes more provocative, hidden histories found in the built environment, investigated by researchers who are concerned with using varying methodologies to come closer to a tangible expression of what the ‘essence’ of a site or object might be. The variability of the method of investigation is, in itself, one of the strengths of this field of study, in that it invests individual researchers with the agency to determine what is of utmost importance in their analysis. This individual approach requires scholars to bring their own experiences and interests to the research question, which leads to richer and more varied lines of research.

3.2 Historical Context

With over 98,800 acres, marshland is an abundant resource along the Delaware River (Fisher, 1993, p. 7), and historically, residents of New Castle, just like many of the other towns on the Delaware Estuary, made ample use of this fertile land. In Figure 1, an early map of Delaware River Valley settlement (Morden, 1688), a dark smudge along the west side of river indicates the imposing presence of the marsh. This graphic not only depicts the location of the marsh, but the prominence it played in the life and success of early settlers in the region. The small town of New Castle is clearly marked on the map, but the size of lettering of the town name is almost as large as Philadelphia, implying that this was a prominent town in the colonies. This map shows the Delaware Estuary or South river, differentiated from the northern Delaware by its brackish condition and tidal influence (Fisher, 1993, p. 5). The riverbanks directly south of New Castle jut out to form a natural cove. The sedimentation that naturally occurs in the tidal deposits of the river would have made this a natural place to settle, and Dutch and Swedish colonists vied for control of this region.
The marsh played a prominent role in the town’s early development. Europeans settled this area in the 1600's. According to Barbara Benson and Carol Hoffecker, “the main attraction of the Delaware River region to both colonial nations was... the lucrative fur trade with the native people” (Benson & Hoffecker, 2011, p. 2-3). The marshland was extensive in this area and the fur trade with the original Lenape inhabitants influenced the naming of the streets in the early settlement, such as Mink (Minquas), Beaver, and Otter), which were first laid out in the late 1600s by the original City founders. The Dutch who gained control of New Castle would have been well versed in draining marshland and building dikes to hold back the tidal river. They built four dikes in and around the city of New Castle to manage wetlands, including Buttonwood Dike, Broad Dike, Gambacorta Marsh Dike, and Army Creek Dike (The Resilient Community Partnership with the City of New Castle, n.d.).

Seasonality dictated the interdependent relationship of early settlers to the marsh. From March to October, tasks would include the controlled burning of marsh, the opening of dikes to allow seasonal flooding, the banking, or shoring up, of meadows, and harvesting and curing of hay. In October and November, traps for animals would be dyed and waxed. The marketing of harvested and cured hay occurred between October and late February, almost simultaneously with the trapping season for muskrats (Hufford, 1986, p. 117). This cyclical connection with the marsh would have figured prominently in day-to-day affairs of the town and health and success of its inhabitants.

The marsh significantly impacted the early appearance of the town of New Castle, and this is the town the surveyor Benjamin Henry Latrobe found in 1804 and 1805, when he was contracted to develop a survey and grading plan to guide the development of the city of New Castle. When he came to the town, the landscape was a combination of rolling hills and marsh, and his recommendations in the plan by Latrobe, Strickland, and Mills meant that, “in subsequent years hills were leveled and the dirt deposited in marshland to provide new spaces for building and better health for residents” (Benson & Hoffecker, 2011, p. 23). Paving and grading ensured that the historic core of the town became exceedingly flat, ostensibly to promote development and trade.

As the town grew, so did the stature of the inhabitants. Early town fathers, such as George Read I, who signed the Declaration of Independence, represented Delaware as delegate at the Constitutional Convention in 1787, and served as Chief Justice of Delaware, played a significant role in the fledgling establishment of the United States, and also were gentleman farmers. (Ibid, p.84) Read practiced law and built an imposing home in the core of New Castle, as well as maintained farms to the west of city limits, to
the north of the Delaware River. George Read’s ‘Stonum,’ built around 1730 and sold by Read around 1769, "commanded a fine view of the Delaware [river]" (Post. R, 1973, p.2). The location of the Stonum house is immediately adjacent to the Gambacorta Marsh, the property would have encompassed it and the view would have been across the marsh, which, given that a view is provided, would have likely been cleared of trees and other visual barriers by its primary use for salt hay grazing for livestock. It is not clear from research whether the Stonum property was a country house or a tenant farm, but correspondence from his contemporaries indicates that it kept Read quite busy regardless. Mr. S. Wharton chides in a 1766 letter “I fear that attention to your meadows will be an injury to your health, as I am persuaded that the exhalations of such grounds are not healthy to the most athletic constitutions” (Read, 1870, p. 31-32). Read’s grandson went on to note in his 1870 collection of correspondence that ‘Stonum’:

Runs up nearly to the southwestern boundary of New Castle. This marsh fronts on the Delaware, there nearly three miles wide, and expanding into a reach [a continuous stretch of river between two bends] below it, and is much exposed to storms from the northeast, but especially those from the southeast. The embankment of this marsh was twice broken and repaired, at great expense by Mr. Read while he held it... after the second breach of the embankment (in 1789), he sold ‘Stonum’ and counseled his sons never to buy marsh. If he did not suffer in health as Mr. Wharton feared, he certainly did in purse. Twenty thousand dollars has lately been paid for ‘Stonum,’ its embankment being now much protected by accumulations of sand, and marsh is less valuable than when Mr. Read owned this farm, in consequence of upland having been made available for grazing by the introduction of clover. (p. 32)

These descriptions indicate prevalent views of the time, namely the 18th century opinion that marsh and meadowland could produce ‘injurious airs’ that could harm one’s health. Whereas, in the 21st century, we think of regulating ecosystem services as the way environment can mitigate disease and climate extremes, educated people of took the opposite position. Though perhaps called a different name, coastal resilience was a concern in the 18th century as well, and the impingement of flooding on fields could be impactful upon the livelihood of a farmer at that time. The description also supports the notion that by this point, marshes were something that must be controlled and tamed to suit the needs of farmers, even if they still offered provisioning and supporting ecosystem services to the populace. Over a hundred years after his grandfather sold the Stonum property, William Thompson Read’s description of the value of marsh land indicates the changing attitudes of farmers and townspeople to the marsh. By the second half of the 19th century, it was no longer a necessity to provide salt hay as forage for livestock as new methods of cultivating cover crops such as clover were established.

Little by little, the nature of this town transformed from being the home of gentleman farmers to a town built on industry. In the first half of the 19th century, the relationship of the town to the riverfront changed drastically. In 1832, the New Castle and Frenchtown Railroad was the first rail line to appear in New Castle, and in rapid succession, a number of additional railroad spurs appeared, built for the purpose of carrying raw materials and finished goods from the burgeoning industrial sector west of town to the banks and wharves along the Delaware River. In 1872, Thomas T. Tasker, Junior and Stephen P. Tasker relocated their father’s successful iron tubing company from Philadelphia, which barred the creation of a new rail spur, to 35 acres in New Castle, which was more amenable to this type of modification to the landscape. Their father, Thomas Tasker, Senior, already well known as an industrialist in New Castle, “founded the Gas Works … which manufactured gas and delivered the gas for cooking, heating and lighting underground through pipes manufactured by his company to dwellings and businesses” ("Thomas T. Tasker", 2014).

Tasker, Senior’s New Castle Gas Company, which supplied light and heat from 1857-1918, was sited directly to the west of town proper, in the area known as the Town Marsh on early maps. Access to the banks of the Delaware River allowed for ease of influx of the raw material, coal, which kept the gas lamps lit. Still visible in the marsh today, a remnant of this industrial use is the round ‘gasometer’, a contraption that, with a floating tank of gas and water pressure, was able to ensure equal pressure of water into the homes and businesses of the town. By-products from this industry included tar, methane, and carbon monoxide (Meek, 2015, p. 5). These toxic by-products are now cause for environmental concern and need for remediation. (Ratsep, 2013)

The large-scale ironworks of the Tasker brothers were incorporated as the Delaware Iron Company in 1876 and comprised of a series of brick buildings west of the New Castle Gas Company and directly on the banks of the Delaware, adjacent to the Gambacorta Marsh. The operation included a rolling mill, a bending mill, a welding mill, and a finishing room. Approximately eight hundred men made eight hundred
tons of iron and steel tubing per week (Scharf, 1888). Dividing the marsh and the Delaware River, along the top of the dike, the Taskers constructed a railroad spur to transport materials between industrial sites. The dike, previously used as a method of flood protection and moisture moderation to assist with seasonal farming and grazing practices, now became a key piece of infrastructure to support the introduction of a new rail line to these industrial concerns from the hub of the New Castle/Frenchtown Railroad. (See figure 2) The marsh, by this point in time thought of as leftover, remnant, or undesirable space for residential development, seemed like a good place to site industries like the ironworks. Their toxic byproducts of heavy metals, the need for water access for raw materials transport, and smoke belching towers, made the marsh on the outskirts of town the ideal location for these massive factories. At this time, the marsh was prized for its residual status, a shift we can note as New Castle advertised proximity to marsh in order to coax perspective industry there, and the town changed its economic base to manufacturing. Due to other qualities inherent to a river front site, this marsh did not always prove to be the perfect location it seemed. During the hurricane of October 21 to 24, 1878, the dikes were breached the entire length of the Delaware riverfront, and workers at the ironworks were forced to abandon their positions (Ramsey & Riley, 2002, p. 32). The danger presented by the very site amenities that made the location so ideal is ironic and highlights the volatile relationship workers of this time-period in the Industrial Revolution would have had with nature. This site would have been rebuilt over time, but for just as it had for the gentleman farmers, the adjacent marsh and Delaware River were not always the friendliest of neighbors. For this location at least, issues of coastal resilience were alive and well in the 19th century.

Figure 2. 1893 Baist Atlas Plan of New Castle, G. William Baist, Plan of New Castle. [map]. Scale 400 feet to 1 inch. Philadelphia: G. Wm. Baist. Reproduced by permission of Special Collections, University of Delaware Library, Newark, Delaware.

A factory of the stature of the Tasker Ironworks would need workers to staff it, and this fact was not lost on Richard J. Dobbins, a speculator and building contractor from Philadelphia. Dobbins purchased land directly to the north of the Tasker/Delaware Ironworks site and built “sixty-two brick dwellings… comprising a settlement known as Dobbinsville” (Scharf, 1888) in 1872. While the sixty two homes in five rows are built in a typical one-third Georgian form, one room wide and two deep, as is typical for the Delaware Valley (Glassie, 1972, p. 403), Dobbins is known for other more high-style commissions in the city of Philadelphia, most notably, Memorial Hall in the Centennial District (Tatman, n.d.). Figure 2, from the Baist Atlas of 1893, has dashed in a network of gridded streets surrounding Dobbinsville, indicating that there were likely intentions to further develop the surrounding area. While this never happened, the prediction of future development supports Dobbin’s decision to create a tiny neighborhood, where, in the manner of many urban streetscapes in Philadelphia, grander and larger buildings, with mansard roofs and corner entries, are sited on the ends of the blocks. These end units provided businesses to be frequented by the inhabitants of
Dobbinsville (Benson & Hoffecker, 2011, p. 207). During the heyday of the Delaware Ironworks, workers would have had a short walk through the marsh, in view of the river, to their posts. We can imagine that, like their counterparts enjoying the river for recreation today, this walk would have been restorative and provided a connection with nature. However, in addition to being separated by the industrial rail spurs, the occupants of the neighborhood were also separated from the core of New Castle by thirty or more acres of marsh. While at the time of original construction, the implications of the environmental decisions made by these 19th century entrepreneurs were not questioned, the siting of Dobbinsville in proximity to the ironworks is in keeping with theoretical constructs of environmental justice, wherein “low-income communities confront a higher burden of environmental exposure from air, water, and soil pollution from industrialization” than those of higher economic status or ethnic and racial majority. (Mohai, et al. 2009) The immediate impact of emissions and toxic dumping of byproducts on the residents of Dobbinsville and those who worked at the Tasker ironworks is insurmountable through writings of the day, but assumed to be likely given manufacturing practices of the industrial revolution.

In 1899, the National Tube Company bought out Delaware Ironworks. This company was a ‘trust’ designed to buy out and eliminate competition, and the industrial site was soon abandoned (Meek, 2015, p. 13). Still, industry of all sorts continued to be encouraged by the city of New Castle, as an advertisement called ‘inducements to manufacturer,’ from George A. Wolf’s book “Ideal New Castle in the State of Delaware as it Appears in 1899” lists: “Beautiful sites. Exemption from taxes for ten years. Free land. Ample wharfage with deep water. Cheap labor. Excellent transportation facilities, both by rail and water. Low tax rate… Pure water… Raw material near at hand.” However, this incentive was not enough, and the dashed in streets on the Baist Atlas never came to fruition. The families who comprised the population of the little three-street, five-row village of Dobbinsville were not able to support themselves without the presence of industry.

By 1907, the Sanborn Fire Insurance Map, Figure 3, indicates three of the five rows of houses in Dobbinsville were ‘dilapidated and vacant.’ In 1910, a newspaper article (“New Lease on Life in Dobbinsville”, 1910) detailed the life, death, and hoped for rebirth of the neighborhood. This article gives insight into what living conditions may have been like for the inhabitants of Dobbinsville:

As soon as the homes were completed they were occupied by the iron workers, the greater number were taken by American workman and their families, but the Poles and other foreigners centered in Dobbins Street. Here it is said from five to ten families were sometimes crowded into a single little four roomed house. (p. 1)

While only 1.5 miles from the post office in the center of town, as shown in the 1907 fire insurance map from the Sanborn Map Company, the marsh and industrial sites would have created a distinct and palpable barrier. Decay set in, and images depict cows grazing in the backyards of the row homes. While
the article states that Richard Dobbins was willing to sell the homes in Dobbinsville at a reduced rate, “no buyers appeared”, it proffered hope for the village, “due in large part to… New Castle’s four new steel plants.” Curiously, the new development promised in this article did not come to pass, and on the 1923 Sanborn Map, Dobbinsville is still listed as vacant. It was not until the mid 1920’s that “a New Jersey real-estate development company purchased the row housing, renovated the units, and sold them on a rent-to-buy arrangement” (Benson&Hoffecker, 2011, p. 207).

In 1931, the relationship between New Castilians and the Delaware River changed yet again, with the decision by the Trustees of the Common to transform the industrial area along the riverfront into Battery Park (Benson & Hoffecker, 2011, p. 59). In the Colonial Revival movement popular in the era after the First and Second World Wars, the quaint town of New Castle represented an idealized American past, which did not align with an industrial riverfront. In addition, the ferry to New Jersey prompted intensified traffic through the town and Battery Park, the riverfront, and the town’s historic core became a place to pass the time for travelers waiting for New Jersey- Delaware ferry (Benson & Hoffecker, 2011, p. 183). After the construction of the Delaware Memorial Bridge in 1951, the ferry service to New Jersey stopped, but Battery Park and historic Old New Castle remain a destination to this day.

The New Castle Gas Company had closed, and the railroad spurs that connected the industrial sites along the dike disappeared. What remained linking the historic core of New Castle to its industrial past was the dike that passed through the old Town Marsh, which as time went by, became known as the Gambacorta Marsh. John (Giovanni) Gambacorta was an first generation Italian-American and a successful business man who owned several car dealerships on route 9 along the north side of the town marsh, between the historic core of New Castle and Dobbinsville (Delaware Community History and Archeology Program, n.d.).

As recently as 1981, proximity to industry still impacted this and other nearby neighborhoods, as a gas leak at the Amoco plant caused an explosion which “injured almost 30 people, blew pollutants into the surrounding marsh, broke windows for miles and ended the 20-year run for the Amoco plant.” (Sharp, 2018)

In the 1980's, a dirt footpath traced the old railroad spur path across the top of the dike, providing a faint connection between Dobbinsville and New Castle. As walking, jogging, and other foot traffic became more and more popular, paving renovations and widening of the dike allowed for additional public use. Even into the present, industrial remnants such as pilings and rangelights dot the landscape, though considerable changes have been made to the path over the past 35 years. The paved path now extends south, beyond Dobbinsville, and large trees and vegetation have been removed and new rip rap installed. One sees many people enjoying the river on a daily basis.

While the environmental concerns and regular breaching of the dike over time impacted the Gambacorta Marsh over time, it is ironically the history of the industry of this town that preserved it. Without the industry making use of the dike for transport and protection, and the marsh for a dumping ground, other types of development may have overtaken the marsh prior to New Castles recognition as an historically important town. In addition, Battery Park’s role as recreation destination ultimately spilled over onto the footpath. Where many acres of marshland have been lost across the eastern seaboard sue to development and flooding, the historical past of the Gambacorta Marsh is key to its continued success. The ecosystem services provided by this marsh allow for great recreational opportunities and other supporting and provisioning examples.

### 3.3 Current Affairs

As awareness grows regarding the environmental repercussions of the industrial past, and the marsh ecosystem is once again perceived as a valuable resource, programs are being instated to rehabilitate the Gambacorta Marsh and Dike. In 2013, a brownfields assessment of the New Castle Gas Company Facility was completed. The analysis of this parcel, the site of the Brosius-Eliason lumber yard for many years, indicates a more conscientious attitude about the impacts of the industry of the past on the marsh ecosystem. For example, the report points out that “structures related to the coal gas plant were located in the boundaries of the Site in areas that are now inundated wetlands” (Ratsep, 2013, p. 3). Furthermore, the report states that “the wetland portion of the site was dry land in the 19th century and was the location of the New Castle Gas Company Facility. Coal gasification, as historically practiced in Delaware, usually resulted in the release of coal tar in the environment.” While the report acknowledged the presence of semi-volatile organic compounds at the site, it does not recommend further action at this time, though “DNREC may
address ecological issues present, if any, in the Gambacorta Marsh as a whole as a separate Operable Unit, to be addressed in a separate proposed plan.” One industrial dumping area of the marsh, historically drained and used as a landfill, was capped to prevent leaching of toxic chemicals. On this superfund site, no trees may be planted in order to prevent puncturing of the membrane holding in the contaminated soil (Meek, interview, 2018).

In addition to the toxic chemicals that may be present due to the industrial past, another concern has come to the forefront in the last decade, in the threat of storm surges and extreme weather events, as well as predicted sea level rise (The Resilient Community Partnership with the City of New Castle, n.d.). As the ecosystem functionality of wetlands and tidal marshes is better understood, significant maintenance of, and alterations to, the existent dike system have occurred. In 2013, “settlement, erosion, revetment protection loss, overtopping, (and) seepage” were identified as points of concern for the four dikes in the city of New Castle (O’Brien & Gere, 2012, p.21). In order to proactively boost coastal resilience, O’Brien and Gere provide the following recommendations for all of the dikes: “Raise dikes to elevation 8.5 feet. Enlarge dike in portions (raising and broadening). Supplement/replace flood side rip rap. Remove trees and woody vegetation. Construct filters on seepage areas.”

The resultant infrastructure, installed in 2013 and hugging the banks of the river, seen in Figure 4, likely bears little resemblance to the dikes of early Dutch settlement, or the embankments of the gentleman farmers of the 19th century. However, it does provide a sense of safety and the perception of control of nature that would not have been lost on those whose goal was to tame the marsh in earlier periods.

![Figure 4. 2016 Annotated Aerial. Diagram by author.](image-url)
marginalized living conditions allow environmental justice and lack of equity of the past to persist. Continued efforts for stakeholder input through community engagement should be developed and, through cultivation of mutual respect between the historic New Castle town core and the village of Dobbinsville, innovative, mutually beneficial, and cost effective resiliency strategies may yet develop. Shaped by its industrial past, Dobbinsville may remain marginalized by its anomalous siting in the landscape, but town planners and the Trustees of the Common can encourage community engagement to develop equitable design strategies and provide desirable amenities. As far as coastal resiliency is concerned, NOAA sea level intermediate predictive models estimate that by 2080, Delaware will see a 4.89 foot rise of mean higher high water, which will place Dobbinsville directly on the banks of the Delaware River. (FirstMap)

3.4 Conclusion

Current development of a large multi-use residential building along the north side of the marsh on route 9 will further impact the ecosystem, as the developer is keen to provide access to the existing Gambacorta Marsh dike walking path via a wooden boardwalk through the marsh (J. Meek, interview, May 3, 2018). As predictions of sea level rise place much of the historic core of the city of New Castle underwater if there were to be even 0.5 meter of inundation at Mean Higher High Water (Meek, 2013), engineers, planners, and landscape architects look to the marsh as a potential resource for water management. Indeed, the Gambacorta Marsh and other marshes surrounding the city of New Castle have the potential to expand and absorb more water, provide additional protection from storm surges, and capture more carbon (St. Laurent, 2017).

As new technologies develop for protecting vulnerable coastlines, it is imperative that designers and stakeholders fully interpret this important functional ecosystem and illuminate its continuous relationship with the community, from the original Lenape inhabitants, to the gentleman farmers of the Colonial era, to the working class, immigrant residents of early 20th century Dobbinsville, to the walkers and joggers of 2019. No matter how humans try to shape, contain, transform, and harness the marsh, it has been a key player in the spatial organization of the town of New Castle. Through exploring this underinvestigated landscape type, and how it affected and was impacted by development patterns related to industry and agriculture, environmental justice concerns, and coastal resilience, the evolving historical, cultural and social contexts of the marsh are exposed. In this case, I examined these thematic relationships with the marsh as a driver of the line of study, which helped qualitatively form an idea of shifting notions of stewardship to this resource. In addition, it provided insight into the intangible values and beliefs associated with the surrounding community over time.

As a child, I sought and found in the marsh a reprieve from organized society and a connection with the forces of nature. Today I witness these forces in the systematic workings of ecosystem services and in the stories told by the land over time. The unintended consequence of much of modern resilience planning is the blotting out of the visibility of these forces, these stories. To be sure, nature has a way of reconnecting the systems, whether we intend it or not, but I argue that in resilience planning, more thought should be given to retaining the phenomenality of the user experience, and in our ability to connect to a site’s history in an intrinsic manner.

4 REFERENCES


Sanborn Map Company, (1907). *New Castle, New Castle County, Delaware*. [map]. Scale 50 feet to 1 inch. Sheet 7. October, 1907. Special Collections, University of Delaware Library, Newark, Delaware.


Sharp, Andrew, (1918). This week in Delaware history: Amoco plant explosion kills 6 near New Castle. retrieved from *Delaware News Journal*.


LANDSCAPE PERFORMANCE

Edited by Christopher D. Ellis & Taner R. Ozdił
BEYOND QUANTITY: ASSESSING TREE HEALTH FOR HIGHER PERFORMANCE IN DESERT PARKING lots

ZAWARUS, PHILLIP
University of Nevada Las Vegas, phillip.zawarus@unlv.edu

1 ABSTRACT
The compounding ecosystem services trees provide such as clean air, runoff reduction, outdoor comfort, and cost-savings can only be maximized if the tree has a life expectancy longer than the average standard urban tree life of fifteen years. The lifespan of urban trees is often predicated on planter size, soil health, and routine maintenance but these factors are marginalized by current county planter codes for parking lots in Southern Nevada leading to poor tree health and frequent tree removal and replacement practices. Through an inventory and analysis of parking lots on the University of Nevada Las Vegas campus, advocacy workshops and partnerships, and volunteer training and community engagement this research will collaboratively identify best practices for parking lots and tree planting that will benefit local communities and establish healthy working forests. By looking at strategies to implement proper tree planting, optimizing parking lot layouts for tree planting, and diversifying tree species based on their range of environmental, social, and economic benefits, parking lots in the desert can be transformed into multifunctional and comfortable outdoor spaces. The challenge of these strategies is the balance of maintaining parking stall count with an adequate tree count and plant communities that provide an extensive variety of benefits due to their prolonged lifespan from proper planting techniques. Transforming parking lots with green improvements will come at a higher initial cost but the long-term savings and benefits from healthy trees will make the innovative solutions cost-effective.

1.1 Keywords
Tree Benefits, Parking Lots, Arid Performance, Stormwater Management, Green Infrastructure
2 INTRODUCTION

Planting more trees in the urban environment of Las Vegas does not guarantee cooler outdoor spaces, stormwater runoff reduction, or wildlife habitat because the current Clark County codes for parking lots and planters does not provide adequate space or conditions for trees to thrive and reach maturity. The challenge is not planting more trees but to design for healthy tree growth in the city. Urban trees have an estimated average lifespan between seven (Moll, 1989) and thirteen years (Moll & Skiera, 1992) due to improper tree selection, planter design, planting techniques, and maintenance practices (Appleton, Horsley, & Harris, 2002). Tree species for parking lots should be low-water use, emit low biogenic volatile organic compounds, fast growing, and tolerant of reflect heat (Southern, 2012). The design of the planters should be adequately sized to promote root growth using a variety of planter strips and fingers, pervious surfaces such as permeable pavers, and structured soil. The planting of trees in the planters can also have a negative impact on the tree health if it planted too deep or on loose soil so that over time the tree will settle and sink deeper than its initial depth. If the tree flare is below the surface or covered with loose soil, then the tree will suffocate from a lack of access to oxygen. Not only should the soil be amended regularly but also irrigation maintenance should be scheduled to adjust emitter placement to be within close proximity to the root lines. Improper maintenance of tree irrigation in these planters is another cause of poor tree health and high tree mortality if the emitters stay within their initial location when the tree is first planted.

The existing Clark County planter codes for parking lots do little to mitigate these issues as the planter sizes do not provide adequate soil volume for their suggested tree sizes. Within the six-hundred-page document of county codes, there is one section that states the use of permeable pavers can be used within the parking stalls to expand the soil volume for root growth, however, those guidelines or specifications are not included with the planter design guidelines. The lack of promotion or advocacy of these practices within the municipal codes undermines the significance of suggesting sustainable practices within the document. Another limitation within the codes is the placement of trees in relation to the parking stalls. It is stated within the codes that one large tree must be planted for every six parking stalls but because there are no specifications of where the tree must be planted for those six spaces the trees are often set to the perimeter of the parking lot leaving the asphalt surface parking lot exposed for thermal heat gain and an uncomfortable outdoor space.

These current planting discrepancies not only impact trees in parking lots within Las Vegas, but also have had a negative impact nationally as evident in the documentation and evaluation of tree health through city tree planting campaigns such as the Million tree initiatives (Roman, 2014). The purpose of these initiatives was to demonstrate and provide a range of environmental and socioeconomic services to their respective city, supported by the monetary benefits that were estimated in the billions of dollars. The modeled projections of the tree benefits had both a low and high tree mortality rate, but the estimations only considered the peak benefits of trees for their entire lifespan instead whereas some trees don’t provide a substantial value until later in their lifespan. According to Lara Roman in her research How Many Trees Are Enough? Tree Death And The Urban Canopy (Roman, 2014) she states:

“In the study about Los Angeles’ million tree program, a low mortality scenario projected that 17% of planted trees would be dead after 35 years, and a high mortality scenario projected 56% mortality” (p. 2).

Although field data has not been recorded from Los Angeles yet, these modeled scenarios can be compared to New York City and Sacramento demonstrating the discrepancy of tree benefits in relation to survival rate:

“For street trees in New York City, eight to nine years after planting, 26.2% were dead. For a yard tree give-away program in Sacramento, five years after planting, 29.1% had died, on top of 15.1% that were never planted by residents” (p. 2).

For these tree planting initiatives and urban forest assessments to have positive impact with ecosystem services, Roman argues that the addition of long-term monitoring and tree mortality data should be incorporated into future planting strategies for more accurate evaluations of tree health and mortality rates in urban environments.

2.1 Research Background

Through sponsored funding from the Nevada Division of Forestry, design strategies have been developed for transforming the performance and perspective of parking lots in an arid urban environment. Las Vegas, located in the driest U.S. desert (Pariona, 2017), is experiencing high tree mortality rates due to poor planting strategies, harsh climatic conditions, abundance of impervious surfaces, and poor storm
Most evident in parking lots, tree health is hindered due to improper designs enforced by regulatory codes. Through an inventory and analysis of parking lots on the University of Nevada Las Vegas campus, advocacy workshops and partnerships, and volunteer training and community engagement this research will collaboratively identify best practices for parking lots and tree planting that will benefit local communities and establish healthy working forests. The study has identified numerous techniques to address the issues of water quality and management, heat island effect, habitat and ecology disruption, reduction in green space, urban sprawl, and infrastructure costs in surface parking lots from best management practices for parking lots from the Environmental Protection Agency (EPA, 2008). Additionally, proper planting and tree selection for parking lots have utilized to improve the overall experience of parking lots with ecosystem services (Southern, 2012).

As automobiles began to replace horses and wagons, there needed to be alternative solution to the on-street parking strategy. The off-street parking, or lots, initially reduced the congestion of traffic on roadways, however, it has yet to fulfill the necessary qualities of life in cities and public spaces. Although the design of lots may have little consideration towards the environment and influence our dependency on the automobile, they can also serve a social function for festivals, markets, and sporting events. If done properly, according to Paul Groth, underappreciated parking spaces can benefit the present-day urban environment:

“The ancient Egyptians organized their life and their gods in reference to the life-giving Nile. Colonial New Englanders organized their village life around the axis mundi of the meetinghouse, the place that manifested their connection to the cosmos. Although it happens just below the level of awareness, the parking space probably generates the most significant sense of personal and social place in the cosmos for today’s urban Americans; it is their major axis mundi” (Groth, 1990).

We often desire the aesthetic and comfort of outdoor public space, and although parking lots may not have immediate qualities, they do serve the purpose of serving our automobile-oriented culture. In fact, they are like the most common daily used public outdoor open spaces. They are a place where pedestrians and vehicles coexist in. Parking lots may be perceived as purely utilitarian spaces but because they significantly influence our daily routines it necessary to bring attention to the potential values and impact that they can positively have on the urban fabric (1990).

Beginning in the early 1980s, the ratio of required parking spaces for different developments has been enforced by municipalities guided by the Institute of Transportation Engineers (ITE). This translates to peak parked vehicles per square footage of a particular zoned use. This formula from ITE is commonly used for transportation models, planning decisions, and municipal ordinances. City officials have relied on the ITE formulas heavily even though it may be detrimental to the community and urban form since the determined parking spots per square footage of building space is taken at face value. Zoning regulations for parking spots in commercial properties vary between three to five spaces per 1,000 gross square feet of building area, but its generally settled at four spaces (Bergman, 1991).

Different studies on parking lot demand have concluded that spaces are often over-supplied with findings that during peak times two to three spots are occupied per 1,000 square feet. A study in Southern California found that 2.1 spots were being used during peak hours, but 3.8 spaces was the average per 1,000 square feet. Another study done for residential commercial lots in Iowa found that ten days prior to Christmas that only 74% of the parking stalls were being utilized (U.S. Environmental Protection Agency, 2001). These formulas by ITE in calculating the ratio of parking spaces to building square footage have been highly criticized for not showing a clear relationship between the two factors but has unfortunately had little traction in changing the policies used by city officials in making decisions regarding the function and aesthetics of a community and the urban fabric (Shoup, 2001).

Researchers have estimated that surface parking lots account for 80 to 90% of all parking demand in the United States (Stocks, 1983). When it comes to commercial and retail use, surface parking lots may account for two to three times as much square footage as the buildings they serve. Shopping malls can take up as much as 50 to 60 acres of land to accommodate the perceived parking demand for users during the peak shopping times of the year. These parking demands from developers is a constant battle with city planners to balance the use of space to also include a dense urban fabric, pedestrian-friendly and walkable neighborhoods, and environmental preservation (Wolf, n.d.). Unfortunately, the physical attributes of large surface parking lots contribute to drainage and flooding issues, urban heat islands, reduced aesthetics, and dependency on private vehicle use (McPherson, 2001).
Street and parking lot trees are often planted as saplings from nurseries into small and narrow sidewalk cut-outs or planting strips. This environmental setting not only places the initially healthy trees in a confined space but also introduces challenges from soil compaction, contamination (Craul, 1999), poor construction (Hauer, 1994) and maintenance practices, and vandalism (Nowak, McBride, Beatty 1990). Many of the tree health issues stem from the immediate start of the construction process and planting practice within parking lots. It begins with the negative impact on soil with existing topsoil being removed, compaction of the subgrade from construction machines and then the compounding effect from layers of aggregate and asphalt. The compacted soil makes it nearly impossible for tree roots to penetrate beyond the planter envelope, while also creating an impervious membrane depriving the roots of oxygen for growth. When trees are placed in these constricted planters within parking lots and along pavement, the shallow oxygen-deprived roots will become desperate and move aggressively towards the surface leading to cracks in sidewalks and the asphalt surface. This not only becomes a concern for the tree health but also makes it a hazardous and liable situation for pedestrians and vehicles using the adjacent space to the planters.

Responding to these parking lot conditions requires planning, on-site stormwater management, surface material selection, and plant communities that enhance the environmental, social, and economic performance of a surface lot. According to studies from the service consultant JACOBS for the Regional Transportation Commission of Southern Nevada and Clark County Department of Comprehensive Planning the occupancy of parking lot spaces in relation to the mandated county code requirement were between 57% and 35% for large and medium shopping centers (JACOBS, 2015). The study also found that developers often over supplied the parking lots with additional spaces above the code requirements, reducing the occupancy of parking spaces even further. Another strategy suggested by the EPA is to reduce the size of the stalls. That idea combined with angled parking and one-way aisles can drastically reduce the asphalt surface in parking lots and repurpose that space for enlarged planters as demonstrated by student work samples.

As stated previously, existing Clark County codes inhibit trees from growing to a mature state, reducing potential ecosystem service output, through inadequate soil volume limited by the planter size and unarticulated use of permeable pavers with structured soils in the document. When comparing the soil volume suggested by the Southern Nevada Regional Planning Coalition (2012) for different tree sizes shown in Table 1 with the mandated planter sizes by Clark County it is evident that trees will struggle to reach maturity or be of good health due to the equated soil space and volume for root growth. The county codes provide an extensive list of tree planting strategies with planters; however, they do not suggest necessary soil volume for different tree sizes. Because this information is not available within the document and there is little to no emphasis on the use of permeable pavers and structured soils, developers are reliant on only the planter size as a provision to specifying tree plantings.

### Table 1. Recommended minimum soil volumes for different tree size categories.

<table>
<thead>
<tr>
<th>Recommended Tree Species Size Categories</th>
<th>Average Canopy Size</th>
<th>Minimum Open Soil Surface Area (Per Tree)</th>
<th>Minimum Open Soil Surface Area for Planting Strips (Per Tree)</th>
<th>Minimum Soil Volume (Per Tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>16ft x 16ft</td>
<td>81ft²</td>
<td>84ft² (6ft x 14ft)</td>
<td>201ft³</td>
</tr>
<tr>
<td>Medium</td>
<td>22ft x 22ft</td>
<td>121ft²</td>
<td>120ft² (6ft x 14ft)</td>
<td>380ft³</td>
</tr>
<tr>
<td>Large</td>
<td>28ft x 28ft</td>
<td>196ft²</td>
<td>198ft² (6ft x 14ft)</td>
<td>615ft³</td>
</tr>
</tbody>
</table>

The Clark County Island Finger design essentially only provides enough soil volume for one large tree, so it becomes extremely problematic when it is required by the county to plant two trees in this confined space. The minimum width of planters needs to increase by an additional 5 feet or double in width in order to accommodate the recommended soil volume as shown in Figure 1. It is suggested that if this is not a viable option that it is required that a stacking combination of permeable paves and structured soil be used to offset the tree’s soil demand. Based on the tree’s dripline, it is recommended that at a minimum the four immediate parking stalls be outfitted with this system, however, implementing this for all the parking stalls is preferred for best root growth and longer tree lifespans.
When comparing the different municipal planter design in relation to the recommended soil volume to sustain healthy trees, the City of Henderson has structured the codes to prioritize the tree health over other parameters when it comes to the planter design by suggesting planter dimensions and alternative paving materials throughout the required codes. The details provided by the City of Henderson in the landscaping and tree planting regulations demonstrate that city officials understand the role trees have for the built environment and how they can positively impact the environment and experience of using the space as part of the community’s daily routine. These are only minor lines of code but can drastically affect the outcome of parking lots for the arid environment where issues of stormwater runoff and urban heat islands continuously plague the Las Vegas valley with undesirable conditions. Urban working forests in parking lots are a key element to invoking change to public policy for the health and well fare of the valley’s population.

Davey Resource Group (DRG) was contracted with the Nevada Division of Forestry in 2012 to provide a tree inventory in public areas throughout the valley that included unincorporated Clark County, North Las Vegas, Las Vegas, Boulder City, and Henderson. DRG was able to inventory nearly 100,000 individual trees on public property that identified unique species, age and size from their diameter at breast height (DBH), health, and calculate their value and cost-benefit using i-Tree. Based on the tree DBH, it was concluded that the overall age of working urban forests in the Las Vegas valley is very young. But when the tree health is compared amongst the different municipalities, the City of Henderson’s tree health is substantially better than the others, with 73% being in good health, in part to their tree planting policies.

Table 2. Municipal tree inventory, size, and health status.

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Tree Count</th>
<th>Tree Size and Age (DBH)</th>
<th>Tree Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unincorporated Clark County</td>
<td>24,552</td>
<td>60% (0 to 6 inches)</td>
<td>Fair (51%)</td>
</tr>
<tr>
<td>Las Vegas</td>
<td>22,731</td>
<td>69% (0 to 6 inches)</td>
<td>Fair (50%)</td>
</tr>
<tr>
<td>Henderson</td>
<td>25,753</td>
<td>71.9% (0 to 6 inches)</td>
<td>Good (73.2%)</td>
</tr>
</tbody>
</table>
These county constraints provided a framework to use the University of Nevada Las Vegas campus, situated in Clark County, as a test site for best management practices from EPA’s documentation, SNRPC’s Best Practices for Urban Trees, student innovation, and collaboration with allied professions to create healthy urban forests in parking lots for the arid environment. With a healthy working forest in parking lots, trees and landscaping can provide substantial value to the environment through aesthetics, erosion control, and carbon dioxide sequestration, and outdoor comfort and heat reduction from shade. For these benefits to be optimized from trees, root care must be considered for healthy growth. It is recommended that planters be designed to allow roots to reach the tree drip line at maturity with the suggested soil volume from SNRPC. Approaching the design of parking lots should consider the preliminary planning aspects, on-site stormwater management, parking surface material selection, and landscaping and irrigation. Designers and planners can improve the quality of the built environment and transform parking lots by decreasing impervious surface area, protecting water quality, reducing stormwater management and maintenance costs, and increase the aesthetic value.

UNLV is a commuter campus of over thirty thousand students (UNLV, n.d.) and another four thousand employees (UNLV, n.d.) with almost twenty asphalt surface parking lots that range from half an acre to nearly thirty acres lined with trees in poor health. The 97 acres of space, or 29% of the entire campus (Figure 2), dedicated to this under-utilized infrastructure leads to undesirable conditions of flooding during rain events and strain on health when traversing the exposed asphalt during warmer temperatures at distances of a quarter of a mile.

**Figure 2. UNLV Site Plan of Parking Lots and Tree Health. Drawing by the author. (R1-2.2)**
There is little to no ecosystem services that can be provided from these areas since trees are on average between fair and poor health and cannot substantially sequester carbon dioxide from the air, intercept stormwater runoff, or shelter wildlife. This range of ecosystem services were the focus for delivering environmental benefits along with the social benefits of cooling the air or surface temperatures for outdoor comfort and wellbeing, and economic benefits of infrastructure cost savings and tree lifecycle cost savings. With most of these parking lots being at the perimeter of the campus, it was also an opportunity to treat the parking lot transformation as a way to serve as the gateway into campus and add curb appeal to the surrounding community since it is the mission of the university to be accessible and inclusive of its residential and business neighbors. The many facets included in the design scope of work required collaboration with university services and colleagues, local practitioners, and non-profit organizations to consult best practices and critical feedback during the design process. The collaboration with The Nature Conservancy’s (TNC) national and state chapter representatives was invaluable to the assessment of existing tree health and inclusion of wildlife habitat for permanent and migratory bird species. Workshops and field work demonstrated necessary considerations for ensuring healthy mature tree growth that could be situated in dense plantings to promote bird habitat as a place of shelter, food source, nesting, and perching. Colleagues from the university assisted through workshops to determine how improved conditions in parking lots can promote safety and well-being for students and pedestrians. The study also worked in tandem with the University of Southern California to assess the feasibility and cost-effectiveness of implemented varying tree planting densities and placement within different campus parking lots.

2.2 Research Purposes

The inventory of urban tree canopies within the University of Nevada Las Vegas parking lots served as the assessment of tree health, benefits, and performance of space beyond the standard utility of parking lots. Best management practices for tree planting in parking lots and long-term benefits were developed from this study to promote healthy urban forests in the many similar conditions throughout the Las Vegas valley. Proposing adequate planting space, alternative program use, and performance function within parking lots, supported by the foundation of healthy mature tree canopies, will alleviate the prominent issues of flooding and the heat island effect, in addition to fragmented wildlife habitats, tree removal costs, and strain on pedestrian health, safety and wellbeing in the campus community.

The positive effects of working urban forests in desert environments have been well documented by Greg McPherson’s *Desert Southwest Community Tree Guide* (McPherson, Simpson, Peper, Maco, Xiao, & Mulrean, 2004) and the Davey Resource Group’s *Urban Forest Resource Analysis of Inventoried Public Trees* (Davey, 2013). Urban tree canopies are particularly influential in harsh desert landscapes that lack surrounding forests to mitigate the effects of air pollution, urban heat islands, and monsoonal storm water events. The existing municipal codes mandate a tree density in parking lots, however, the overall tree vitality and public health benefit has become an evident issue due to lack of soil volumes necessary to sustain the trees, the impervious surfaces hindering rainfall capture, the lack of canopy area to absorb carbon emissions, and the negative human comfort experience. To establish and conserve working forests and promote the public benefit of trees throughout the Las Vegas metropolitan area, design codes must consider the environmental benefits of healthy urban trees. By starting with parking lots on the UNLV campus as a case, this research intends to influence and impact future development with the implementation of proper tree establishment in the urbanized Mojave Desert.

3 METHODS

Qualitative and quantitative methods were used in the assessment of existing tree health in the parking lots during the analysis phase along with determining appropriate tree species and plant communities during the design phase for the proposed parking lot planters using specific criteria for environmental, social, and economic benefits. Through the workshops with TNC, a rating criterion using the United States Forest Service Forest Ecologist Rich Hallett’s Tree Health Metrics (Hallet, 2018), tree health was assessed by documenting the tree’s crown health and measuring the trunk diameter at breast height (DBH) of forty-eight different tree species. TNC’s Nevada Chapter also provided bird habitat workshops led by Leonard Warren to assist with the necessary tree selection, plant communities, and planting densities appropriate for twenty-four bird species using criteria of nesting, diet, migration, and shelter from The Cornell Lab of Ornithology’s *All About Birds* online resource and field work examining different habitats. Municipal
codes require that tree planters also provide a certain number of shrubs and groundcover, however, the recommend amount does not provide an adequate density to promote any form of wildlife habitat. Dense plant communities in parking lots is also important to the overall health and establishment of trees by providing a diverse ecology to combat issues of monocultures and susceptibility to disease.

Methods used for determining environmental and economic benefits from individual trees came from the online calculators i-Tree Design (2017) and the National Tree Benefit Calculator (Casey, n.d.). The i-Tree Design calculator was used to record both tree DBH growth rate, gallons of stormwater interception, and pounds of carbon dioxide sequestration. The National Tree Benefit Calculator was used to determine the monetary benefits of trees at the same DBH sizes used from i-Tree Design. Using these two calculators was necessary since i-Tree Design does not break down the monetary savings into different categories like the National Tree Benefit Calculator. These tools are continuously changing, being updated, and consolidated frequently so it is important to become familiar with the latest tools at the time of inquiry and implementation. The Green Values National Stormwater Management Calculator was used to determine cost savings associated green improvements, material selection, and tree quantity for annual and lifespan performance for the overall parking lot redesign proposals. Qualitative methods for appropriate plant selection utilized the work of Stephen Kaplan’s theory of Attention Restoration (Ackerman) in workshops for understanding the aesthetic and ephemeral qualities of different plant characteristics to alleviate stress and promote a sense of well-being in parking lots.

3.1 Existing Tree Health Assessment

The Nature Conservancy’s coordinator of the Healthy Trees, Healthy Cities (HTHC) urban tree health monitoring national initiative, Rachel Holmes, lead the tree health assessment and early pest detection for all the trees within the nineteen inventoried campus lots. This workshop trained student volunteers in the process of documenting and measuring of tree health using the Healthy Trees, Healthy Cities mobile application; which incorporates Hallett’s Tree Health Metrics into a digital interface. The training included measuring the tree DBH using either a dedicated DBH tape measurer or standard sewing tape for different tree types while noting the tree’s planting conditions, trunk irregularities, and planting slope. Another component to the tree health assessment was observing and documenting the tree crown health using the HTHC mobile application criteria and photographs of the tree crown characteristics. When documenting the tree crown, volunteers were instructed to rate the fine twig dieback, leaf discoloration, leaf defoliation, crown light exposure, vigor or combination of the previous criteria and large broken or dead branches, and finally crown transparency (Hallet, 2018). Through this training, students were able to access the health of nearly five hundred individual trees throughout the UNLV parking lots. The data recorded for each individual tree was also georeferenced using a coordinate system to place the tree with its health rating within a three-meter range of its approximate location on campus. After all the trees had been assessed and georeferenced onto a site plan, priority parking lots were determined for further analysis and design proposals, reducing the previous parking lot count from nineteen to nine.

3.2 Environmental Benefits

Assessing the stormwater runoff of the nine different sites was one of the primary drivers in improving the environmental performance of a parking lot. Analysis of the parking lot layout and configuration, surface materials, and tree species count and health were some of the main drivers used to inform responsive design solutions. Providing more healthy and appropriate trees can have an immediate impact on the performance and perception of a parking lot through shaded outdoor comfort, stormwater interception, and also well-being from aesthetics. But in order to achieve these benefits in parking lots, there needs to be adequate open space and soil volume to sustain and promote mature tree growth. Reconfiguring a parking lot layout with angled parking and one-way aisles can reduce the space allocated for cars and be used for more planter space. Parking stalls receive less traffic volume so they can be retrofitted with permeable pavers and structured soil underneath to expand soil volume for root growth. The compounding of these modifications can have a higher potential for environmental benefits in a parking lot.

Incorporating these green improvements can be measured and calculated against the existing conditions to provide a baseline comparison to assess and evaluate the overall performance and feasibility of these transformations. The Green Values National Stormwater Calculator was used to measure and compare potential runoff reduction and feasibility between an existing conditions and design proposals. Rain events with 0.25” and 0.50” of precipitation are common in the arid region of Las Vegas during the wet
season (Data, n.d.). The benefit of using this calculator is the ability to include for comparison a pre-development or a natural state, the existing conditions and the incorporated green improvements using the same variables. By having runoff values calculated from a pre-development, existing, and green proposal, a relative comparison can be made to evaluate the stormwater performance of the design. The i-Tree Design software was also used to measure the potential runoff interception and carbon dioxide sequestration of specific individual tree species over a 100-year time span to evaluate the impact tree health and growth rate have on these potential environmental values as shown in Figure 3.

Figure 3. Environmental tree benefits from a Honey Mesquite tree. Drawing by the author.
The data chart shown in Figure 2 was created by inputting the annual tree growth change (DBH) into the i-Tree Design calculator in one-year interval changes for the first ten years, then increases to intervals of 5 from years 10 to 40, and then intervals of 15 from years 45 to 90 in Table 2. The reason for this is that the DBH or tree growth begins to slow down at those increment changes, so to reduce redundancy by recording every annual value the beneficial values were interpolated for those interval changes.

**Table 2. Charted annual environmental values from a healthy and poor health Honey Mesquite.**

<table>
<thead>
<tr>
<th>Excellent</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Comp</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBH</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5.1</td>
<td>5.3</td>
<td>6.2</td>
<td>6.3</td>
<td>6.8</td>
<td>7.3</td>
<td>7.7</td>
<td>8</td>
<td>8.4</td>
</tr>
<tr>
<td>Age Growth Interval</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Stormwater (gallons)</td>
<td>133</td>
<td>254</td>
<td>272</td>
<td>355</td>
<td>389</td>
<td>430</td>
<td>480</td>
<td>516</td>
<td>543</td>
<td>579</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO2 (lbs)</td>
<td>51</td>
<td>78</td>
<td>85</td>
<td>86</td>
<td>86</td>
<td>86</td>
<td>86</td>
<td>86</td>
<td>86</td>
<td>86</td>
<td>1150</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Poor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBH</td>
<td>66</td>
<td>119</td>
<td>135</td>
<td>159</td>
<td>182</td>
<td>206</td>
<td>230</td>
<td>247</td>
<td>272</td>
<td>288</td>
<td></td>
</tr>
<tr>
<td>Age Growth Interval</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Stormwater (gallons)</td>
<td>86</td>
<td>119</td>
<td>135</td>
<td>159</td>
<td>182</td>
<td>206</td>
<td>230</td>
<td>247</td>
<td>272</td>
<td>288</td>
<td></td>
</tr>
<tr>
<td>CO2 (lbs)</td>
<td>30</td>
<td>40</td>
<td>45</td>
<td>50</td>
<td>55</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>59</td>
<td>740</td>
</tr>
</tbody>
</table>

The table measures the annual and compounding benefits for a healthy and unhealthy tree specimen, while adjusting for unhealthy tree removal and replacement every fifteen years as suggested from the previous stated research on tree mortality. By adjusting the projected values from both a healthy and poor tree specimen, the environmental tree benefit model can project the lifespan benefits from a flourishing mature tree that has been properly planted and maintained versus the existing planter design from the Clark County codes. This model becomes valuable in assessing the impact tree quality has on ecosystem services and the need to ensure trees reach a mature state and full lifespan.

The standard 100-year interval was used to create a relative baseline comparison between all the tree specimens. In reality, the table should adjust for each tree’s unique expected lifespan and the probable reduced lifespan for an urban environment. These considerations are on-going in the continual study of tree health and benefits in arid urban environments. Additionally, with the study being about transforming the functional and perception of parking lots it is also important to realize that the demand for surface parking lot is less than what municipal codes require. The need for large off-street surface parking lots may also change over the 100-year projection so it should not be expected that the context of trees in parking lots will remain the same over that same period of time. The model for these tree savings also includes the cost associated with tree removal and new tree purchasing costs to emphasize the impact properly maintained and planted trees have as a long-term investment opportunity as shown in Table 3.

**Table 3. Charted annual cost savings from a healthy and unhealthy Honey Mesquite tree.**

The above chart shows the annual benefits from a Honey Mesquite tree in intervals of 1, 5, and 15 years for the different categories based on the tree’s DBH. The next set of rows show how a healthy and unhealthy tree compare in monetary value during those same intervals. The chart allows considers the tree’s context so if there are no adjacent buildings one can see the tree’s value without benefitting the property’s value or save on electricity. Small Commercial Business was selected as the land use category required for the National Tree Benefit Calculator since the UNLV campus would most likely not be considered either a
multi-family residential or an industrial or large commercial business. Tree value is also adjusted in the next set of rows by including purchasing and annual maintenance costs for the different tree conditions. In the last line of rows, the benefits and costs are calculated to give an adjusted annual tree value. For the unhealthy tree specimen, the benefits revert back to the initial 1-year values after every 15 years to account for that tree’s average 7 to 15-year mortality rate supported by studies mentioned earlier.

4 DESIGN IMPLEMENTATION

The first phase of the design implementation was conceptualizing a transformed parking lot found suitable for the arid environment of Las Vegas that performed environmental, social, and economic benefits. Part of the initial concept objectives was to reconfigure the parking lot layout and structure by suggesting different parking stall angles and aisle widths, new circulation routes, and additional program use beyond parking a car. The immediate challenge in this process was to maintain the existing stall count while providing more planting space for the growth and longevity of mature trees within a predominately fixed site boundary, although some of the UNLV parking lots had opportunities to expanding the site boundary in order to accommodate the range of additional site amenities. The first step in addressing this challenge was to negotiate alternative stall angles, widths, and surface material when appropriate to necessitate larger planter areas. This included implementing one-way aisles and new vehicular and pedestrian circulation to address traffic calming and safety, decreasing potential conflict between the two groups. The goal of the transformed parking lots was to go beyond adding larger planters and more trees by re-programing how a parking lot may function for the needs of students, faculty, and the surrounding community when occupying these spaces on campus.

4.1 Site Analysis

Students inventoried their respective site’s surface materials, traffic volume and routes, pedestrian preferences, and other unique characteristics to inform their analytical studies and methods and critically address the intentions of their conceptual ideas. The information found during this process served as a foundation for their evidenced-based and responsive design solutions by evaluating the impact of these existing conditions through both observation and analytical methods that include photographs, videos, the Green Values National Stormwater Calculator, i-Tree Design, the National Tree Benefit Calculator and conventions from James LaGro’s Site Analysis (LaGro, 2013). The site analysis was refined to center around the student’s performative goals of environmental improvement, safety and comfort, and feasibility. Environmental improvements included stormwater management, drainage, and filtration of different rain events that provide on-site mitigation practices. Analyzing the existing vehicular and pedestrian circulation to determine points of conflict and exposure to the elements informed strategic placement of trees for shade and designated pathways for safe passage through the space. The construction, maintenance, and lifecycle costs of the existing conditions were recorded to serve as a baseline target to either match or reduce with their proposals. The different components inventoried during this process were analyzed as a symbiotic network to demonstrate the impact one system may or may not have on another system, such as the significance surface material may have in not only restricting root growth but also contributing to the urban heat island affect and cost associated to maintain and replace over its lifespan.

4.2 Transforming a Parking Lot

The evidence-based response to the analysis and tree benefit matrix demonstrates specific strategies that transform a parking lot beyond it singular use by reducing stormwater runoff, creating wildlife habitat, providing outdoor comfort for pedestrians and outdoor classrooms or other activities, along with being a feasible long-term investment. The selection of specific tree species was also carefully considered depending on their preferred performance environmental, social, or economic impact within the parking lot. Comprehensive strategies were developed that demonstrated an ability to maintain or increase parking stall count while providing substantial plant sizes and use of alternative surface materials to expand root growth for mature healthy trees. These examples shown in Figure 4 and Figure 5 transformed the parking lot and found innovative solutions that highlight the extensive level of benefits native Mojave Desert trees can provide within a parking lot and the overall identity of the UNLV campus if maintained within refined parking lot standards.
Large and extensive amounts of exposed impervious surfaces such as concrete and asphalt contribute to many of the before mentioned environmental issues of the urban Heat Island Effect, poor air quality, an increase in runoff volume, and high concentrations of pollutants in the runoff. Substituting these materials with permeable materials can begin to mitigate these negative impacts to the environment. Alternative and successful proven permeable materials for parking lots include gravel, cobble, wood mulch, high reflective concrete, brick, open jointed pavers filled with turf or aggregate, turf blocks, natural stone, and pervious concrete. It is important to note, however, that the performance of pervious concrete in desert environments is not optimal due to the voids being easily filled with dust and requiring constant maintenance to ensure permeability. Replacing all of the asphalt with these alternative materials is not necessary but can be implemented in the parking stalls, crosswalks, and overflow lots. Because some of these materials are not suitable for high volumes of traffic or for emergency vehicles, conventional use of asphalt or concrete can be maintained in the parking aisles and driveways.

Best Management Practices for stormwater management are becoming more frequently incorporated into the performance of parking lot design in order to mitigate the damaging impact of flooding water to property during monsoonal rain events as well as the receiving water bodies. This on-site strategy is referred to as Low Impact Development (LID). The goal of this concept is to mimic the pre-development ecology of the area while replicating its environmental performance in respect to hydrological systems, temperature mitigation, and wildlife habitat. Students found creative and innovative ways of managing stormwater with their design proposals by collecting between 95% and 100% of the runoff using a systematic
combination of permeable pavers, bioretention, and urban forests. The economic feasibility of these proposals is also provided later in this section.

The primary functions of LIDs are to reduce, collect, filter, remediate runoff with passive landscape systems that replicate the natural water cycle process of infiltration, evapotranspiration, and precipitation. The LIDs are soil- and plant-based for optimal function in the form of vegetated swales, filter strips, detention and bio-retention systems, and permeable surface cover. The vegetation selection and establishment of plant communities is cost effective with little to no maintenance practice because their ecological composition consists of producers, consumers, and decomposers for environmental balance.

5 CONCLUSIONS

Parking lots are an extremely undervalued and underappreciated piece of the urban fabric lined with opportunities to reduce the environmental, social, and economic constraints they have on the principles of ecological design in arid environments. These expansive components of the urban infrastructure can be re-programmed to contribute ecosystem services from healthy trees and green infrastructure instead of hindering or diminishing their contribution to the health and wellbeing of those occupying them. Although parking lots were the case study of this research, the overall goal was to demonstrate the value mature trees can provide to the built environment if municipal codes could be amended to promote healthy tree growth that reach their natural lifespan. Tree planting initiatives can continue to advocate for more trees in cities but additionally their needs to be long-term monitoring efforts and changes to policies that enable
those efforts to reach their ideal output of ecosystem services. Developing a comprehensive solution to address multiple issues simultaneously was a key component to the design concepts. The integration of environmental, social, and economic strategies resulted in innovative and feasible opportunities for retrofitting existing parking lots with green infrastructure and working forests as well as proposing revisions to existing municipal codes for new parking lot construction. Some of the comprehensive components for alternative parking lot design that promote healthy tree growth are (1) configuring parking lots with angled stalls and one-way aisles with decrease space allocated for parking and increase opportunities for larger tree planters. (2) Replacing asphalt surface materials in the parking stalls with alternative permeable paving materials can reduce runoff volume, lower surface temperatures, and becomes cost-effective. (3) Refining island finger planters with curb cuts and adjacent permeable pavers supported by structured soil to provide adequate soil for trees and excess moisture or runoff to infiltrate into the soil for root growth, and reduces runoff volume. (4) Arranging planters as a buffer to separate pedestrians from vehicular traffic with delineated and shaded walkways will promote outdoor comfort and safety. (5) Using dense and diverse vegetation types in addition of shade trees to encourage wildlife ecologies that mitigate pest presence and reduce chances of disease. (6) Plan for the ecosystem services of the trees and parking lot performance to be a long-term investment and cost-effective strategy.

The main goals from this study are to encourage municipal code change that promote healthy tree growth in parking lots through revised planter design guidelines and to promote the environmental, social, and economic value of trees to transform the singular utility of parking lots into an opportunity for mixed use and ecological stewardship. Looking ahead to the future from this study, the next steps would be to assess and analyze a typical municipal tree planter along with a demonstration planter designed from the recommendations provided in this report. Those recommendations will require the tree planter to have curbs cuts, adjacent permeable pavers, and enough structured soil for adequate root growth. The two planters will be assessed and compared for their environmental, social, and economic benefits to the immediate area. Weather monitoring tools, surveys, and material costs will be used to measure the benefits within a performance matrix. And although surface parking lots are beginning to lose demand as ride-share programs, autonomous vehicles, and more online services reduce the need to drive individual vehicles to large retail shopping center, the principles of this research still serve as a foundation when considering alternative design approaches to streets, plazas, and other outdoor spaces that reside within the urban fabric. It is still critical to implement policies that prioritize the health and longevity of trees regardless of their context. Planting, monitoring, and maintaining trees in the city will be needed to counteract the other conventional practices that diminish the health of our environment.

6 REFERENCES


UNLV. (n.d.). Retrieved August 12, 2018, from https://www.unlv.edu/hr/employee-info/employee-counts


BASELINERS: COLLECTING BASELINE DATA TO MEASURE SOCIAL BENEFITS IN TRANSFORMED LANDSCAPES

DE ALMEIDA, CATHERINE
University of Nebraska-Lincoln; University of Washington, Seattle, WA, cdealmei@uw.edu

LOPRESTO, HANNAH
University of Nebraska—Lincoln, Lincoln, NE, hmlopresto@gmail.com

1 ABSTRACT
Quantifying environmental, economic, and social benefits of performing landscapes generally require the acquisition of baseline data in order to compare pre- and post-project conditions and impacts. Unless design firms collected data in pre-project conditions, assessing the impacts of projects through comparative studies leads to less rigorous evaluations due to a high level of assumptions and limitations. Additionally, assessing social benefits is challenging due to the number of variables involved with collecting and quantifying social data, particularly when surveys were not conducted under pre-project conditions to obtain baseline information. The Landscape Architecture Foundation’s Case Study Investigation program enabled a University of Nebraska-Lincoln research team to partner with two landscape architecture firms to conduct post-occupancy evaluations of two projects that transformed underutilized sites into high-performing landscapes in the Great Plains—Tom Hanafan River’s Edge Park in Council Bluffs, IA and P Street Corridor in Lincoln, NE. The research team documented, measured, and evaluated social, environmental, and economic benefits at each site to capture the transformative aspects of these projects. With minimal social baseline data present for either site, survey questions directed to users with pre-existing site knowledge—baseliners—was a critical component of the team’s methodology to capture comparative perceptions of before and after conditions. This paper presents the team’s findings and recommendations for the simultaneous collection of pre- and post-project data to quantify social benefits in landscape performance studies when documenting changes in user perceptions related to environmental aspects, such as safety, ease of access, and increased levels of activity.

1.1 Keywords
Landscape Performance, Landscape Architecture, Social Benefits, Baseline Data, User Survey Methodology
2 INTRODUCTION

Landscape performance measures the “effectiveness with which landscape solutions fulfill their intended purpose and contribute to sustainability. It involves assessment of progress toward environmental, social, and economic goals based on measurable outcomes” (Canfield, Yang, & Whitlow, 2018, p. 1). Every year since 2010, the Landscape Architecture Foundation (LAF) has funded partnerships between university faculty, students, and landscape architecture firms to complete a Case Study Investigation of a constructed landscape as part of their Landscape Performance Series. These case studies measure the social, environmental, and economic benefits of high performing landscapes around the world. Firms collaborate with university faculty-student research teams to develop methods and a case study document focused on highlighting and measuring the performative benefits of the featured project.

2.1 Two high-performing landscapes in the Great Plains

A University of Nebraska-Lincoln (UNL) research team participated in the 2018 Case Study Investigation program, collaborating with Design Workshop to evaluate P Street Corridor, and Sasaki Associates to evaluate Tom Hanafan River’s Edge Park. Under the guidelines and goals set forth in the program, the team collected on-site data and documented their methodology for assessing social, environmental, and economic benefits at each site. The focus of each assessment was determined through a joint effort between the Landscape Architecture Foundation, the firm, and the research team.

P Street Corridor is a redesigned streetscape spanning six blocks in downtown Lincoln, Nebraska. Design Workshop’s goals for the project included addressing the lack of efficient on-street parking and creating safer pedestrian experiences (Figure 1). Located only two blocks from the University of Nebraska-Lincoln’s city campus, P Street is frequented by business professionals, local families, and many university students. The width of each vehicular lane was reduced by four feet, slowing vehicular traffic and enhancing multimodal safety for pedestrians, bikers, and motorists. Curb extensions were also added at intersections to increase on-street parking, planting areas for stormwater retention, and pedestrian safety (De Almeida, LoPresto, & Zambrano, 2018a).

Located along the edge of the Missouri River, Tom Hanafan River’s Edge Park is now a public park and event space in Council Bluffs, Iowa that was strategically sited in the floodplain. Severely impacted by the 2011 flood of the Missouri River, the site was previously an inaccessible wooded area of ATV use and invasive species that were deteriorating the landscape. Sasaki’s goals for the project emphasized designing the ability for the park to be resilient to future flood events by accommodating inundation rather than preventing it. The park features an open event lawn, amphitheater, established meadow, and connection to regional trail networks (Figure 2) (De Almeida, LoPresto, & Zambrano, 2018b).
3 RESEARCH OBJECTIVES

Research objectives for LAF’s Case Study Investigation program vary across projects, but are motivated by the desire to quantify the sustainable benefits of constructed landscapes. This program emerged to provide a venue for the landscape architecture profession to study and assess the performance of a project in its post-occupancy phase, bridging the gap between academia and the profession. Over the last nine years, LAF has built a searchable case study database (https://www.landscapeperformance.org/) of over 100 exemplary projects that have quantified social, environmental, and economic benefits. The database includes a summary of the research findings that highlight metrics, and an accompanying methods document that provides replicable approaches to quantifying benefits in landscape performance.

The purpose of a performance evaluation is to “measure outcomes, not outputs,” which are “the impacts or achievements of the outputs, or, essentially, the benefits they provide” (Canfield et al., 2018, p. 3). These benefits are quantifiably measured, with metrics that are focused on an increase or decrease to a prior condition. Comparisons, therefore, “can be an effective way to quantify the impact of a design intervention” (Canfield et al., 2018, p. 4), and the UNL research team used comparisons as the underlying method for evaluating both projects. As per LAF’s Evaluating Performance Guidebook, there are three common types of comparison in landscape performance evaluation: before/after; conventional/sustainable; and benchmark or average (p. 4).

Since both projects had goals related to revitalizing existing landscapes, the UNL research team focused on developing comparative methods concentrated on before/after conditions in order to produce metrics that were as accurate and rigorously studied as possible. This type of evaluation, however, requires the collection of baseline data that provide metrics for pre-project conditions. A lack of baseline data presents many challenges, and requires a research team to rely on generalized, secondary data sources they are able to uncover.

Between environmental, social, and economic benefits, obtaining baseline data for measuring social benefits appears to be the most difficult, particularly when pre-project data collection was not completed. This paper presents methods and strategies developed by the UNL research team that enabled the simultaneous collection of baseline (pre-project) and present-day (post-project) data for the evaluation of social benefits in revitalized landscapes. The identification of users with pre-existing knowledge of pre-project conditions led the UNL research team to develop the term and concept “baseliners”. Capturing the experiences of baseliners, or people with previous knowledge or familiarity with a site, was integral to the development of these methods, as they enable the collection and comparison of pre- with post-project social data.
4 METHODS FOR MEASURING SOCIAL BENEFITS

While environmental and economic benefits rely on easily measurable, quantifiable values such as carbon sequestration or property value, social benefits can be more challenging to quantify due to their qualitative condition. LAF’s Evaluating Performance Guidebook lists the following categories of social benefits: recreational & social value (promoting play, relaxation, and interaction); cultural preservation (retaining or restoring culturally significant features, areas, practices, or views); health & well-being (supporting physical health, mental health, and quality of life); safety (improving safety and reducing crime and perceptions of danger); educational value (fostering knowledge and awareness); noise mitigation (reducing actual or perceived levels of undesirable sound); food production (supporting urban agriculture); scenic quality & views (improving the visual quality of an area); transportation (foster walking, biking, mass transit, and other alternative modes); and access & equity (creating or improving access to facilities and amenities) (Canfield et al., 2018, p. 51).

Social benefits are often difficult to measure because they require qualitative and quantitative assessments. These assessments rely on documenting human perception, or “the way people select and organize what they are aware of in a situation through all their senses” (Goodey, 1971, pp. 2-3; Theodorson and Theodorson, 1970, p. 295); [a process of] making sense of environment[s]” (Zeisel, 2006, p. 291). A majority of the social benefit categories listed in the Guidebook rely on the acquisition of qualitative data from users, or “the people who directly or indirectly use the setting [or the project, with its physical and social characteristics] being evaluated” (Zimring, 1987, p. 274). For example, while the perception of a space feeling safe may be qualitative, the quantity or percentage of users that express perceiving the space as safe yields a precise number that provides a measurable finding. Moreover, measuring a change in perception from pre- to post-project conditions can provide an even more precise and specific qualitative social benefit. Rather than solely uncovering whether a user feels safe in a project, researchers may also measure by how much in order to distill the changes in environmental characteristics that cause this shift. As an important tool that documents and measures social benefits, standardized questionnaires, or surveys, enable the collection of qualitative and quantitative data from users that have experiential knowledge of a setting.

4.1 Surveys as a tool for measuring social benefits

Browsing the over 100 methods documents from LAF’s Case Study Investigation, surveys are the most common method for measuring social performance. As Canfield et al. describe, “surveys can gauge frequency and type of use and perceptions related to quality of life, sense of place, safety, and health benefits” (2018, p. 51). Evaluating the social impacts of designed environments typically include two survey types: standardized questionnaires and focused interviews (Zeisel, 2006). Standardized questionnaires can uncover regularities and irregularities “among groups of people by comparing answers to the same set of questions asked of a large number of people” (Zeisel, 2006, p. 257). They allow respondents to complete questions either in person or at their own convenience if given the option to complete on-line, often independently at a location of their choosing, which can lead to an increased level of honesty in the responses. Focused interviews offer face-to-face interaction where the respondent can ask for clarification and interact more closely with the survey distributor (Sendich, 2006) and allow for probes, or the opportunity for an interviewer to get a respondent to clarify a point (Zeisel, 2006).

Within a standardized survey, questions are either asked in closed- or open-ended formats. Closed-ended, or pre-coded responses to questions, “partition possible response alternatives into sets of categories for respondents to choose from that are exhaustive, mutually exclusive, and have a single level of abstraction” (Zeisel, 2006, p. 265). Closed-ended formats provide nominal answer categories such as yes or no responses, or those that provide a more extensive multiple-choice format (Zeisel, 2006). The second type of closed-ended surveys are ordinal (Zeisel, 2006), which are often variations of a Rating Scale, Likert Scale, or Numerical Scale (Sendich, 2006). Ordinal survey responses are arranged in a rank order to represent different degrees or magnitudes, and provide the ability to “analyze intensity, direction, and quality of such variables as verbally expressed attitudes and perceptions” (Zeisel, 2006, p. 266). The Rating Scale measures respondents’ position between two opposing word pairs such as hot-cold or noisy-quiet (Sendich, 2006). Likert Scale asks the extent to which the respondent agrees with a statement. For example, at Park Lane, an LAF streetscape case study project similar to P Street’s conditions, a Likert Scale was incorporated into the survey to measure users’ perceived levels of safety, favorability, ADA access, and sense of identity, among others (Ozdil, Khoshkar, Munshi, & Pradhan, 2017). A Numerical Scale correlates a respondent’s
positions with a numerical value (Sendich, 2006). At Yanxiu Park, an LAF waterfront case study similar to Tom Hanafan River’s Edge Park’s conditions, the administered survey asked users to rate their overall satisfaction with the park by choosing from a scale that ranged from 1=extremely unsatisfied to 5=extremely satisfied (Wu & da Silviera, 2017). The interviewer’s objectives should dictate which of the two formats to use.

Since one key objective of the UNL research team was to measure perceptual changes between pre- and post-project conditions, surveys with pre-coded, ordinal responses were administered at both P Street Corridor and Tom Hanafan River’s Edge Park during their post-occupancy evaluation. At both projects, surveys were administered over the course of three weeks in June to correlate with events, and distributed at different times of the day and week, including weekends, and during event and non-event days, to capture a diverse cross-section of users. Each person a researcher encountered was asked to participate in the survey, whether they were walking, running, or sitting. As a destination, the sampling size for Tom Hanfan River’s Edge Park was 50 participants due to infrequent users on a day-to-day basis. The sampling size for P Street corridor was 100 participants since the street experiences much greater activity because it is used as a means for traveling to various destinations.

All surveys were distributed in person, and a majority were completed on site, which allowed the research team to respond to any questions from respondents. However, a few surveys were completed remotely via an on-line link to a Surveymonkey version provided at the top of hard copy surveys. These options provided respondents with the flexibility to take the survey privately at home or on-site while conversing with the survey distributor. All hard copy surveys were entered into the Surveymonkey platform by the UNL research team, easing the collation and interpretation of collected data to visualize findings and regularities. Surveys for each location asked each user standard questions using ordinal scales, but provided a section in which baseliners—users with knowledge of pre-existing conditions—could diverge from the questionnaire, enabling the team to capture baseline data.

4.2 Defining the “baseliner”

Most landscape architecture firms do not measure landscape performance benefits or complete post-occupancy studies, and therefore, typically do not collect baseline data due to added costs and time involved with completing these studies that are not built into project costs. Having baseline social data is the rare exception rather than the rule. While it would generally be easier to compare pre- and post-project data if a pre-project survey was distributed, the UNL research team developed methods to quantify social benefits without access to pre-project data, and depended on baseliners—users that have knowledge of preexisting site conditions during a post-project survey. The team found that baseliners are essential participants that enable research teams to compare user perceptions of environmental conditions before and after a project (Figure 3).

The user surveying process highlighted the importance of establishing baseline data for preexisting conditions, especially for evaluating social benefits that rely on changes to environmental perceptions. Baseliners, therefore, were critical in establishing baseline data for the comparative measurement of social benefits, especially for such reclaimed sites. Asking baseliners specific questions that document and record their knowledge of pre-project conditions, with the simultaneous documentation of their present-day perceptions of environmental changes from a new project, was a significant additional assessment tool for the team to measure social benefits through comparative methods.
In the 2013 *Landscape Research Record*, Jessica Canfield and Bo Yang explain, “The validity of performance benefit statements largely depends on the quality and reliability of data sources. First-hand, verified data is most desirable for performance analyses, though it was not always feasible to obtain due to geographical limitations, cost implications, and/or the short duration of the CSI program” (Canfield & Yang, 2013, p. 4). First-hand data, whether collected by a firm or measured on-site, is most reliable for measuring social benefits such as reduced crossing times on P Street (De Almeida et al., 2018a, pp. 11-13). However, while baseline data collected by a firm is “first-hand,” it may not always be the most reliable data source option when measuring social benefits centered on perception. Surveying approaches may differ, or there is often a lack of documentation for methods used, and therefore, cannot be replicated. Baseliners are a more reliable source to identify perceptual changes between pre- and post-project conditions, capturing a direct change in perception for the same individual rather than a completely different set. Through the P Street survey, baseliners provided social benefits, such as improved user perception of the street’s appearance, without the presence of pre-project data collection (De Almeida et al., 2018a, pp. 13-14).

In order to identify baseliners and document their baseline data, the research team developed specific question sets, created as variations of the Likert and Numerical Scale, which were used to separate them from other survey participants (Table 1).

**Table 1. Baseline question sets for P Street and Tom Hanafan River’s Edge Park Surveys.**

<table>
<thead>
<tr>
<th>P Street</th>
<th>Ordinal Scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you familiar with what P Street looked like before the 2014 renovation?</td>
<td>None (Yes/No)</td>
</tr>
<tr>
<td>Do you find walking on P Street easier or more difficult after the reconstruction?</td>
<td>Numerical (More Difficult [-5]  Neutral [0]  Much Easier [5])</td>
</tr>
<tr>
<td>Do you find biking on P Street easier or more difficult after the reconstruction?</td>
<td>Numerical</td>
</tr>
</tbody>
</table>
4.3 All Inclusive Surveying

Developing a surveying methodology to be all-inclusive was a primary goal for the UNL research team to gather as many responses as possible from baseliners. The initial surveys created for both P Street and Tom Hanafan River’s Edge Park were nearly identical. The surveys, which were distributed during similar times of day, included the same general format and questions. With each site having its own summer event series (Jazz in June near P Street (Figure 4, left) and Hanafan’s Loessfest), surveys were distributed at both event and non-event days to gather a broader sampling of age ranges, locals, visitors, levels of education, and abilities. While distributing surveys at Tom Hanafan River’s Edge Park, fishermen agreed to complete the survey, but were unable to read. One student researcher from the team read the questions to them aloud, and completed the surveys using an interview-like method (Figure 4, right). Having fished along the Missouri river on site for years before the project was constructed, the fishermen provided valuable baseline data of the site’s previous fishing popularity and levels of accessibility on self-made trails.
5 FINDINGS, CHALLENGES, AND OPPORTUNITIES

Although the surveys followed very similar formats, the UNL research team observed significant differences between surveying environments from the two projects. As expected, P Street’s daily foot traffic density was much higher than Tom Hanafan’s, whether or not an event was taking place, making survey distribution and collection faster. A larger variety of users was also easier to encounter on P Street due to the corridor being part of a daily commute or destination for workers or university students. At Tom Hanafan River’s Edge Park, daily foot traffic density was much lower, making it more difficult to collect surveys on non-event days. These on-site observations led the research team to collect 100 completed surveys from P Street and 50 completed surveys from Tom Hanafan River’s Edge Park. However, on P Street, 52% of surveyed users had baseline knowledge (Table 2) while on Tom Hanafan River’s Edge Park, 65% of surveyed users had baseline knowledge (Table 3). The research team speculates this is due to the transient university population around P Street. While locals were easier to come by on P Street, many have not lived there long enough to have pre-existing site knowledge.

Table 2. P Street’s social benefits

<table>
<thead>
<tr>
<th>Social Benefits (De Almeida et al., 2018a)</th>
<th>Baseline Data Obtained From…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improves perception of pedestrian safety and comfort for 67% of 63 surveyed users who had visited the corridor before reconstruction(^1)</td>
<td>baseliner survey question</td>
</tr>
<tr>
<td>Reduced street crossing time for pedestrians from an average of 11.5 seconds to 6.9 seconds per crossing, a 40% reduction.</td>
<td>on-site measurements</td>
</tr>
<tr>
<td>Improved user perception of the appearance of P Street, with 80% of 100 surveyed visitors rating the street’s appearance as “good” or “very good” as compared to 23% before the redesign(^2)</td>
<td>firm’s pre-project survey results</td>
</tr>
</tbody>
</table>

\(^1\) These results indicate 63 / 100 surveyed users on P Street were baseliners, but only 51 users reported having knowledge of pre-existing conditions. This indicates that either a) non-baseliners answered baseline...
questions or b) Baseliners failed to indicate they had baseline knowledge on the appropriate survey question.

2 This benefit was calculated by comparing the design firm’s baseline data to the post-project survey data collected by the UNL research team.

Table 3. Tom Hanafan River’s Edge Park social benefits

<table>
<thead>
<tr>
<th>Surveys Distributed: 50</th>
<th>Reported Baseliners: 32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Benefits (De Almeida et al., 2018b)</td>
<td>Baseline Data Obtained From…</td>
</tr>
<tr>
<td>Increased ease of access to the Missouri River according to 89% of 35 surveyed users.</td>
<td>baseliner survey question</td>
</tr>
<tr>
<td>Creates a safe public park space according to 84% of 37 surveyed users who said that they perceive the park as safer than before the reconstruction.</td>
<td>baseliner survey question</td>
</tr>
<tr>
<td>Increases levels of outdoor activity for 68% of 47 surveyed users.</td>
<td>none required</td>
</tr>
<tr>
<td>Provides new community event opportunities to 65% of 49 surveyed users.</td>
<td>none required</td>
</tr>
</tbody>
</table>

The research team encountered some challenges while attempting to filter out baseliners from other survey respondents. Although the section for baseliners was clearly labeled with a bolded statement, errors emerged in survey results when it became apparent that a) some non-baseliners had answered baseline questions or b) baseliners failed to indicate they had pre-existing site knowledge on the appropriate question. To avoid this error in the future, the UNL research team recommends baseliner questions be physically separated on a different sheet of paper. Rather than ask respondents via the survey whether they have knowledge of pre-existing conditions, survey administrators may ask respondents in person after they agree to participate in the survey, and be given the questions if they verbally answer “yes”. If administered on-line, participants can be automatically directed to the questions relevant to them. Additionally, this separation would allow for further analysis between baseliners and non-baseliners, and the regularities and irregularities between these groups for comparing perceptual data, an opportunity the UNL research team was unable to explore due to the constrained time frame for participating in LAF’s Case Study Investigation.

After measuring social benefits from both firm baseline data and baseliners, the UNL research team advocates for more rigor in the type of data and methods used to collect social baseline data (Figure 5). Certain social benefits, such as increased park space, are best suited for referencing baseline data provided by the design firm, but specific social benefits focused on more perceptual aspects of environmental changes may be more accurate if collected from baseliners during post-occupancy evaluations. This ensures that perceptual shifts are captured by the same person, thereby increasing data accuracy, rather than comparing data provided by different users at different times. An ideal scenario would be to have the same participants complete questionnaires during pre- and post-project conditions, since users are referencing memory rather than real-time experiences in their completion of a survey during post-occupancy evaluations. However, this method becomes increasingly complicated and lengthy due the long time frame and high possibility of participants moving away within 5-10 years of the conducting pre-construction inventory for the project.
6 CONCLUSIONS

As a common method for measuring social benefits (Canfield et al., 2018, p. 51), surveys were an instrumental tool for capturing social baseline data for the UNL research team. For both P Street Corridor and Tom Hanafan River’s Edge Park, surveys were administered in person with hard copies, with the option for users to participate on-line by following a link provided in the survey. Within the surveys for each location, standard questions were asked using Ordinal Scales, such as Likert and Numerical scales. However, in the pursuit of missing baseline data, the survey included specific comparative questions targeting baseliners in order to evaluate changes in environmental perception.

As demonstrated by the findings from the UNL research team, baseliners are an immensely valuable resource for obtaining missing baseline data, and rigorous methods need to continue to be developed to target and document the experiential knowledge embedded in these users. In their book Landscape Architecture Research: Inquiry, Strategy, Design, M. Elen Deming and Simon Swaffield explain, “Evidence-based design demands increasingly rigorous measurements that ‘prove’ (or at least promise) the likelihood of adequate long-term performance and value of capital investments, especially when compared to the environmental services and other resource values that may be lost in development” (Deming & Swaffield, 2011, pp. 187-188). Baseliners are a key to providing accurate and comparative social benefit data in order to back future investments in high performing landscapes. By utilizing and documenting the knowledge base provided by baseliners, and continuing to develop rigorous approaches to collecting this data, designers may be able to distill which altered characteristics resulted in which changes to perceptions, ultimately aiding in informing future practice.

To find baseliners, full inclusivity of all people in the survey process should be a primary objective to ensure a diverse user audience is captured. To achieve this, research teams must be flexible and able to adapt to unexpected factors in the surveying environment by conducting surveys during varying days and times of the week, being available to answer questions from respondents, and even being open to conducting a more interview-like questionnaire for users that are unable to read or write. As a professional practice, it is becoming increasingly important for landscape architects to collect baseline data in order to test whether their design goals are being met as part of a feedback loop, learning process. This is especially true for evaluating social benefits. Perceptual in nature, they require baseliners in order to perform comparative studies with greater precision that can be quantified. Unless firms are proactive about measuring landscape performance benefits, post-occupancy evaluation is difficult. Baseline data collection is essential to giving performance value to the designed landscape, especially when it comes to projects that are transforming underutilized, marginal landscapes, by capturing degrees of perceptual shifts and their causes. Through a more meticulous approach to social baseline data collection, firms and researchers can identify which benefits correspond most appropriately to either pre-project data collection, post-project surveys, or a mix of both, generating more reliable data sets that inform the profession.

7 REFERENCES


March 6-9, 2019


CELA MEDIA STATEMENT

Dear CELA Authors:
Please consider include in this space a research summery in 100 words or less that would best describe your topic, its principal results and/or impacts, written in clear language that would be of interest to public media outlets. In addition to the research summary, you may provide an optional graphic abstract that further explains the topic.

Title of Paper or Research:

Author:

Institution or Professional Affiliation:

Authors please select one of the following: I DO _____ DO NOT____X____ want to prepare a media statement for general release from the 2018 CELA Conference. (If you choose DO NOT, you do not need to prepare a media statement).

Media Statement (100 words max.):

(Optional) Graphic Abstract: please insert the illustration below. Authors: please seek copyright permission if copyrighted materials are used.
LANDSCAPE PLANNING AND ECOLOGY

Edited by Chingwen Ching & Dongying Li
FEASIBILITY OF A CONSTRUCTED WETLAND FOR WASTEWATER TREATMENT IN JULIAETTA, IDAHO

TOMPKINS, ALISON
University of Idaho Landscape Architecture Graduate Program
Nez Perce County Planner and Floodplain Coordinator
atompkins@roadrunner.com

AUSTIN, GARY
University of Idaho Professor of Landscape Architecture
gaustin@uidaho.edu

1 ABSTRACT
Rural communities have a small tax base, limited staffing, and must meet all federal and state requirements for the treatment of wastewater. Many small communities in the United States now face the challenge of how to replace aging rural infrastructure like wastewater treatment systems with limited resources. This is compounded by increasingly stringent water quality standards for treated effluent. A review of current literature regarding the use of constructed wetlands for wastewater treatment is summarized. Case studies of effective wastewater treatment wetlands in cold climates are presented. Federal, state, and local government sources are reviewed to evaluate permitting and funding options available to rural communities. Permitting and funding logistics are discussed, with specific examples from a rural community in Idaho. Cost, effectiveness, and benefits of a constructed wastewater treatment wetland are compared to traditional systems to demonstrate the value and feasibility of a constructed wastewater treatment wetland for the conceptual redesign of a system in Juliaetta, Idaho. Cold climate does not limit the use of constructed wetlands for sustainable wastewater management. Constructed wetlands provide a cost-effective solution for wastewater treatment that can be applied to small, rural communities and provide sustainable benefits that traditional engineered systems cannot, such as wildlife habitat, energy savings, irrigation water, and recreation area.

1.1 Keywords
Cold climate; constructed wetland; funding; permitting; wastewater treatment
2 INTRODUCTION

Small communities across the United States have aging wastewater infrastructure that can no longer meet federal or state water quality standards. Replacement of wastewater treatment infrastructure is costly and project costs can run in the millions of dollars. Small towns do not have a large tax base to support infrastructure costs or multimillion-dollar levies to upgrade or replace a wastewater treatment system. Most cities (large and small) rely on grant money and/or federal loans together with a local match to fund replacement or renovation of wastewater treatment systems. Small communities also face other difficulties like staffing, and often only have one or two staff members to operate and maintain the wastewater system at all times. It can be difficult for small towns and cities to attract and retain staff with the skills, experience, and/or certifications to run and maintain a wastewater treatment system, so they often rely on on-the-job training.

Juliaetta, Idaho, is a rural community utilizing a centralized wastewater treatment system completed in 1977 that still uses much of the original equipment from that time. Replacement parts for a system this age are becoming more difficult to obtain and based upon performance levels it will be unable to meet 2018 discharge permit requirements (Keller Associates Inc., 2018). The system receives wastewater from 590 connections consisting of residential and light commercial uses and is operated and maintained by a staff of two system operators-in-training. It discharges treated effluent to a wetland basin adjacent to the Potlatch River under a National Pollutant Discharge Elimination System (NPDES) permit that was approved in 2018 (US EPA, 2018b). In 2018, Juliaetta contracted with an engineering firm to complete a facility plan to facilitate the funding and renovation or replacement of the existing system with a facility capable of treating effluent to current NPDES permit standards. Literature demonstrates the efficacy of constructed wetlands for wastewater treatment in small communities like Juliaetta. Selected case studies in the United States demonstrate the affordability of constructed wetlands compared to traditional treatment methods and their ability to meet state and federal permitting standards in cold climate areas like Idaho. Literature and case studies guide the conceptual layout of a constructed wastewater treatment wetland for the city of Juliaetta, Idaho. The principles of landscape architecture are applied to provide sustainable benefits to both the community and the natural environment.

2.1 Site Inventory and Analysis

The City of Juliaetta, Idaho, is a small town with a population of 609 in 2018 that has remained stable for more than 20 years (City-Data.com, n.d.; US EPA, 2018a). The climate in Juliaetta is temperate with an average temperature of 3°C (28°F) in winter and 31°C 88°F in summer. It is located 352m (1155 ft) above sea level (City-Data.com, n.d.). Winter is generally wet with occasional snow accumulation. The average annual precipitation in Juliaetta is 457mm (18 in) per year (Sperling’s Best Places, n.d.), most of which occurs from fall to spring. This results in high peak flows of the Potlatch River in early spring and extremely low flows in late summer (Idaho Department of Environmental Quality, 2008). The United State Department of Agriculture (USDA) cold hardiness zone is 7a (PlantMaps, n.d.b) and the American Horticultural Society heat zone is 3 (PlantMaps, n.d.a).

The Potlatch River watershed encompasses approximately 153,942 ha (380,400 ac) and drains into the Clearwater River. Land uses within the watershed include forestry, livestock, agriculture, rural residential, commercial, and industrial areas, and undeveloped hillsides (Idaho Department of Environmental Quality (IDEQ), 2008). Designated beneficial uses of the Potlatch River include cold water aquatic life, salmonid spawning, primary contact recreation, and domestic water supply (IDEQ, 2008). Pollutants identified in the 2008 Potlatch Watershed Total Maximum Daily Load (TMDL) report for the portion of the watershed from Big Bear Creek (at Kendrick) to the mouth at the confluence with the Clearwater River include bacteria, dissolved oxygen, ammonia, nutrients, oil and grease, organics, pesticides, sediment, and temperature. Salmon species, especially Chinook salmon, are prone to disease, injury and stress when water temperatures exceed 60°F. This was illustrated in July 2015 when water temperatures in the Willamette River, in Oregon rose above 70°F and caused the death of hundreds of fish (Friesen, 2015). The Environmental Protection Agency (EPA) has determined that Juliaetta cannot currently meet water temperature limits (<21.3 °C/70.34 °F) based on the updated 2018 Draft Potlatch River TMDL and has proposed a 13-year compliance schedule in the 2018 NPDES permit (US EPA, 2018a). Effluent temperature standards pose a significant challenge during summer months, when low flows of the Potlatch River can drop below 2 cubic feet per second. The previous NPDES permit did not include standards for water
temperature, and this is a significant change with substantial design implications for the treatment system (US EPA, 2018a).

Juliaetta’s existing wastewater treatment plant is located between State Highway 3 and the Potlatch River, which run parallel to one another in a north-south direction. The Juliaetta Volunteer Fire Station is located opposite an oversized gravel parking area. The treatment plant is adjacent to the 100-year floodplain of the Potlatch River according to the Federal Emergency Management Agency’s Flood Insurance Rate Map. In order to minimize flood risk to Juliaetta’s wastewater treatment infrastructure and avoid unnecessary costs, a replacement system should not be located below the base flood elevation. Soil of the site is characterized as aquic xerofluvents of 0-3% slopes (USDA Natural Resources Conservation Service (NRCS), n.d.) with a frost depth of 24 inches. This soil type occurs in floodplains and stream terraces and consists of gravelly loam from 0-7 inches, with stratified sand to very cobbly sandy loam from 7-60 inches deep. It is prone to flooding and depth to the water table is approximately 18-24 inches (USDA NRCS, n.d.), indicating that a liner or other material will be necessary to prevent untreated wastewater from leaching or mixing with groundwater.

The region is experiencing a growing wine industry with the approval of the Lewis-Clark Valley American Viticultural Area in recent years. Hillsides downriver from Juliaetta are now flourishing with vineyards which require irrigation during summer months and for which surface water is drawn from the Potlatch River. If vineyards are established nearer to Juliaetta, reuse of partially treated wastewater for vineyard irrigation may become an advantageous undertaking, as the water still retains plant available nitrogen. This would reduce the demand for surface water from the Potlatch River, which in turn preserves higher stream flows and helps maintain lower water temperature for endangered salmonid species. A city park is connected to the wastewater treatment site by an abandoned railroad bed running parallel to State Highway 3, though railbed paving stops short of connecting the two sites. The railroad bed presents an opportunity to extend recreational use south of the city park and ballfields to the treatment site.

3 RESEARCH OBJECTIVES

Green infrastructure is rarely used in rural areas, but constructed wastewater treatment wetlands provide the opportunity to apply sustainable water management practices to rural issues while implementing best practices of community planning, landscape architecture, and engineering. The purpose of this research is to address the need of small communities to replace aging wastewater treatment systems with the limited funding and staff that is typical of small towns. Constructed wetlands have successfully been used all over the world to treat wastewater, even in cold climates where treatment efficiencies are impacted, but they still are not common in the United States and none exist in Idaho. When properly constructed, wetlands can effectively remove excess nutrients and solids from wastewater. Furthermore, constructed wetlands are cost-effective and can contribute ancillary benefits that traditional engineered systems cannot, such as wildlife habitat, energy savings, irrigation water, and recreation area.

4 METHODS

4.1 Literature Review

Literature provides data relating to the types of constructed wetlands utilized for wastewater treatment in cold climates, their efficacy, and the components critical to proper function and treatment. There are two parts to the literature review: Acquisition and assessment of the literature, and review of selected sources to acquire the theory, processes, techniques, and pitfalls revealed in the studies. Scientific literature was acquired in September 2018 by searching the complete University of Idaho library database with the use of keywords. Results were refined as shown in Table 1, yielding a total of 55 scholarly articles for review. Specialized equipment and other uncommon wastewater treatment applications such as microbial fuel cells, bioreactors, biofilters, and integrated household wetlands do not meet the criteria of sustainability and affordability for this project. For this reason, these 15 articles were not evaluated for their application to rural communities.
Table 1. Summary of literature acquisition and refinement of search results.

<table>
<thead>
<tr>
<th>Literature Search and Assessment</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyword search: constructed wetland + wastewater treatment + cold climate</td>
<td>349</td>
</tr>
<tr>
<td>Eliminated results older than 10 years</td>
<td>222</td>
</tr>
<tr>
<td>Reviewed by title and eliminated items related to stormwater, agricultural or industrial use, pollution control, and warm climates</td>
<td>90</td>
</tr>
<tr>
<td>Reviewed abstracts and eliminated items not related to constructed wastewater treatment wetlands</td>
<td>70</td>
</tr>
<tr>
<td>Discarded items concerned with specialized equipment or uncommon applications</td>
<td>55</td>
</tr>
</tbody>
</table>

The literature assessment revealed five primary topics related to constructed wastewater treatment wetlands:
- Types and general function of constructed wastewater treatment wetlands
- Aeration, hydraulic loading rate, and hydraulic retention time
- Plants
- Substrate
- Temperature

4.2 Case Studies

Case studies provide data relating to the capability of constructed wetlands to treat wastewater to meet state and federal water quality standards and permitting requirements. They guide the articulation of goals and design criteria that can be applied to constructed wastewater treatment wetlands in other small communities such as Juliaetta. This research method yields concepts and techniques tested by construction and monitoring of built works. Empirical evidence guides designers toward proven techniques and away from problems or design failures.

Case studies also demonstrate how constructed wetlands can be utilized for the effective treatment of wastewater from small communities of various sizes (545-50,000 population equivalent). Climate plays a critical role in the proper design of constructed wetlands to achieve water quality standards for effluent. Below freezing temperatures during winter months will slow biodegradation processes (US EPA, 1999). Therefore, case studies were selected for their location in cold winter climates to demonstrate their effectiveness in the most restrictive climatic conditions. Design elements responsive to cold winter conditions can be extrapolated to other communities like Juliaetta which experience extended periods of below freezing conditions in winter months. Case studies were evaluated by population, land area, wetland type, system capacity, benefits, and challenges. They were also selected for their applicability to small communities. The small size of these communities presents a challenge to the researcher because information about wastewater treatment systems is often not readily available. A public works department is usually non-existent, only a staff of one or two individuals who maintain the wastewater system along with city property. Very little documentation exists on the world-wide web. Much of the information about these case studies was collected through a detailed review of public records from state regulatory agencies and phone interviews with local municipal departments and state regulatory agencies.

4.3 Federal, State, and Local Agency Review

Federal, state (Idaho), and local government sources were reviewed to evaluate regulatory standards, permitting, and funding options available to rural residential communities. Interviews with communities, regulatory agencies, and engineers practicing wastewater treatment system design and planning provided additional information regarding permitting, construction, operational costs, and perceptions about alternatives to traditional treatment methods.
5 RESULTS

5.1 Literature Review

 Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, filter media, and their associated microbial assemblages to improve water quality (US EPA, n.d.). Constructed wetlands are a popular method of wastewater treatment for small communities and remote locations worldwide due to their low energy needs and fewer operational requirements compared to conventional treatment systems (Wu et al., 2015). They can produce quality effluent at lower power requirements than conventional activated sludge systems (Redmond, 2012). Constructed wetlands offer several benefits compared to traditional centralized treatment systems: lower energy demand, maintenance, and cost, added SW recreation area, resource conservation, habitat for wildlife and aquatic life, and attractive aesthetics (Wu et al., 2016).

 Constructed wetlands generally fall into two categories based upon hydrology – free water surface wetlands and subsurface flow wetlands. Free water surface wetlands look similar to natural wetlands. They consist of shallow water over a substrate that is saturated by the water (Wu et al., 2015). Subsurface flow wetlands are different in that water flows horizontally or vertically through the substrate. Based upon this flow direction, they can be further categorized as horizontal subsurface flow or vertical subsurface flow. A hybrid system utilizes two or more wetland types (Wu et al., 2015) and takes advantage of the benefits that each system has to offer. Vertical subsurface flow wetlands require only half the space of horizontal or free water surface systems, using approximately 2 m² per person (Austin & Yu, 2016). Horizontal and vertical subsurface flow wetlands have some advantages over free water surface wetlands, such as lack of odors, mosquitos, and minimal risk of human contact with contaminants (US EPA 1993).

 The French reed bed is a vertical subsurface flow system that is unique in that it receives raw wastewater without the use of a septic or Imhoff tank for primary treatment (Figure 1). Pretreatment consists of grit removal followed by an equalization tank which traps oil and floatables and ensures consistent distribution to wetland reed beds (Rizzo et al., 2018). Raw effluent is distributed on the surface of the first stage reed bed for a period of three to four days followed by a resting period of about one week (Masi et al., 2017). During the resting period, effluent is alternately distributed to one or more additional first stage reed beds with similar hydraulic loading and resting periods, preserving aerobic conditions and preventing odors (Rizzo et al., 2018). Sludge slowly accumulates on the top layer of the reed bed (10-20 mm y⁻¹) and is removed after 10 or more years. Effluent from first stage reed beds is sent to a pumping station which feeds second stage reed beds in a manner similar to the first (Masi et al., 2017). Subsequent stages vary depending upon the level of treatment desired and may include free water surface wetlands, chlorination, or other tertiary treatment methods. Treatment improves with the establishment of vegetation and growth of a proper sludge layer after year one (Masi et al., 2017).

Figure 1. Schematic of a vertical flow French reed bed (2018). Adapted by Alison Tompkins from multiple sources.

Aeration is commonly used in the secondary treatment of wastewater in traditional treatment plants. It is an important component in the removal and aerobic digestion of organic matter by microorganisms. In conventional and biological wastewater treatment, these beneficial bacteria utilize oxygen to digest organic
matter found in wastewater. This process results in the reduction of organic matter (biodegradation) and the transformation of organic nitrogen into ammonia (ammonification), then nitrite and nitrate (nitrification) and finally nitrogen gas (denitrification). Denitrification is conducted by anaerobic bacteria that convert nitrate to nitrogen gas. Removal of a particular pollutant is typically associated with specific aerobic and anaerobic microbial groups. Aerobic zones increase nitrification while anaerobic zones facilitate denitrification (Faulwetter et. al., 2009). Flow rate and depth of water through the constructed wetland – hydraulic loading – affects the efficiency of pollutant removal by increasing or decreasing the contact time with media that are colonized with microbes. It also determines the type of plant materials used. Feeding modes may be intermittent or continuous. Intermittent modes (also called batch feeding or tidal flow) promote aerobic conditions while continuous feeding promotes anaerobic conditions. In a vertical French reed bed, an ideal hydraulic loading scheme allows formation of the sludge layer on top of the bed and an increase in loading rates, improving efficiency over time (Masi et. al, 2017). Hydraulic retention time is the amount of time effluent is retained in the system. Studies show that nutrient removal is higher using a longer (8 hour) hydraulic retention time than controls with a shorter (4 hours or less) retention time (Chavan et. al., 2008). A lower hydraulic load rate results in more complete treatment, but must be balanced with hydraulic retention time to maximize aerobic and anaerobic conditions for nitrification and denitrification, respectively.

Selection of plant material is also critical to establishing the wetland and sustaining performance (Wu et. al, 2015). The relationship between vegetation, substrate, and living organisms is a major mechanism of pollutant removal in constructed wetlands (Valipour & Ahn, 2016). The use of plants differentiates constructed wetlands from sand filters or lagoons (Vymazal, 2011) and greatly improves aesthetics compared to traditional facilities. Plants provide thermal protection against ice and play an important role in oxygenation, density, and activity of microbial populations in the rhizosphere - the region of soil near plant roots in which chemistry and microbiology is influenced by plant growth, respiration, and nutrient exchange (Wang et. al., 2017). Plant roots are an important location for microbial biodiversity (Faulwetter, 2010), and optimizing conditions in support of the microbial community should be a priority for the effective design of treatment systems (Faulwetter et. al., 2012). Using a polyculture of cold-hardy vegetation further improves pollutant removal (Zhu et. al, 2017; Yates et. al., 2016). In summary, a polyculture of evergreen or deciduous cold-hardy plants with well-developed roots and rhizomes provides insulation against cold temperatures, supports microbial life, and provides oxygenation, all of which improve treatment efficiency and effectiveness. Native plants with these characteristics are preferred to support native wildlife and discourage the spread of invasive and introduced species.

Substrate, or filter media, selection is critical to establishing the wetland and sustaining performance. It provides the growing medium to support vegetation and microbial life and provides surface area for colonization by bacterial biofilms while still allowing water to move through pore spaces (Collison, 2010). Substrates vary in permeability and pollutant-adsorbing capacity. Mixed substrates have reactive surfaces for microbial attachments and high hydraulic conductivity which allows water to move easily through pore spaces. Specific substrates can be selected to target the removal of pollutants such as phosphorus and nitrogen (Austin & Wu, 2016).

Cold climate areas have specific challenges to overcome due to a reduction in treatment performance in cold conditions. Several processes are slowed in cold temperatures: microbial activities (nitrification/organic matter removal, denitrification), plant metabolism rate, chemical precipitation, and adsorption (Yan & Xu, 2014). Wang et al., 2017, found that temperature has a significant effect on ammonium nitrogen and total nitrogen removal efficiencies. Cold climate does not have a significant effect on the removal of total phosphorus, total suspended solids (TSS), biochemical oxygen demand (BOD₅), and chemical oxygen demand (COD) (Vymazal & Březinová, 2014). Despite the challenges noted above, studies have shown that cold climate wetlands can provide treatment performance comparable to tropical regions (Vymazal & Březinová, 2014). For example, a French reed bed effectively treats wastewater from a portion of the city of Orhei, Moldova (population equivalent 20,000), despite winter air temperatures below -20°C and basins covered by ice and snow for several weeks (Masi et. al., 2017). Several common-sense rules can also be applied to reduce temperature losses: utilize southern aspect to increase sunlight exposure, bury filter-feeding pipework and valves, and alternate filters twice a week to minimize filter freeze up (warm wastewater warms the filter, but it cools during rest periods) (Prost-Boucle et. al., 2015).

Reducing the temperature of treated effluent prior to discharge is a significant challenge during summer months, even in cold climate areas. The heat generated by decomposition of organic matter in wastewater combined with high ambient temperatures and low seasonal stream flows often results in water
temperatures that are detrimental to cold water aquatic species such as salmonids. A pilot study conducted in Moscow, Idaho, proved that free water surface flow constructed wetlands effectively reduce water temperature. The study reports that performance could be improved by modifying flow rate, water depth, and wetland vegetation (JUB Engineers Inc., 2015). Additional suggestions include the use of berms and shade trees to reduce solar heat gains during daytime and use of a subsurface flow system to capitalize on subsurface temperature moderation. Comparatively, traditional mechanical methods of cooling water require high energy inputs to operate specialized equipment such as chillers and evaporative cooling towers.

5.2 Case Studies

The Prinsburg, Minnesota, Wastewater Treatment Facility serves a population of 497 (207 households) (Prinsburg Minnesota Community Guide, n.d.) and is sized to accommodate 545 people (20% population growth) by 2020 and treat 206 m$^3$ d$^{-1}$ (54,500 gal. d$^{-1}$) (Environmental Quality Board, 2003). It is located on land previously used for agricultural cropland located between the city and Chetombka Creek (44°56'29.53" N, 95°11'41.54" W). Wastewater is collected by a gravity sewer system connecting a 102 mm (4 in) service line from each home/business to the main sewer line. Wastewater is then pumped by two lift stations to four 76 m$^3$ (20,000-gal.) septic tanks for primary treatment/removal of solids. Over time, sludge accumulates in the septic tanks and requires annual pumping/removal. From the septic tanks, wastewater is discharged into a metering manhole, which splits the flow evenly into four horizontal subsurface flow constructed wetlands with forced bed aeration to increase bacterial oxidation of organic matter. Each wetland cell is 1589 m$^2$ (17,100 ft$^2$) in size for a total of 0.64 ha (1.57 ac). Water flows from the wetlands to two 57 m$^3$ (15,000 gal.) dosing tanks which pump it to two sand filters. The sand filters are a vertical subsurface flow system for secondary treatment. Chlorine disinfection and dechlorination is used prior to discharging treated effluent to nearby Chetombka Creek (Environmental Quality Board, 2003). The October 2004 treatment facility as-bid costs were $1,281,762 USD. The collection system, legal, administrative, engineering, interim interest, and contingencies costs brought the as-bid project costs to a total of $3,300,400 USD. Collection system costs included the construction of city sewer lines because residents previously discharged to an unpermitted underground system. The project was primarily funded by the USDA – Rural Development program, together with funding from Minnesota and the City of Prinsburg. The city employs a public works manager and pays for annual sludge cleanout. Contracted services for system monitoring, maintenance, and operation cost $30,000 USD y$^{-1}$ (Van Dyken, 2018). Project challenges include shallow depth of 4.6 m (15 ft) to groundwater and poorly drained, impermeable soils. Therefore, a PVC liner was used to prevent seepage of wastewater into the groundwater supply. Rodents are discouraged from the site to avoid damage to the liner and underground piping by burrowing activity. Wetland benefits include minimal odors due to the subsurface nature of the system and aesthetics of a naturalistic site. Area wildlife includes deer, raccoon, fox, skunk, rabbits, moles, gophers, mice, waterfowl, songbirds, birds of prey, snakes, frogs, toads and turtles (Environmental Quality Board, 2003). Minnesota is well-prepared to permit constructed wetlands for wastewater treatment, and has permitted 24 of these systems as of this writing.

The Minot, North Dakota, Wastewater Treatment Facility serves a population of 50,000 (North Dakota Department of Health, 2015) and treats 28,391 m$^3$ d$^{-1}$ (7,500,000 gal. d$^{-1}$). Constructed in 1991, it is one of the largest cold-climate constructed wetlands treating municipal wastewater. It is permitted as a lagoon facility with wastewater stabilization ponds (i.e. free water surface constructed wetlands) providing secondary treatment. The system was constructed to upgrade Minot’s previous method of treatment, a five-cell lagoon arrangement. Treatment begins in two eight-acre aeration basins followed by five 57 ha (140 ac) lagoon cells for further treatment and retention prior to entering the constructed wetland. The total wetland portion of the system occupies 65 ha (160 ac) which includes four constructed free water surface wetland cells 51 ha (126 ac) in size. Final treatment occurs in a modified, four km (2.5 mi) drainage way that discharges to the Souris River (North Dakota Department of Health, 2015). The system discharges to the Souris River from May through December and represents most of the Souris River flow during summer months. Therefore, low NH$_3$ parameters are included in the discharge permit (Mander & Jenssen, 2002). The system was designed to equally distribute flow to all four wetland cells, but initially flow was directed to the fourth cell to allow vegetation to establish in other cells (Mander & Jenssen, 2002). Each wetland cell was constructed with five marsh-pond zones of various depths and plant species to serve specific purposes: reduce BOD$_5$ and TSS, facilitate nitrification and denitrification, and remove nutrients and fecal coliform bacteria (Mander & Jenssen, 2002). Aesthetic benefits are similar to Prinsburg on a larger scale, and provide
pond zones and small islands for wildlife nesting and loafing. Treatment efficiency of aerated lagoons and wetlands declines with water temperature during winter months. This is compensated by providing storage capacity for wastewater generated during winter. Adequate removal of NH$_3$ is a challenge (Roerick, 2018). Aerated lagoons achieve good NH$_3$ removal in warm weather through nitrification by bacterial oxidation. Wetlands achieve good TSS and BOD$_5$ in warm weather, but receive low levels of effluent because aerated lagoons are operated to maximize NH$_3$ removal at that time. Effluent to wetlands is increased during cold weather, but wetlands do not function as well at low temperatures (Mander & Jenssen, 2002). The entire system is therefore limited at the front end (aerated lagoons) because wetlands are not at capacity during the most effective time of year. Increasing efficiency or expansion of lagoons would facilitate higher hydraulic loading of wetlands and improve system efficiency.

The Boston Mills Historic District is located in the Cuyahoga Valley National Park, Ohio. Population served is unknown but the system is designed to provide wastewater treatment for six structures in the Boston Mills Historic District: the Hines Hill Complex with Main House, Conference Center and Tenant House, the Boston Store Complex with Visitor Center, public restrooms, and offices, and four 3-bedroom, 2-bathroom residential properties. Average daily water usage was calculated for structures based on water usage records over a 5-month period, October 2003 - February 2004. A 50% increase in water was added to account for summer usage, and preliminary sizing based on estimated design flow of 18.92 m$^3$ d$^{-1}$ (4999 gal. d$^{-1}$) (URS Corporation, 2006). Total cost of installation was $132,507 USD. The use of septic tanks is combined with a free water surface and subsurface flow wetland. Septic tanks provide primary treatment, removing settling and floating solids to prevent clogging of the entry zone into the wetland. Secondary treatment occurs in the subsurface wetland, where aerobic and anaerobic processes remove BOD$_5$ and small suspended solids. Final biological treatment occurs in the free water surface wetland, where effluent is disposed through infiltration and evapotranspiration. A discharge permit is not required because effluent is not discharged to a water body. This significant benefit reduces the amount of permitting and regulatory oversight needed to operate the system. Challenges include lack of access to power and close proximity to the 100-year floodplain which was avoided. The system is located adjacent to the Cuyahoga River, between two highways. The naturalistic look of the facility blends well in the national park. A feasibility study compared the cost of a constructed wetland treatment system to sub-surface drip irrigation (re-use). The constructed wetland system was lower in cost and maintenance and included benefits such as water conservation, zero discharge, and use of solar power (URS Corporation, 2006).

5.3 Federal, State, and Local Agency Review

There are three phases to obtaining a permit to discharge wastewater in Idaho: planning, engineering, and permitting. First a facility plan is developed by a licensed engineer or engineering firm. It is a planning document and engineering report that contains a comprehensive assessment of operational needs and system requirements. It includes information the Idaho Department of Environmental Quality (IDEQ) requires for permitting and eligibility for state grant and/or loan funding for design and construction. The facility plan is reviewed and approved by the IDEQ. The second phase of the permitting process is developing the preliminary engineering report. This report is completed by the community’s engineer (typically a contracted engineer for small communities) and includes plans and specifications for the proposed treatment system. This must also be reviewed and approved by the IDEQ. For the third and final phase, the community may re-apply for a new disposal permit or request modification of an existing permit. Depending on the location and proximity to surface water, this might be an Idaho Pollutant Discharge and Elimination System (IPDES) permit (formerly NPDES permit) and/or a reuse permit. Disposal to surface water requires an IPDES permit and must be approved by the IDEQ prior to implementation of a wastewater treatment system. If no hydraulic connectivity to surface water exists, it may be possible to permit constructed wetlands as a reuse system. This would be similar to rapid infiltration basins that eventually discharge to ground water with the added advantage of cooling water through subsurface seepage and streambank recharge.

For a constructed wetland to be permitted, the system must first be included in a community’s facility plan. A constructed wetland may be included in the facility plan at the request of the community or at the discretion of the engineer serving the community. If the wetland treatment system is not included in the facility plan at the beginning of this three-phase process, it cannot be approved for engineering or permitted for construction. Permitting challenges do exist. Water quality standards are not typically written to accommodate seasonal variations in natural systems like wetlands, despite demonstrated ecological and
social benefits of a wetland system over a mechanical system. Surface water discharge permits generally have a concentration and a load limit with maximum daily, average weekly, and average monthly effluent limitations and varying requirements for sampling frequency. These requirements are usually static throughout the year, which is at odds with the seasonal variability of a wetland system, whether natural or man-made. This creates challenges for engineers who must design a system to meet standards year-round, despite potential for seasonal variability. There are exceptions to static limitations, such as water temperature and ammonia, which sometimes have seasonal limitations in a permit.

Opportunities exist to provide incentives to engineers and permitting agencies in regard to constructed wastewater treatment wetlands. From a regulatory standpoint, constructed wetlands can provide all five beneficial uses of water identified in Idaho Administrative Code (IDAPA 58.01.02.100); they directly support aquatic life, provide recreation area, maintain a sustainable water supply, provide wildlife habitat, and improve aesthetics. Technically they do not qualify as “beneficial uses” while the water is retained in a private treatment system, but benefits are acknowledged by regulatory agencies. Benefits are also felt in the community and impact receiving waters. Aquatic life such as endangered salmonids benefit from improved water quality and lower water temperature. It is important to promote awareness of these benefits at a local level to encourage community support for constructed wetlands and include them in facility plans for treatment systems. Traditional mechanical systems cannot provide these beneficial uses.

Even with community support, permit approval by the regulatory agency poses a challenge because constructed wetlands are relatively uncommon in the United States. From the perspective of communities and engineers, the ability to obtain permit approval and funding for a proposed treatment system is a huge incentive. Engineers and communities depend upon the regulatory agency to facilitate a permitting process that is timely in its review of constructed wetland technology, despite the fact that it has yet to be implemented in Idaho for wastewater treatment. The IDEQ, with its dual role as permitting agency and potential funding source, is ideally positioned to incentivize constructed wetland systems by prioritizing cost-effective constructed wetland projects with demonstrable benefits over mechanical systems.

Total cost of any treatment system includes materials, capital costs for labor and site work, and operation, maintenance, and depreciation over the life of the system. System size and complexity will also affect the overall cost. Selection of a preliminary system design should consider long-term maintenance needs in addition to start-up costs for construction/installation. Low maintenance translates into large cost savings over the lifetime of the treatment system. Standard maintenance of wetlands includes controlling flows during year one to establish vegetation, preventing clogging of filter media/substrate, cutting back vegetation if overgrown, and sludge management (septic pumping or sludge layer removal) (Rizzo et. al., 2018). Once a preliminary wetland design schematic is selected, project costs can be estimated using local cost figures for materials and labor and current cost figures for monitoring and basic maintenance activities.

Costs of a French reed bed system for 500-1000 population equivalent in Italy was studied from 2014-2016 and provides an excellent example of costs for a typical rural Idaho community (Rizzo et. al., 2018). In this case study, cost of new construction was 364 Euros ($417 USD) per population equivalent, translating to $417,000 USD for a system with treatment capacity of 1000 population equivalent. The study also demonstrates that the primary operation and maintenance (O&M) costs of these systems is for energy, personnel for inspections, reed harvesting, and water quality samples (monitoring), with an average annual O&M cost of 5,531 Euros y⁻¹ ($6340 USD). It concludes that construction costs of French reed beds are in line with activated sludge systems in the Italian context, with lower O&M costs compared to classical constructed wetlands primarily due to reduced sludge management. Comparatively, the cost for new construction or renovation of existing mechanical and/or lagoon treatment systems will normally range in the millions of dollars. In a review of IDEQ construction loans issued from 2015-2018 for cities with a population of less than 6,000, loans ranged from $1.09 to $30 million USD.

There are several funding options available for the design and/or construction of wastewater treatment systems (Table 2). USDA, IDEQ, and Community Development Block Grant funding sources can be leveraged together to provide the required percentage of community matching funds. For example, a community can apply for IDEQ and USDA funding simultaneously, citing a 50% community match by using the funding requested/obtained from the other agency (i.e. a $60,000 project can be fully funded with $30,000 from IDEQ and $30,000 from USDA). Grants are very competitive, and a community that demonstrates commitment to completing a project by providing a portion of its own matching dollars may receive a higher priority ranking for funding than a community that does not.
Table 2. Funding programs for wastewater systems

<table>
<thead>
<tr>
<th>Agency</th>
<th>Program</th>
<th>Purpose</th>
<th>Eligibility</th>
<th>Grantor/Community Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idaho Department of Commerce</td>
<td>Community Development Block Grant</td>
<td>Public facilities construction and improvements – sewer, water, etc.</td>
<td>&gt; or = 51% Low-moderate income communities</td>
<td>Minimum 50/50 to be competitive</td>
</tr>
<tr>
<td>Idaho Department of Environmental Quality</td>
<td>Wastewater Planning Grant; State Revolving Fund Low Interest Construction Loan</td>
<td>Wastewater facility planning and construction</td>
<td>Public entities and non-profits</td>
<td>50/50 Planning; 100% Construction</td>
</tr>
<tr>
<td>National Rural Water Association</td>
<td>Rural Water Loan Fund</td>
<td>Water/wastewater project pre-development and small capital projects</td>
<td>Public entities and non-profits, rural communities up to 10,000 population</td>
<td>Maximum $100,000 or 75% of total project cost</td>
</tr>
<tr>
<td>U.S. Army Corps of Engineers</td>
<td>Section 595 Program – Environmental Infrastructure Technical Assistance &amp; Training (TAT) – Water &amp; Waste Direct Loans and Grants</td>
<td>Rural water/wastewater improvements</td>
<td>Nevada, Montana, Idaho; &lt;10,000 population preferred</td>
<td>75/25</td>
</tr>
<tr>
<td>U.S. Department of Agriculture – Rural Development</td>
<td>Technical Assistance &amp; Training (TAT) – Water &amp; Waste</td>
<td>Broad: construction, improvements, relocation, connections, land acquisition</td>
<td>Rural communities up to 10,000 population</td>
<td>Grant - none; Loan - 45/55</td>
</tr>
</tbody>
</table>

6 CONCLUSIONS

Wastewater treatment systems serving small communities must meet federal and state discharge permit requirements and water quality standards, be maintained by one to two staff typically employed by small cities (dedicated to wastewater management only part time), be affordable to construct and maintain, and be sustained by the community for the lifetime of the system. Constructed wastewater treatment wetlands fulfill all these requirements. They also provide ancillary benefits over traditional treatment methods, and do so in a more cost-effective manner. The vertical subsurface flow French reed bed system is preferred because it requires less area per capita (2 m²) than horizontal or free water surface systems and reduces construction and maintenance costs over other constructed wetland designs by reducing sludge management over the lifetime of the system, only requiring removal of accumulated sludge every 10 years or more. Permitting a French reed bed system in the United States may be challenging, particularly in areas where regulatory agencies are unfamiliar with this type of technology. Engineers will bear the burden of demonstrating the safety and efficacy of this and other constructed wetland systems, just as they would with traditional systems. In any constructed wetland, gravity flow should be utilized as much as possible to reduce costs associated with pumping effluent.

Permitting agencies such as the IDEQ are ideally positioned to incentivize constructed wetland systems like the French reed bed by prioritizing projects which provide ecological (habitat, reduced water temperature) and social (recreation, reduced cost) benefits compared to a traditional system. The low cost of constructed wastewater treatment wetlands compared to costs of recently completed construction/renovation of traditional systems in Idaho should provide a strong incentive to consider wetland technology. In addition, five separate funding sources for constructed wastewater treatment wetlands are available to communities in Idaho.
Figure 2. Conceptual site design of a French reed bed system for Juliaetta wastewater (2019). By Alison Tompkins.
A population projection for Juliaetta utilizing a modest growth rate of two percent/year for 20 years yields a projected population of 905 in 2038. A treatment system designed for this population equivalent accommodates future growth and ensures functional capacity over the lifetime of the treatment system. The conceptual plan for rural Juliaetta, Idaho integrates beneficial uses of water with effective site design for a municipal wastewater treatment facility. While the French reed bed will not allow direct contact recreation due to pathogens, it can be incorporated into a landscape design with recreational pathways, benches, river access and wildlife viewing that connect to the city park (Figure 2). Existing, underused gravel parking areas located above flood elevation provide an ideal location for new construction – flood risk is avoided and disturbance of natural habitat is minimized. This plan preserves the existing wastewater treatment system until the new constructed wetland treatment system is operational. Once the new system is operational, the original mechanical system can be decommissioned and storage constructed for water recirculation or reuse. The integration of additional storage for water reuse (irrigation of the city park, agricultural use, etc.) increases flexibility for future uses. Alternatively, storage of treated water provides a convenient supply for the adjacent community fire station, should the need arise.

Additional design recommendations include planting trees and native woody shrubs suitable for riparian and upland ecosystems. Large deciduous trees strategically located south of the constructed wetland provide shade during hot summer months, a critical component for reducing water temperature and supporting cold water aquatic life in the adjacent salmonid-bearing Potlatch River. After leaf fall when temperatures have dropped, sun will reach the wetland and aid in heat retention, supporting biological processes that slow in cold temperatures. Woody shrubs provide shade, cover, and food sources for wildlife, not to mention aesthetic appeal for a site that is highly visible from the adjacent highway. Alternatives to potentially invasive species should include native perennial wetland grasses, reeds, and sedges to maximize treatment efficiency, diversity, and support of wildlife. Opportunities for gravity flow of treated effluent to infiltration basins should also be investigated at the facility planning stage as a means of further cooling water temperature, providing streambank recharge, and permitting as a reuse facility. Effluent receives secondary treatment prior to infiltration and is therefore not at risk of contaminating surface water if flooding of infiltration basins should occur.

The design principles for constructed wastewater treatment wetlands presented here can be applied to other rural communities where sufficient space is available. Critical wetland components can be manipulated to overcome site constraints and treat wastewater to regulatory standards. Constructed wetlands can remove nutrients and solids from wastewater, meet water quality standards, and provide sustainable benefits that traditional engineered systems cannot, such as wildlife habitat, energy savings, irrigation water, and recreation area.

7 DISCUSSION

The research verifies that constructed wetlands provide a cost-effective solution for wastewater treatment and yields design principles that can be applied to conditions faced by small communities everywhere, even in cold climates. Currently, the only advantages of traditional mechanical systems over constructed wetlands are the reduced land area needed for treatment and the acceptance/familiarity of permitting agencies with traditional methods, which can ease the permitting process. This is particularly true in Idaho, where a single constructed wetland for wastewater treatment has yet to be permitted, and less of an issue in states such as Minnesota that are well-versed in the review, monitoring, and permitting of constructed wetlands. With any treatment system, the burden of proof lies with the community and its engineer(s) to demonstrate that water quality standards can be met and public health, safety, and welfare are not at risk.

Federal and state water quality standards and permits require engineering by a licensed engineer and these details beyond the scope of this research, though numerous studies and sources are referenced as a means to that end. Literature and case studies demonstrate that compared to traditional systems, constructed wetlands provide a low energy, low maintenance, cost efficient means of wastewater treatment when adequate land area is available. The literature review includes case studies of effective wastewater treatment systems with detailed specifications for system design, aeration, hydraulic load rate, hydraulic retention time, plants, and substrate. Corresponding treatment efficiencies and effectiveness in cold climates are also detailed in the literature (Rizzo et. al., 2018; Masi et. al., 2017), demonstrating that state and federal water quality standards can be met. Standard maintenance of wetlands includes controlling flows during year one to establish vegetation, preventing clogging of filter media/substrate, cutting back
vegetation if overgrown, and sludge management (septic pumping or sludge layer removal in French reed beds) (Rizzo et. al., 2018).

Collectively, this data provides a basis for the design of a constructed wetland to treat wastewater for Juliaetta, Idaho, and other small communities in cold climates. The design proposal assumes that wastewater from small residential communities is not significantly different than municipal wastewater reviewed in literature and case studies, and that similar design specifications will therefore result in similar and effective treatment efficiencies. Additionally, these criteria provide a basis from which a wastewater treatment wetland could be engineered to operate at or above the same level of effectiveness as those reviewed in literature and case studies. The use of native plants in constructed wetlands is not specifically addressed in literature, though natives are preferred to support native wildlife and prevent the spread of invasive/introduced species. Additional research is needed to identify a regionally appropriate polyculture of native species that can be substituted for invasive and other non-native species.

8 REFERENCES

22. Roerick, J. (Personal communication, 2018) (City of Minot Public Works Department, North Dakota, USA).
32. Van Dyken, S. (Personal communication, 2018) (City of Prinsburg, Minnesota, USA).
NEW TOOLS FOR LANDSCAPE CONSERVATION PLANNING: LOCAL CONSERVATION PLANNING THAT COMPLEMENTS STATE AND FEDERAL CONSERVATION PLANS

GRECO, STEVEN E.
University of California, Davis  segreco@ucdavis.edu

1 ABSTRACT
To achieve sustainable nature conservation across regional landscapes there is a great need for incorporating comprehensive systematic conservation planning at the local level in city and county general plans. In the USA land use is controlled at the local level and conservation lands need to be identified at the local level by addressing all natural communities and native species. Locally-based conservation planning is needed to complement federal Habitat Conservation Plans (HCPs) and state-level plans that typically focus conservation efforts only on a small set of special-status species. General plans for most municipalities lack modern systematic conservation strategies in the mandated “elements” for conservation or open space. These conservation strategies should be scientifically based using ecological principles. HCPs, as prescribed in the federal Endangered Species Act, typically employ these strategies, however, they only focus on conserving listed or likely to be listed species. The state of California’s Natural Community Conservation Planning (NCCP) Program partially addresses the need for more comprehensive conservation and is oftentimes integrated into an HCP planning process. A case study in Yolo County, California is used to explore these conservation planning issues. A novel planning process is described to create a voluntary, non-regulatory “local conservation plan” (LCP) to complement a federal HCP and a state NCCP for the county. The LCP subsequently was integrated into a new conservation planning tool in California called a Regional Conservation Investment Strategy (RCIS) that facilitates advanced mitigation. The research objectives for this article are to: (1) describe the relationship between municipal general plans and conservation planning using a case study, (2) contrast two types of conservation planning, one at the federal level (the HCP) and one at a state level (the NCCP), (3) present two new concepts, or “tools,” for local conservation planning (the LCP and RCIS) that complement the federal and state tools, and (4) discuss approaches for the future of sustainable landscape conservation.

1.1 Keywords
Habitat conservation plan, natural community conservation plan, regional conservation investment strategy, local conservation, general plans
2 INTRODUCTION

A key objective of sustainable landscape conservation is the long-term maintenance of wildlife populations and natural communities, and "virtually all conservation issues are ultimately land-use issues" (Wiens, 2003, p. 3). To achieve sustainable wildlife conservation across regional landscapes there is a great need for incorporating comprehensive systematic conservation planning into local planning processes and to coordinate among multiple spatial scales including the local and ecoregional scales to continental scales (Baldwin et al., 2018; Huber et al., 2010; Powell, 2010). In this context, “comprehensive” means conservation planning for more than only special status species. In particular, we need to incorporate comprehensive systematic conservation planning principles into city and county general plans and coordinate those plans with regional conservation plans. In the USA land use is controlled at the local level (Duerksen et al., 1997) and conservation lands need to be identified at the local level by addressing the needs of all natural communities and native species. Locally-based conservation planning is needed to complement federal Habitat Conservation Plans (HCPs) and state-level plans that focus conservation efforts only on a small set of special-status species, such as Natural Community Conservation Plans (NCCPs). Regional advanced mitigation planning (sensu Thorne et al., 2009) could also benefit from this approach.

2.1 What is landscape conservation?

A typology of 'landscape conservation' by Hackett (1980) describes three main aspects of the field including (1) natural landscapes, (2) archeological landscapes, and (3) historic landscapes (including parks and cultural gardens). This paper focuses on natural landscapes. Campellone et al. (2018, p. 65) define landscape conservation as: “…the rapidly growing practice of people working together across large geographies, regardless of political boundaries, to conserve our natural and cultural heritage and ensure a sustainable future for both people and nature (Network for Landscape Conservation, n.d.). It connects wild lands, working lands, and urban areas into whole, healthy landscapes [or social-ecological systems], and enhances the conservation value of all lands [and waters] through the development of strategies that promote adaptation and resilience.” Equivalent terms for landscape conservation are “large landscape conservation” or “landscape scale conservation” (Network for Landscape Conservation, n.d.).

2.2 What is systematic conservation planning?

A seminal paper by Margules & Pressey (2000) describes a framework for systematic conservation planning as a six-stage process. The process begins with an inventory as the first stage to compile data on the planning region. The second stage identifies conservation goals and objectives, including quantitative and qualitative targets and selection of focal species. The third and fourth stages involve reviewing existing reserves and selecting additional reserves through techniques such as conservation gap analysis and assessment of complementarity, irreplaceability, and vulnerability. The fifth stage is implementation of conservation actions which involves management decisions, assessing feasibility, and timing. Finally, the sixth stage is to maintain the conservation values through adaptive management techniques designed to monitor species and natural communities and potentially change management as new data informs future decisions. Two key aspects to systematic conservation planning are (1) creating a connected network of representative local ecosystems and the species that use them, and (2) long-term persistence of those populations and ecosystems through maintaining habitat (natural plant communities) and ecosystem processes. Critiques of this approach to systematic conservation planning identified a lack of social science in the planning process (e.g., stakeholder identification) and an update to this protocol was published by Sarkar & Illoldi-Rangel (2010) adding seven more stages and refining the planning process for a total of 13 stages or planning components (also see Pressey & Bottrill, 2008).

2.3 General plans and landscape conservation

General plans for most municipalities typically lack modern systematic conservation planning strategies in the mandated plan "elements" for conservation or open space. These conservation strategies should be scientifically based using ecological principles. Over the past three decades the development of the field of landscape ecology has been highly informative to the field of conservation biology and vice-versa.

John Wiens provides insight to how the two fields intersect in a paper entitled “Landscape ecology as a foundation for sustainable conservation” (Wiens, 2009). In it he explains four themes from landscape
ecological theory that inform conservation: (1) “context”—that functional habitats are largely dependent on spatial configuration of larger land cover mosaics; (2) “threats”—the surroundings of a reserve may produce negative edge effects from human land uses that can reduce the actual size of a reserve; (3) “scale”—an administrative area may not match the spatial needs of wildlife populations, disturbance regimes or ecosystem processes; and, (4) “sustainability”—human activities will require tradeoffs between land use and biodiversity values (Wiens, 2009).

The field of conservation biology has also produced a classic set of reserve design principles reviewed and presented by many in the field (Diamond, 1975; Noss et al., 1997, Primack, 2004). These design principles have also been adapted to be used in city and regional planning (Dramstad et al., 1996; Soule, 1991). The design guidelines were developed from observations stemming from island biogeography theory being applied to fragmented landscapes in terrestrial systems, however, most island theory has largely been replaced by landscape ecological and metapopulation dynamics theory (Laurance, 2008).

2.4 HCPs: Threatened and endangered species conservation

A HCP, as prescribed in the federal Endangered Species Act, is a type of biodiversity offset program for threatened and endangered species designed for compensatory mitigation due to impacts from human land uses. HCPs typically employ modern conservation strategies, however, they focus only on conserving threatened and endangered species or species likely to become listed and do not address the conservation needs of any other species. Typically, large-scale HCPs (such as a county with multiple projects) require many years (>10) to complete and can cost millions of dollars for the planning process, depending on the area, its complexity, and the number of species involved. At its core, a HCP is an "incidental take permit" meaning listed species in the plan and their habitat can be destroyed in exchange for conservation elsewhere (Noss et al., 1997). The HCP has a time period over which the take permit is valid, generally ranging from 10-100 years and plan spatial extents can vary from a single property to entire counties or multiple counties. Since the amendment to the federal ESA in 1982 that created the HCP program it has become quite popular. There are now hundreds of HCPs that have been approved or are in development nationwide.

For municipalities that decide to invest in creating a HCP, an advantage to having one is streamlining the permitting process for human land use development. A developer simply needs to write a single check (permit fee) to the implementing agency (usually the county itself; which ensures local control) and no further negotiation or mitigation action is needed. Without an approved HCP a land developer would have to negotiate with the US Fish and Wildlife Service and mitigate on a project-by-project basis, resulting in potentially enormous legal fees, great uncertainty in approval, and long delays in starting a project. The resulting compensatory conservation actions are also ad hoc and uncoordinated and can result in piecemeal mitigation that does not function as intended (McKenney & Kiesecker, 2010). An advantage to implementing a HCP is coordinated mitigation that can result in larger, more connected and more functional reserves.

2.5 Criticisms of HCPs

There are numerous criticisms leveled against HCPs. Many criticisms center on the uncertainty of the science and the assumptions of models used for planning while others are wary of a lack of scientific peer-review, a lack of adequate monitoring, a lack of context planning, a lack of assurances that species will survive (given the "no surprises" policy and "safe harbor" agreements), lack of an ecosystem approach, a lack of recovery plans with designated critical habitat identified, among others (Duerksen et al., 1997; Noss et al., 1997). A particularly worrisome criticism is that HCPs have a "jeopardy" standard for species' populations rather than a "recovery" standard, meaning the intrinsic population growth rate of a listed species in a HCP does not have to achieve positive levels and result in population size increases, but, rather, be maintained at current population levels (Stanford Environmental Law Society, 2001). Many, but not all, of these criticisms have been addressed in the California NCCP Act.

2.6 NCCPs: Natural community conservation planning in California

The state of California’s Natural Community Conservation Planning (NCCP) Program partially addresses the short-comings of HCPs and the need for more comprehensive conservation (Noss et al., 1997). In California a NCCP is optionally integrated into a HCP planning process. A significant feature of the NCCP planning process is that it allows species not officially listed as threatened or endangered to be
included in the plan. This effectively elevates alternative “special status” species for plan consideration. The California Department of Fish and Wildlife (CDFW) has several special status species categories including one called “species of special concern” and another called “candidates” for the California Endangered Species Act (CESA)—species that are nearing endangerment status. The other significant feature of the NCCP planning process is the inclusion of a list of all the natural (plant) communities in the plan area that act as habitat for the plan’s covered animal and plant species. Conservation targets are developed for both.

Additional benefits of the NCCP process are (1) the requirement for an independent science review team to advise the Board and the Advisory Committee, and (2) NCCPs require a recovery standard for listed species populations, exceeding the HCP jeopardy standard. Both HCPs and NCCPs require monitoring (with an endowment fund) to inform adaptive management to verify success or failure of the plan.

Despite the criticisms of HCPs discussed above, there is some evidence that a HCP combined with a NCCP can be an effective conservation tool. In a case study using San Diego County, California, Underwood (2010) compared a region of the county with an approved and implemented HCP/NCCP in one portion but not in another, and found the HCP/NCCP area “increased conservation for many rare species, often 5-10 times more than the comparison area” (Underwood, 2010, p. 121). Thus, for species and natural communities listed in the plan, the conservation plan appears highly effective, as opposed to having no plan.

2.7 New Tools: Local conservation plans (LCPs) and RCIS

Comprehensive systematic conservation planning is missing from nearly all municipal general plans. The logical place to put these planning concepts is in the “open space” or “conservation” elements that cover natural resources and management for any home rule jurisdiction (see OPR, 2017). Oftentimes the conservation element needs to cross-reference the land use element and/or the open space element, especially in regards to agricultural land and its potential role in conservation. In most current general plans the principles of systematic conservation planning are used in vague and general ways and are non-comprehensive in nature. If a species list is included it usually is a list of special status species (e.g., threatened or endangered species) which is inadequate for comprehensive conservation.

Local conservation plans (LCPs) that include all the stages of systematic conservation planning and address all species and natural communities in the municipality should be incorporated into the open space and conservation elements of all general plans. Federal and state wildlife agencies should provide outreach and funding to assist in these efforts when general plan updates are scheduled for any municipality. In essence a LCP is a “permitless” conservation strategy which is not necessarily approved by a wildlife agency, but a framework for comprehensive conservation planning of a local municipality. It should be noted that this idea (i.e., the local conservation plan) is new and is not yet an established term, or concept. The idea grew out of the East Alameda Conservation Strategy (ICF 2010), a county-based plan in California.

In 2016 a new law by the California legislature created the CDFW’s Regional Conservation Investment Strategy (RCIS) Program. This is a voluntary and non-regulatory program to encourage local jurisdictions and state agencies to collaborate on identifying future conservation needs, priorities, and actions for advanced mitigation purposes (CDFW, 2018). A RCIS plan would “increase options for project proponents, including public infrastructure agencies, to create compensatory mitigation that supports regional conservation priorities in advance of the impact” (CDFW, 2018, p. 1-1). There are three parts to this program: (1) regional conservation assessments (RCAs), (2) regional conservation investment strategy (RCIS), and (3) mitigation credit agreements (MCAs). The RCA is an ecoregional assessment at a landscape scale that puts a locality within its in context; this is an important but optional planning process for developing RCISs and MCAs. However, a RCIS must be approved before an MCA can be developed.

3 RESEARCH OBJECTIVES

The research objectives for this article are to: (1) describe the relationship between municipal general plans and conservation planning using a case study, (2) contrast two types of conservation planning, one at the federal level (the HCP) and one at a state level (the NCCP), (3) present two new concepts, or “tools,” for local conservation planning (the LCP and RCIS) that complement the federal and state tools, and (4) discuss approaches for the future of sustainable landscape conservation.
4 METHODS

To explore the issues presented above, a case study approach is used to describe (1) the current General Plan in Yolo County, California, (2) a process to develop a federal HCP and a state NCCP conservation plan, and (3) the creation of a voluntary, non-regulatory comprehensive local conservation plan (LCP) to complement the HCP/NCCP. The jurisdiction of Yolo County, in the Central Valley ecoregion of California, is used as an example (Figure 1). To begin the process of creating a LCP and the rationale for it, I co-authored a white paper for the Advisory Committee of the Yolo Habitat Conservancy (YHC) (formerly known as the Yolo Natural Heritage Program or “Yolo NHP”) to explain the need for it (see Greco et al., 2013). With extensive input and multiple revisions, I wrote a second white paper to articulate six biological and ecological goals and 32 sub-goals with five notes on prioritization for the Yolo County LCP (Greco, 2015).

With approximately $40,000 of “seed funding” allocated from a state wildlife planning grant, the YHC Board contracted with the Yolo HCP/NCCP plan consultant, ICF (Sacramento, CA), to prepare a first draft LCP in 2016. This draft was based on (1) the two white papers, (2) species accounts and data from the first administrative draft of the HCP/NCCP that were not used in the second administrative draft (the dropped species, see Results section), and (3) conducting numerous meetings with the Biological Subcommittee of the YHC Advisory Board (including myself and four others) to refine the concepts and approach. In 2017 Yolo County was chosen as a pilot project for the new RCIS program. The draft LCP subsequently was integrated into the new RCIS conservation planning tool in California.

Figure 1. The location of Yolo County (black fill) within the California ecoregion of the Landscape Conservation Cooperative (LCC) and the sub-ecoregions in the state of California and Baja California. Map graphic by the author. Data obtained from Data Basin (https://databasin.org).
5 RESULTS

5.1 Yolo County General Plan
The Yolo County General Plan was updated in 2009 and contains a combined conservation and open space element that lacks comprehensive systematic conservation planning methods. It contains a single species list with 38 special status species. The County of Yolo 2030 Countywide General Plan’s implementation program for the Biological Resources portion of the Conservation and Open Space Element calls for adopting and implementing the Yolo HCP/NCCP developed through the Yolo Natural Heritage Program (the former name of the YHC) and integrating it into the general plan (see Action CO-A26; Yolo County, 2009).

5.2 Yolo HCP and NCCP
A HCP and NCCP planning process was conducted from 2002-2018. The first administrative draft was completed in 2013 and covered 32 special status species and 25 natural communities (including agricultural semi-natural types). The estimated cost of implementing the first administrative draft was determined to be too great and with the advice of the USFWS, the species and community lists were reduced in scope. The second administrative draft for the Yolo HCP/NCCP was completed in 2017 and covers 12 special status species and 19 natural communities (including agricultural semi-natural types) with a permit period of 50 years (YHC, 2017). The cost of developing the second administrative draft was $4.9 million. The implementing county agency is the Yolo Habitat Conservancy that consists of a joint powers authority (JPA) Board (membership consisting of an elected representative from each member agency: Yolo County, and the cities of Davis, Woodland, Winters and West Sacramento, and an ex-officio member from UC Davis) and an Advisory Committee. The YHC Advisory Committee that assisted in developing the plan consisted of an Executive Director and support staff along with three stakeholder groups (environmental, agricultural, and urban development) each having approximately 3-5 representatives for a total committee size of about 12-18 members at any one time.

Of the 12 special status species selected for the plan, two are federally endangered (one bird and one plant), four are federally threatened (one reptile, one bird, one invertebrate, and one amphibian), two are exclusively California state threatened (both birds), one is a CESA Candidate (a bird), one is California “fully protected” (under California Fish and Game Code) (a bird), and two are California “species of special concern” (a bird and a reptile). It should be noted that there are no mammals or fish on the Yolo HCP/NCCP covered species list.

5.3 Yolo LCP and RCIS
From 2015-2018 a combined draft LCP/RCIS was developed as a conservation framework for the species not covered in the Yolo HCP/NCCP (see ICF, 2018). An administrative draft was completed in 2018. The LCP/RCIS contains three focal species lists with 40 species for the RCIS and 71 species for the LCP.

As noted above there are no mammals on the official HCP/NCCP species list, however, as part of the NCCP process, an Independent Science Review Team recommended several wide ranging (non-special status) mammals that are designated as “planning species,” including mule deer and American badger, for habitat connectivity planning over the broader landscape (Spencer et al., 2006).

6 DISCUSSION
The future of landscape conservation requires both a bottom-up approach (e.g., city and county general plans, HCPs, NCCPs, LCPs, and RCISs) and a coordinated ecoregional top-down approach (with federal and state leadership) to achieve meaningful and sustainable conservation results (Baldwin et al., 2018). This multi-scalar approach integrating local and regional scales is critical to future success of landscape conservation planning because important local habitat resources can be omitted in regional planning analyses and local planning can myopically miss regional connectivity patterns (Huber et al., 2010).

A key challenge with HCPs and NCCPs is the sheer cost and length of time to needed to complete them. Frequently, an elected representative must take on the role of being the “champion” of the project and since the process can be complex and require a steep learning curve, losing a champion between election cycles can severely set back a plan’s progress leading to delays or abandonment. Also, attracting and retaining knowledgeable experts on the Advisory Committee over long time periods can be problematic.
Some municipalities simply lack local experts or environmental advocacy groups exposing a lack of community capacity to even undertake a HCP/NCCP process.

An important aspect of the Yolo RCIS/LCP is its voluntary, non-regulatory approach. Local control is a large issue in Yolo County and out-of-county mitigation is a local concern (i.e., that other nearby municipalities outside Yolo County will use Yolo County to mitigate their impacts—creating competition and thus creating higher prices for Yolo County project mitigation). This was a major concern for the HCP/NCCP planning process. For the RCIS/LCP the concern was additional costs associated with additional conservation and where the funds would come from. To get local political support it had to be deemed voluntary and non-regulatory. The RCIS component would receive funds from an agency that has succeeded in establishing a MCA from an approved RCIS. The LCP is dependent on receiving funds from grants or philanthropy. The advantage for Yolo County is that by having a LCP this type of funding can be attracted more readily.

Federal and state wildlife conservation agencies need to fulfill a local leadership role by assisting local municipalities with data and expertise to develop LCPs as part of, or as an addendum to, general plan open space or conservation elements (similar to how university extension agents help local farmers). These larger agencies frequently develop regional plans but have no way to implement them because all land use planning is done at the local home-rule level. A good example of this type of planning is the “Essential Habitat Connectivity Project” by the CDFW in California (Spencer et al., 2010). In this statewide study key connected and intact habitats were identified to act as, or to preserve as, wildlife corridors, but there are few local plans to implement it. Federal and state agencies need to provide the leadership (and funding) to bring these plans to the local level from the regional analysis level.

6.1 Landscape Conservation Cooperatives (LCCs)

In 2010 the US Fish and Wildlife Service created a program called Landscape Conservation Cooperatives (LCCs). The objective of the program is to apply systematic conservation planning to large regional landscapes to develop ecoregion plans and account for climate change. The LCC program divides North America into 23 ecoregions (Figure 2) and each ecoregion is further subdivided into sub-ecoregions. As an example, the California ecoregion is divided into seven sub-ecoregions (Figure 1).

![Figure 2. Landscape Conservation Cooperative (LCC) ecoregions in North America. The Pacific Islands and Caribbean ecoregions are not shown. Map graphic by the author. Data obtained from Data Basin (https://databasin.org).](image-url)
Importantly, in California the LCC ecoregions and sub-ecoregions could create the regional conservation areas (RCAs) needed to give RCISs the proper context for local planning as discussed above. The LCC ecoregions and sub-ecoregions could act as a framework for regional and continental conservation strategy.

Unfortunately, the current US administration has allocated nothing in its current budget for the LCC Program and its future is uncertain. What is certain, however, from the standpoint of the scientific community, is that the LCC program is on the right track towards creating a sustainable ecological network at a continental scale (Baldwin et al., 2018).

6.2 Engaged scholarship and landscape conservation

Since 2015 I have participated in eight meetings of the California LCC to develop a pilot landscape conservation plan using the sub-ecoregion boundary of the Central Valley in California (Figure 1). This project is attempting to use cutting edge science and systematic conservation planning to create a “climate smart” landscape conservation plan (*sensu* Groves et al., 2012; Stein et al., 2012; Stein et al., 2014) using a suite of focal species and natural communities. I was invited to these meetings because I have much expertise with several threatened and endangered species in the Central Valley, as well as the habitat types and natural communities.

The most significant outreach project I have participated in over the past decade is serving as an Advisory Committee member for the Yolo Habitat Conservancy (YHC) since 2010. I was nominated and appointed to be an environmental stakeholder (by a Davis City Council member), since that is my professional expertise. Since 2012 I participated in 38 Advisory Committee meetings in Woodland, CA, and 30 ancillary meetings related to the work of the Advisory Committee, such as subcommittee meetings. Occasionally I was asked to chair some of the Advisory Committee meetings. All of these stakeholder meetings were at least 2-hours in length. In addition to these meetings, I participated in 29 meetings of the Yolo Habitat Conservancy Board (the Joint Powers Authority that oversees the Advisory Committee). I frequently gave testimony and advice to the Board, as well as reporting progress of the Advisory Committee. Advisory committee members frequently worked with personnel from the environmental consulting firm ICF to review and edit the conservation plan(s) chapters. Final approval of the Yolo HCP/NCCP from the federal, state, and local officials occurred in the summer of 2018 and this was a major accomplishment.

The service work described above relates directly to my teaching and research programs at UC Davis. My research program with the Agricultural Experiment Station is entitled “Landscape Conservation Planning and Design: Enhancing ecological function through reconciliation of cultural and natural systems.” My teaching program includes an undergraduate course called “Site Ecology” (LDA 050) where I teach introductory landscape conservation concepts and a graduate seminar called “Landscape Conservation” (LDA 280) where more advanced research is explored and discussed. This seminar focuses on theory and application of landscape ecology to conservation planning, design, and management techniques for natural resources. It examines ecological theory, methods, policy, and case studies as it relates to the establishment and management of conservation areas. Climate change and reserve design are recurrent themes in the course.

The learning objectives for the graduate course are presented below (Table 1). My outreach work feeds back directly to my research and teaching and vice-versa. I bring to the classroom what I learn in research and what I learn in my “real world” service projects, and I bring what I learn in doing research and teaching to my service projects. The profession of landscape architecture needs to embrace not just the field of ecology, but the field of conservation planning and design—the strategic application of ecological principles. This is a landscape architecture pedagogical imperative.

<table>
<thead>
<tr>
<th>Learning Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To articulate the principles of landscape ecology, biological conservation, and systematic conservation planning</td>
</tr>
<tr>
<td>2. Be able to explain the following concepts: patch-matrix model, patch dynamics, succession, disturbance, habitat analysis, ecological networks</td>
</tr>
</tbody>
</table>
3. Learn conservation policy: federal Endangered Species Act, California Natural Communities Conservation Planning (NCCP) Act
4. Understand basic components of habitat conservation plans (HCP) and NCCP plans
5. Explore systematic conservation planning methods, such as conservation gap analysis, focal species, wildlife-habitat relationship modeling
6. Analyze the human dimension of conservation planning & the role of environmental ethics
7. Explore case studies

7 CONCLUSIONS
It is essential to start integrating systematic conservation planning into municipal general plans at the local level. This approach promotes comprehensive conservation and focuses beyond special status species. This is critically important to prevent future listings of endangered species and to sustain existing wildlife populations and natural communities. However, HCPs and NCCPs are both optional planning processes and most municipalities will not engage in those processes due to time, expense, politics, and lack of local experts (i.e., inadequate community capacity). Therefore, federal and state wildlife conservation agencies need to develop outreach programs to proactively assist local governments in developing comprehensive systematic conservation plans for their respective open space or conservation elements within their general plans. This type of effort will result in greater sustainability of local wildlife and plant communities for future generations. As Nina-Marie Lister (2017, p. 31) so wisely states in the New Landscape Declaration, "we must (re)weave the tapestry of the wild back into the landscape of the future. ... To lose the wild is to lose that which makes us most human."

8 ACKNOWLEDGEMENTS
This work was supported by the USDA National Institute of Food and Agriculture, Hatch Project 1011533. I wish to thank the Yolo Habitat Conservancy Board and Advisory Committee members and others with whom I collaborated on the development of the Local Conservation Plan for Yolo County, including C. Roberts, J. Hopkins, G. Holstein, ICF consultant E. Berryman, YHC Executive Director P. Marchand, and YHC staff members S. Garbini and C. Alford, for their professional advice, guidance, and support. The author thanks E. Berryman and P. Huber for reviewing and providing useful comments on an earlier version of this article.

9 REFERENCES


IDENTIFYING OIL SPILL HAZARDS IN NORTH DAKOTA, THROUGH HYDRAULIC MODELING AND CONSERVATION PLANNING

SONG, YANG
North Dakota State University, y.song@ndsu.edu

DAVIS-KOLLMAN, MORGAN
North Dakota State University, morgan.daviskollma.1@ndsu.edu

1 ABSTRACT
North Dakota is the second largest in oil production in the United States with 85 paramount oil spills within the last 20 years. In 2006, a broken pipeline burst more than a million gallons of brine wastewater into Charbonneau Creek in Northwestern North Dakota, altering ecosystem services and the residents who relied on the land and surrounding water bodies. These Oil spills are extremely unpredictable, with little available information of when, where and how they occur. While most literature focuses on the reporting protocol and response actions, this study will propose an analytical strategy to estimate the environmental threat of oil spills to water resources through environmental planning. Geospatial and hydraulic modeling tools will be introduced using USGS StreamStats for watershed-based drainage delineations, basin characteristic visualization, and streamflow estimation. Impacted land uses will be examined and analyzed to inform environmental intervention. The result will present an efficient framework for hazard identification, vulnerability analysis and ecological planning for an endangered watershed area on Fort Berthold Reservation. The goal is to produce new perspectives on possibilities of creating a more resilient and sustainable tribal community.

1.1 Keywords
Geographic Information System, Hazard identification, Oil Spill, Conservation Planning
INTRODUCTION

North Dakota state is ranked number two in US in oil production, just behind the state of Texas, producing 1.3 million barrels of oil per day (Crude oil production, 2017). Approximately 1.4 million crude oil with regulated hazardous liquid run with pipelines across the state, with loose regulations on oil spill reporting (David, 2016; Oil Transportation Table, 2018). However, the state does not require that the public be notified in the event of an oil spill, making it a closed-door industry. Research in many regions throughout the nation have shown that contamination from fracking has been fairly sporadic and inconsistent; in North Dakota it is widespread and persistent, with evidence of direct water contamination from fracking (Daniel, 2016). A recent analysis from 2013-2017 found that 42% of oil and 57% of brine spilled was uncontained, spewing nearly 37,000 barrels of oil and over 169,000 barrels of toxic saltwater. Lack of regulation and expansion of industry has enabled an average of 4.4 spills a day across the state since 2013 (Springer, 2016).

2.1 Environmental hazard within the pipeline oil spill

Pipeline spills are releasing toxins into soils and waterways at alarming rates, exceeding the nation’s water quality standards (Scientists Say Oilfield, 2016). One gallon of wastewater or oil can make nearly a million gallons of freshwater undrinkable (Office of Research and Development, 2016). This improper disposal of these contaminants percolate and infect the groundwater, damage surface soil, water resources and inhabitants of the affected area. With increased implementation of wells and pipelines, the number of spills and leaks have followed. In the United States on average, from 1986-2013, one significant oil or gas pipeline incident occurred every thirty hours (Daniel, 2016). Spills and pipeline failures transpire in a variety of ways such as mechanical failure, human error and/or subfreezing temperatures which cause ruptures within the system (Pipeline Risks, 2017). The implementation of metals into water sources inhibits carbon, sulfur and phosphorus mineralization and nitrogen transformations, hindering photosynthesis and reproduction cycles. Due to the rise in spills, corruption of natural resources has multiplied. Only about 20% of oil compounds degrade within water, revealing 35x the level of ammonium and selenium in sampled water that the United States Environmental Protection Agency considers safe for freshwater aquatic life and use (Office of Research and Development, 2016).

2.2 Fort Berthold reservation

The increase of oil rigs and pipeline development across the Western part of North Dakota have led to detrimental impacts within Native American reservations. Most of them do not benefit from oil discovery and extraction financially and many times suffer environmentally which influence their vital farming and ranching practices. Fort Berthold is one reservation within the Bakken, with tribal land being owned by Native American as individual allotments or communally by the tribe (Three Affiliated, 2016). As of March 2016, 15,013 registered tribe members were reported (Demographics | North, 2016). This tribal land is subjected to serious threats from oil industry since North Dakota Department of Health revealed more than 8,000 spills [both pipeline and rigs] were recorded from 2008 to 2015 in the region (Cozzarelli et al, 2017).

2.3 Oil spill contingency planning and environmental planning

Most of the current effort on oil spills are based around the containment and recovery, focusing on the techniques after the oil spill event. Typical strategies include the use of booms, skimmers, sorbents or in-situ burning and other specifics (Oil Program Center, 1999, p9-18). The Environmental Protection Agency (EPA) has also specified a contingency plan for preparing oil spills events which consist of hazard identification, vulnerability analysis, risk assessment the use and response action. However, this contingency plan does not provide environmental planning guidance but “like a ‘game plan,’ or a set of instructions that outlines the steps that should be taken before, during, and after an emergency” (Oil Program Center, 1999, p27).

Environmental planners perform duties lie (March 2010, p24) hazard assessment which specifically aim for identifying vulnerable areas in environments where an industrial use exists and would risk damage to occur. Risk Management involves building strategies dealing with hazards and providing emergency relief services. Both Hazard Assessment and Risk Management planning started gaining serious attention to issues such as storm surge, riverain flooding, earthquake, and wildfire (p.24), while oil spills are rarely investigated in the field of environmental planning.
2.4 Hydrological analysis

Water is the key component in environmental planning problems (Dunne, T., & Leopold, L. B., 1978). Planners and landscape architects use hydrological analysis to understand the movement of water over and under land surface, as well as the geomorphic, geochemical and biologic processes of water flow. Specifically, the estimate of the rate and amount of runoff as overflow is extremely important. The runoff is currently calculated using runoff models such as rational methods, Unit Hydrograph, SWAT, HSPF, HEC-HMS, etc., (Sitterson et al, 2017) which involve extensive data collection such as rainfall record, land use, slope and topography, soil properties, runoff coefficients table, etc. Resulting parameters like 10-year peak flow and annual runoff could help planners specify areas with intense hydrological processes to inform actions, goals, and developments for resilient communities.

In this paper, we investigate the environmental hazard and vulnerable environments around Fort Berthold Reservation in North Dakota by implementing USGS StreamStats, a web based analytical service. The goal is to present a form of analytical framework for environmental planning issues around pipeline oil spills.

3 METHODS

3.1 Watershed and flow network

This study uses Lake Sakakawea basin as the main study area for 4,940,539.18 Acres (6-digit HUC 101101) where the Fort Berthold Reservation is located at the south end downstream of the basin (Figure 1). Based on 2011 National Landcover data, the basin has roughly 36% of land as Herbaceous, 44% Cultivated Crops, 3.1% Development, 2.4% wetland, 1.8% deciduous forest, 1.3% shrub/scrub. 8.5% is Open Water where Lake Sakakawea is a 307,000-acre man-made reservoir created by Garrison Dam.

Since most oils are lighter than water, they flow on top of the water. Many oil spill incidents reach and damage lakes, rivers and wetlands through the surface flow network (Oil Program Center, 1999, p5-8). In January 2015, a pipeline burst contributed to a spill of over 3 million gallons of oil and wastewater into nearby Blacktail Creek and traveled 27 miles to reach the Missouri River (Cozzarelli et al, 2017). GIS data on flow network from NHDPlus Dataset by EPA was collected to the creeks, rivers, streams, canals, lakes, ponds etc. in the study area. This will help us locate the likely hazardous and vulnerable areas after oil spill incidents occur.
3.2 Hydrological analysis through StreamStats

Developed by the U.S. Geological Survey (USGS), StreamStats is a web application that provides hydrological modeling functionalities for water resources planning and management, and engineering purposes (Kernell G et al, 2008). This study will focus on two tasks using StreamStats:

3.2.1 Drainage basin delineation:

As the sample StreamStats report shows in Figure 2, the USGS StreamStats provides web services to delineate the drainage basin for a stream point (SP) of interest by integrating multiple datasets, such as the National Hydrography Dataset (NHD), the Watershed Boundary Dataset, and the 3D Elevation Program. In this study, we collected 101 points of interests where the streams enter the land boundary of Fort Berthold Reservation and then ran all the drainage basins for these points of interests. The resulting drainage basins will show all the areas where surface runoff flows into Fort Berthold Reservation to help identify the impacted watershed by potential Oil Pipeline Spills.

3.2.2 Streamflow modeling

The other key function by StreamStats is the automatic estimation of Streamflow Statistics for each drainage basin delineated (Figure 2). With large amounts of data from more than 25,000 Gaging Stations around the United States (USGS Gage Locations, 2018), the USGS has developed many regression equations that can be used to estimate various streamflow statistics for locations on ungauged streams throughout the nation. As an example, the equation for estimating the 100-year flood for ungauged sites of Northern Idaho is:

\[ Q_{100} = 5.39 \times DA \times 0.0874 \times (E/1000) - 1.13 \times P \times 1.18 \] (Berenbrock, 2002)

Where: \( Q_{100} \) is the peak flow that occurs, on average, once in 100 years (1-percent chance of occurrence in any year), in cubic feet per second; \( DA \) is the drainage area, in square miles; \( E \) is the mean basin elevation, in feet; and \( P \) is the mean annual precipitation, in inches.
StreamStats will automatically detect the correct equation for the drainage basin of interests and generate corresponding flow statistics. There are also API and batch services available for requests with multiple basins (only 200 requests are allowed each time). In this study, we developed a customized StreamStats requesting script using Python to fetch all the drainage basins and their corresponding 10-year peak flow rate in GeoJson format. All results will then be aggregated into a shapefile for further analysis.

![StreamStats Report](image)

**Figure 2. StreamStats Report**

### 3.3 Hazard Indexing

After the hydrological analysis using StreamStats, we are able to estimate how much stormwater runoff will flow through each stream point (SP) on the reservation boundary at a 10-year event. We then estimated the overall runoff ratio of each cubic feet of rainfall at a 10-year event use (similar concept with Rational Method) the following equation:

\[
R_{10\text{-YEAR}} = \frac{3600 \times 12 \times Q_{10\text{-YEAR}}}{1.8 \times A}
\]  

Where \(R_{10\text{-YEAR}}\) is the runoff ratio of each cubic feet of rainfall at the 10-year event in the area; \(Q_{10\text{-YEAR}}\) is the 10-year peak flow of the drainage basin calculated from StreamStats, in cubic ft per second; 1.8 is the 10-year rainfall intensity of the study area in inch per hour (Hershfield, D. M., 1961); \(A\) is the area of the drainage basin, in square ft;

We then estimate the level of oil spill hazard by calculating a Hazard Index that using three assumptions:

1. Oil spills flow with the storm runoff, the \(R_{10\text{-YEAR}}\) equals the runoff rate of each cubic feet of oil spill at the 10-year event in the area.
2. The probability (P) of oil spill per mile pipeline is equal and independent.
3. The estimated damage of a pipeline oil spill event is a constant \(X\), there is no difference in terms of damage between multiple leaking spot simultaneously and one leaking spot.

Therefore, the Hazard Index (HI) for one drainage basin is calculated as:

\[
HI = R_{10\text{-YEAR}}(1-(1-P)L)X
\]
We use an estimated ratio of $P=0.1\%$ from an analysis between 1982 and 1991 (Hovey, D. J., & Farmer, E. J, 1993); $L$ is the total mileage of the pipeline in the drainage basin. $1-(1-P)L$ is the probability of at least one leakage of the total $L$ mile pipeline in the drainage basin; the damage constant $X=1000$;

### 3.4 Vulnerability analysis

The Hazard Index (HI) can help compare and rank the damage level of the pipeline oil spill inflows at each stream point (SP). We then traced the downstream flow network for all stream points (SP) to identify the streams that will flow into reservation land. The Hazard Index will be aggregated to the downstream flow network to evaluate the vulnerability of the pipeline oil spill hazard for the reservation. Finally, we conducted an overlay analysis and descriptive statistics in ArcGIS for the ecosystem types being affected in the reservation.

### 4 RESULTS

Hydrological analysis started with the watershed delineation which provides a thorough understanding of drainage basins that flow into the reservation. As Figure 3 showed, all drainage basin delineations are generated from StreamStats and illustrated with 101 blue polygons in ArcGIS, with sizes ranging from 0.03 square miles to 221 square miles. 14 drainage basins (orange polygons) that have oil pipelines installed are identified as impacted basins in which most are from the west side of the reservation due to intense oil extracting and transporting activities.

Data gathered from StreamStats for Table 1 include all the basic characteristics of the impacted drainage basins such as mean slopes, length of longest flow path, average agriculture land percentage, mean basin elevation, total stream length, drainage area, average soil permeability and average percentage of impervious area, as well as the ten year peak flow rate, with the Basin ID in a clockwise order. The topography is relatively hilly with the median slope of 8.31 percent, especially at the west side of the reservation. Most impacted drainage basins are well-drained with a median average soil permeability of 1.57 inches per hour except the two at the north side where main agricultural lands are located. Overall, these basins consist of 573.61 miles of total streams, 363 square miles of drainage area, and a total of 6762.9 cubic feet per second 10-Year Peak Flow.

**Table 1. Basic Characteristics of the Impacted Drainage Basins.**

<table>
<thead>
<tr>
<th>Basin Id</th>
<th>Mean Basin Slope from 10m DEM</th>
<th>Length of Longest Flow Path (mile)</th>
<th>Ag Land Percentage</th>
<th>Mean Basin Elevation</th>
<th>Stream Length Total (Mile)</th>
<th>Drainage Area (Square Mile)</th>
<th>Average Soil Permeability (Inches Per Hour)</th>
<th>Average Percentage of Impervious Landcover from NLCD 2011</th>
<th>Average 10-Year Peak Flow Rate (Cubic Feet per Second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11.21</td>
<td>22.99</td>
<td>14.29</td>
<td>2326.30</td>
<td>105.20</td>
<td>48.76</td>
<td>1.54</td>
<td>0.23</td>
<td>1085.43</td>
</tr>
<tr>
<td>2</td>
<td>8.26</td>
<td>16.43</td>
<td>32.78</td>
<td>2327.61</td>
<td>45.08</td>
<td>22.27</td>
<td>1.93</td>
<td>0.34</td>
<td>736.87</td>
</tr>
<tr>
<td>3</td>
<td>9.21</td>
<td>12.60</td>
<td>24.90</td>
<td>2301.87</td>
<td>63.31</td>
<td>24.34</td>
<td>1.92</td>
<td>0.45</td>
<td>1100.85</td>
</tr>
<tr>
<td>4</td>
<td>4.69</td>
<td>0.60</td>
<td>39.89</td>
<td>2306.45</td>
<td>0.26</td>
<td>0.13</td>
<td>0.94</td>
<td>0.68</td>
<td>20.70</td>
</tr>
<tr>
<td>5</td>
<td>6.47</td>
<td>2.28</td>
<td>17.75</td>
<td>2297.24</td>
<td>2.61</td>
<td>1.31</td>
<td>1.15</td>
<td>0.25</td>
<td>111.66</td>
</tr>
<tr>
<td>6</td>
<td>7.64</td>
<td>1.10</td>
<td>0.00</td>
<td>2317.39</td>
<td>0.73</td>
<td>0.38</td>
<td>0.97</td>
<td>0.00</td>
<td>53.20</td>
</tr>
<tr>
<td>7</td>
<td>8.37</td>
<td>0.86</td>
<td>0.00</td>
<td>2341.88</td>
<td>0.52</td>
<td>0.21</td>
<td>1.04</td>
<td>0.33</td>
<td>44.34</td>
</tr>
<tr>
<td>8</td>
<td>9.71</td>
<td>1.91</td>
<td>0.00</td>
<td>2331.75</td>
<td>3.73</td>
<td>1.00</td>
<td>0.18</td>
<td>0.10</td>
<td>147.19</td>
</tr>
<tr>
<td>9</td>
<td>17.79</td>
<td>4.71</td>
<td>0.82</td>
<td>2340.38</td>
<td>16.71</td>
<td>5.79</td>
<td>1.92</td>
<td>0.08</td>
<td>592.88</td>
</tr>
<tr>
<td>10</td>
<td>11.03</td>
<td>8.18</td>
<td>20.46</td>
<td>2349.33</td>
<td>21.47</td>
<td>8.84</td>
<td>1.96</td>
<td>0.35</td>
<td>561.69</td>
</tr>
<tr>
<td>11</td>
<td>9.59</td>
<td>3.51</td>
<td>26.37</td>
<td>2282.33</td>
<td>3.14</td>
<td>1.69</td>
<td>1.60</td>
<td>0.60</td>
<td>178.26</td>
</tr>
<tr>
<td>12</td>
<td>8.07</td>
<td>9.44</td>
<td>38.83</td>
<td>2286.95</td>
<td>30.22</td>
<td>13.69</td>
<td>1.46</td>
<td>0.37</td>
<td>490.11</td>
</tr>
<tr>
<td>13</td>
<td>5.21</td>
<td>12.52</td>
<td>45.14</td>
<td>2204.57</td>
<td>36.55</td>
<td>23.30</td>
<td>3.26</td>
<td>0.44</td>
<td>679.85</td>
</tr>
<tr>
<td>14</td>
<td>4.01</td>
<td>42.97</td>
<td>57.56</td>
<td>2121.63</td>
<td>244.07</td>
<td>211.44</td>
<td>3.64</td>
<td>0.26</td>
<td>959.88</td>
</tr>
</tbody>
</table>

**Median 8.31 6.45 22.68 2311.92 19.09 7.32 1.57 0.33 525.90**
As the color-coded polygons in Figure 4 have shown, the Hazard Index provides quantifiable criteria to measure the expected impacts of each impacted drainage basin on the environmental safety of the reservation. The basins at the west side of the reservation have higher pipeline oil spill hazard than the two basins (ID 13&14) at the north. This is due to a densely located pipeline layout and higher 10-year runoff ratios (Table 2). Basin ID 1, 2 and 3 are the three most hazardous areas with multiple large-scale oil operation facilities between Mandaree, ND and Johnsons Corner, ND. Basin 4, 6, 7 and 8 are smaller basins with smaller Hazard Index but higher 10-year runoff ratios.


Table 2. Flow Statistics and Hazard Index of the Impacted Drainage Basins.

<table>
<thead>
<tr>
<th>Basin Id</th>
<th>Total Length of Pipelines in the Basin (mile)</th>
<th>10-Year Runoff Ratio</th>
<th>Hazard Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23.181</td>
<td>0.019</td>
<td>0.439</td>
</tr>
<tr>
<td>2</td>
<td>16.627</td>
<td>0.028</td>
<td>0.470</td>
</tr>
<tr>
<td>3</td>
<td>11.669</td>
<td>0.039</td>
<td>0.452</td>
</tr>
<tr>
<td>4</td>
<td>0.265</td>
<td>0.136</td>
<td>0.036</td>
</tr>
<tr>
<td>5</td>
<td>0.949</td>
<td>0.073</td>
<td>0.070</td>
</tr>
<tr>
<td>6</td>
<td>0.700</td>
<td>0.122</td>
<td>0.085</td>
</tr>
<tr>
<td>7</td>
<td>0.367</td>
<td>0.183</td>
<td>0.067</td>
</tr>
<tr>
<td>8</td>
<td>0.767</td>
<td>0.127</td>
<td>0.097</td>
</tr>
<tr>
<td>9</td>
<td>2.517</td>
<td>0.088</td>
<td>0.222</td>
</tr>
<tr>
<td>10</td>
<td>3.276</td>
<td>0.055</td>
<td>0.179</td>
</tr>
<tr>
<td>11</td>
<td>0.671</td>
<td>0.091</td>
<td>0.061</td>
</tr>
<tr>
<td>12</td>
<td>4.488</td>
<td>0.031</td>
<td>0.138</td>
</tr>
<tr>
<td>13</td>
<td>0.727</td>
<td>0.025</td>
<td>0.018</td>
</tr>
<tr>
<td>14</td>
<td>1.653</td>
<td>0.004</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Figure 4. Hazard Index of Impacted Drainage Basins
Downstream tracings based on the direction information of the NHD flow network for the stream points (SP) at the reservation boundary of the impacted drainage basins. 71.56 miles of NHD flow networks were identified as vulnerable streams for ecological conservation and hazard management in the future. As Figure 5 shows, all the pipeline oil spill hazards will flow through four different creeks in which three are named as Bear Den Creek, Clarks Creek, and Shell Creek. We coded and aggregated each drainage basin Hazard Index value to all the corresponding streams based on their flow order. Therefore, the hierarchies of each stream segments can be evaluated as the color-coded polylines in Figure 5. Bear Den Creek, Clarks Creek, and their tributaries in the western part of the reservation are the most vulnerable areas, flowing into the Missouri River and Lake Sakakawea.

![Figure 5. Vulnerable Streams](image)

Finally, to give us a clear understanding on the impacted ecosystems typology, the Land Cover Data from the USGS National GAP Analysis Project was analyzed in the 1-mile buffer zone of the impacted streams (Figure 5). The Northwestern Great Plains Foothill and Piedmont Grassland are the most
dominating ecosystems at 52.66% of the reservation, followed by Western Great Plains Wooded Draw and Ravine (10.86%), Cultivated Cropland (8.46%), and Open Water (7%). Table 3 lists all the ecosystems in percentage.

Table 3. Ecosystems in the Vulnerable Streams.

<table>
<thead>
<tr>
<th>Ecosystems in GAP Analysis</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwestern Great Plains Shrubland</td>
<td>1.92</td>
</tr>
<tr>
<td>Western Great Plains Dry Bur Oak Forest and Woodland</td>
<td>2.22</td>
</tr>
<tr>
<td>Western Great Plains Wooded Draw and Ravine</td>
<td>10.86</td>
</tr>
<tr>
<td>Northwestern Great Plains Foothill and Piedmont Grassland</td>
<td>52.66</td>
</tr>
<tr>
<td>Western Great Plains Tallgrass Prairie</td>
<td>0.36</td>
</tr>
<tr>
<td>Western Great Plains Sandhill Steppe</td>
<td>5.12</td>
</tr>
<tr>
<td>Western Great Plains Depressional Wetland Systems</td>
<td>4.30</td>
</tr>
<tr>
<td>Inter-Mountain Basins Big Sagebrush Steppe</td>
<td>0.08</td>
</tr>
<tr>
<td>Western Great Plains Badland</td>
<td>1.46</td>
</tr>
<tr>
<td>Cultivated Cropland</td>
<td>8.46</td>
</tr>
<tr>
<td>Pasture/Hay</td>
<td>3.65</td>
</tr>
<tr>
<td>Modified/Managed Southern Tall Grassland</td>
<td>0.47</td>
</tr>
<tr>
<td>Open Water (Fresh)</td>
<td>7.00</td>
</tr>
<tr>
<td>Developed, Open Space</td>
<td>0.38</td>
</tr>
<tr>
<td>Developed, Low Intensity</td>
<td>0.14</td>
</tr>
<tr>
<td>Developed, High Intensity</td>
<td>0.91</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

5 DISCUSSION

This study presents a method of identifying potential hazards for the Pipeline Oil Spills in North Dakota. By introducing NHDPlus flow network and USGS StreamStats, we were able to conduct Hydrological analysis (Figure 2) without sacrificing accuracy and reliability. Making requests from the StreamStats' large hydrology datasets, our drainage basin delineation and streamflow modeling tasks didn't have to include tedious data collection process such as land cover, precipitation, time of concentration, etc. We developed a customized Python Script to automate the estimation of peak flow runoff using StreamStats Web Service which utilizes regression techniques from large amounts of data from more than 25,000 Gauging Stations around the United States (USGS Gauge Locations, 2018). The processing time for the 101 points of interests cost approximately 2 hours. The results (Table 1 and 2) such as drainage area, soil permeability, and 10-year peak flow rate can help understand the hydrological characteristics of the region and inform environmental hazards of pipeline oil spills. With little modification, this hydrological analysis approach could also be used in many other regional planning objectives such as flood control, ecological restoration, and water resource management.

Additionally, we demonstrated the process of using StreamStats’ 10-year peak flow results to estimate Pipeline Oil Spill Hazards for each drainage basin by developing a customized Hazard Index. Through this, it concluded that the drainage basins (Figure 4, Table 2) at the west side of the reservation between Mandaree, ND and Johnsons Corner, ND pose the most significant threats to Fort Berthold Reservation. This area has large amounts of oil industry operations present and should gain extra attention from land policymakers. Stricter hazard assessment and environmental monitoring actions are desperately
needed before further water and soil contamination occurs. Ecological restoration investments should be made for lands currently suffering from sustaining environmental pollutions within the reservation.

Regarding the vulnerability analysis (Figure 5), we identified the vulnerable streams by down tracing the NHD flow network to assess the vulnerability level by aggregating the Hazard Index (HI) of corresponding upstream Stream Point (SP). Bear Den Creek and Clarks Creek are identified as high-risk areas in a pipeline oil spill event. Major impacted ecosystems are Northwestern Great Plains Foothill and Piedmont Grassland with large areas of mixed grass species such as Bluestem Grass and Needlegrass. The appearance of oil spill pollutants could harm the health of one or more species in the local food chain, which may lead to damage for food and water resources to human beings (Oil Program Center, 1999, p7). Tribal administration should prioritize these areas for conservation purpose, and if necessary, State and Federal agencies could also provide fiscal and policy incentives to facilitate projects that establish new natural communities for protecting potential threats.

This study focuses on pipelines as the major source of oil spill hazard. Other forms of oil spills from tankers, drilling rigs, wells, and refinery facilities are not considered. To gain a more holistic understanding of the environmental issues around Fort Berthold Reservation, more investigations are needed in the future.

6 REFERENCE


Oil Program Center. (1999). *Understanding Oil Spills And Oil Spill Response*. U.S. Environmental Protection Agency


PEOPLE-ENVIRONMENT RELATIONSHIPS

Edited by Deni Ruggeri & Ole Sleipness
BUILDING THE OUTSIDE-IN CLASSROOM

McCullough, Michael
Project Sustainability, Michael@projectsustainability.org

Martin, Michael
Iowa State University, Department of Landscape Architecture, mdmartin@iastate.edu

Sajady, Mollika
University of Minnesota, Department of Developmental-Behavioral Pediatrics saja0007@umn.edu

ABSTRACT

This paper describes a primary school curriculum that engages students in a project-based learning module. The module promotes environmental education by allowing students to design, install and maintain a “green wall” system constructed within the classroom. This program requires active participation and thoughtful engagement of participants and can be adapted for use across learning environments for students of all ages. The program is grounded in pedagogical research that indicates educational benefits from utilizing outdoor elements in learning environments and project-based curricular strategies. Elements from the fields of science, technology, engineering, arts, and mathematics (STEAM) provide the basis for the interactive learning curriculum. Our premise is to utilize contemporary and cost-effective modular green wall technologies for the transformation of classrooms as learning environments, while affording instructors and students the opportunity to be directly and continuously involved in that transformation.

Keywords
Outside-in classroom, living wall, green wall, STEAM, STEM, environmental education, project-based learning, active learning, elementary school.
BRINGING NATURE INTO THE CLASSROOM USING GREEN WALLS

Students are often indoors for the majority of their school day, frequently without adequate visual access to the outside (National Center for Education Statistics, 2008). This disconnection between children and nature may contribute to poor attention and focus during the school day (Li & Sullivan, 2016; Kuo & Faber-Taylor, 2004). There is a call for researchers to advance knowledge about the importance and impact of incorporating nature within educational settings (Jordan & Chawla, 2019). The growing body of nature intervention research is inspiring leaders in education and design to find new opportunities for environmental education and student access to nature for promoting academic performance and well-being. For the purposes of this paper, the authors include supporting evidence and a general framework for the creation of a green wall environmental education program.

A green wall, or living wall, is defined as a vertical garden attached to an interior wall that includes living greenery, a growing medium substrate, some sort of armature that provides structure for the plants, and often an integrated water delivery system. The green wall can be affixed to a pre-existing wall or be built as a free-standing structure. Its advantage over typical interior plantscapes, such as plants in pots or planters, is that green walls do not significantly reduce floor space (Figure 1). Interior plantscapes of various forms provide environmental health benefits for individuals in institutional settings (Claudio, 2011). The space-saving attribute of green walls provides a significant advantage within multipurpose interior settings such as classrooms, where floor plans and desk arrangements may be modified on an intermittent basis to suit the needs of different learning activities.
Green walls typically range from $90 to $150 per square foot for initial installation costs (Livewall, 2019). Green walls also require ongoing maintenance, which approximate to the average capital cost every five years (Nedlaw, 2019). This expense can often be a limiting factor for schools due to restricted budgets. The problem of the cost burden to schools encouraged a six-month collaboration among school administrators, teachers, and the authors to design a program that would make green walls more affordable and accessible for schools. To reduce costs, a proprietary green wall system was developed with the goal of removing many barriers related to high industry purchasing costs. In addition to the development of a cost-effective modular system, the authors also developed relationships with plant growing businesses to obtain plants at wholesale pricing. Student, teacher, and even parent and guardian participation in the design, installation, and on-going plant care provides schools with a viable model to introduce and maintain green walls in the classroom. This model reduces initial capital costs for the school by 75% on average, with limited financial obligations related to recurring plant care.

The environmental health benefits and space-efficiency of green wall systems make them an ideal option for classrooms, and studies in applied pedagogical design have shown that direct exposure to the natural environment can enhance learning by improving student attention and behaviors (Kaplan, 1995; Taylor et al., 2002; Li and Sullivan, 2016; McCormick, 2017). Directed Attention Fatigue (DAF), for example, is a phenomenon in which the brain cannot stay focused for prolonged periods of time without a break, and attention is ideally restored through exposure to natural settings (Itti, Rees, et al., 2005). DAF is a common phenomenon for primary school students, because of the necessary focus on academic demands throughout the school day. Emerging evidence suggests that exposure to natural elements indoors has related effects of ameliorating attention and focus difficulties (van den Berg et al., 2016). The green wall itself is also an experiential teaching and learning tool. The wall system—its design, construction, and maintenance—can afford opportunities for hands-on project-based learning. This active approach to learning is a pedagogical strategy that has shown to be effective for enhanced cognitive development across the spectrum of educational levels and subject areas (Lieberman and Hoody, 1998; Chawla et al., 2014).

Design and construction of a simple modular green wall system has the potential to inspire critical thinking through a combination of project-based learning strategies and environmental education. The authors outline a curriculum involving the implementation of an indoor living wall system within a classroom environment that incorporates project-based learning principles. This curriculum model can connect students interactively with indoor nature and has the potential to inspire real-world thinking related to science, technology, engineering, art, and mathematics (STEAM) fields within the indoor learning environment. Through a combination of these passive and interactive experiential learning modes, students make connections to nature in the indoor environment, regardless of weather conditions outdoors.

THE GREEN WALL CURRICULUM: OUTDOOR-IN NATURE AND PROJECT-BASED LEARNING

The model curriculum is designed to incorporate a simple and inexpensive modular green-wall prototype as a means to enhance passive “indoor nature” within the classroom. This model simultaneously creates an interactive learning workshop, which engages students in the conceptual basis, design, and construction of a green wall. The workshop touches on STEAM concepts and has been piloted as a prototype program in five schools within the United States.

The curriculum begins with lessons on the efficacy of green walls and their recent emergence as components of interior architecture. Green walls are presented as an interior enhancement for indoor air quality and aesthetic appeal for human-occupied buildings, particularly for learning centers. Students learn that green walls can conceivably be placed anywhere within the learning spaces inside a school. However,
Green walls are presented as especially valuable within intensive-use environments such as classrooms, because of the opportunity for more continuous passive exposure, as well as enhanced opportunities for interactions with the plantings.

**GREEN WALL WORKSHOP**

The green wall workshop is a hands-on, intensively interactive approach that engages students directly in a design-build experience and installation of the green wall. The workshop incorporates aspects of STEAM and can be utilized as a learning module within a great range of academic courses. This workshop is designed as a project-based learning module, which is a pedagogical strategy in the “active learning” mode that has its roots in the work of psychologist and educational reformer John Dewey (McDermott, 1981).

Active learning is an engaged process, which is learning by doing or learning while doing. It contrasts with passive learning modes such as listening to lectures or completing reading assignments. Active learners advance beyond the passive mode of learning to seek out and synthesize information interactively. Project-based learning is a type of active learning that encourages the student to apply new ideas and research information in purposeful fashion in order to complete a directed project. For project-based learning within a science course, for example, students might investigate questions for possible solutions, propose hypotheses and alternative explanations, discuss their ideas with others, challenge differing perspectives, and try out new ideas (Krajcik and Blumenfeld, 2006). This strategy can be utilized by educators in any discipline as a pedagogical device. Design educators have relied on project-based learning as long as there have been design schools (Erdman et al., 2002). In a successful project-based learning experience, the student constructs meaning and knowledge based on direct experience with some aspect of their environment.

The workshop is divided into three sections that provide students opportunities to learn about the importance of nature in their daily lives, to engage them in design collaborations, and to physically construct the green wall systems.

**Workshop part 1: living walls, human connection to nature, and plants**

Part one of the workshop provides an overview of both traditional and contemporary methods for utilizing plants as components of interior design, along with information about the recent discoveries of the physiological, psychological, and educational benefits provided by indoor nature. Students also learn that the green wall component is adaptable, and can be customized for individual users and various settings. This introductory presentation leads to hands-on learning through experimentation and one-on-one conversations with the consulting green wall specialist, if available, or with a school staff member who understands the process that constitutes the workshop. The objective of the specialist or staff leader is to introduce and promote the green wall concept, but also to inspire the students’ interest in future education tracks or even career possibilities within the STEAM disciplines that underlie the concept and design of green walls.

Students then learn about some of the physical attributes of interior plants, including characteristics such as appropriate plant varieties, overall form, growth habit, foliage color and texture, and scale (Figure 2).
Figure 2. Students study texture, color, form, and structure of individual plants to learn how the unique characteristics can inspire a planting plan. Written permission for the publication of this figure was obtained from students’ parents. Photo by the Delta School.

Students work with some of these variations in characteristics by designing individual small-scale multimedia collages. They utilize construction paper as design media in colors similar to the plants, employ drawing utensils to simulate foliage textures, and assemble collages with adhesive. The objective is for students to understand that individual plants feature unique characteristics, and that those variations allow students to create larger patterns and contrasts within the vertical garden *parterre* of their green wall preliminary design. During this design process, students engage in ongoing discussions that link the concept of the green wall back to STEAM-related issues. For example: What are the benefits of green walls? How is interior nature alike or different from outdoor nature? How can outdoor nature experiences and qualities influence green wall design? What sort of natural and mechanical systems are at work within green walls and their environments? By integrating concepts with design in this manner, students better understand the essential relationship between their project and the various STEAM disciplines.

**Workshop part II: designing of a planting plan**

Students then break into groups to develop alternative planting plans. In cases where more than a single green wall will be built, groups may be constituted or orchestrated based on the number of installations involved. In cases with just one green wall, the students participate in a
consensus-based design competition. In developing planting plans, team members are encouraged to consider the characteristics of plants, to employ a range of possible mathematical and geometrical concepts for pattern-making, and to collaborate in the creative process throughout all stages of the project.

The initial planning stage is conceptual, and not yet orthographic. What overall formal concepts might be employed, and for what reasons? Teams generate a unique design concept or theme that they can abstract in the pattern of the planting plan. Themes might include a natural process, such as the movement of water, or a static form of an object, such as the shape of a leaf. After achieving a team consensus on the concept, the next step is to reconcile that theme within the limitations of the modular grid pattern that the green wall incorporates, utilizing colored paper sheets on a wall-mounted grid that is a reduced-scale version of the entire green wall (Figure 3). This scale-model “mock-up” of the wall is meant to be adjustable and manipulable, allowing team members to rearrange the paper as needed to achieve a consensus scheme that successfully abstracts the team’s original concept theme. This stage of the exercise employs three essential aspects of the collaborative design process that is intrinsic to work in STEAM disciplines: the translation of an abstract concept to a physical pattern, collaborative decision-making at the team or whole-class level, and engagement in iterative design, which is a cyclical process that allows students to consider a succession of alternative solutions. The take-away for students is to understand that this same general design process can be employed to accomplish projects in other STEAM-based scenarios.
Figure 3. Students collaborate through a design-thinking exercise to develop their own planting plan. For this exercise, students chose two plant varieties and abstracted them using colored paper that approximated each plant’s color. Written permission for the publication of this figure was obtained from students’ parents. Photo by Michael McCullough.

Workshop part III: fabrication of green walls

Fabrication includes construction and installation phases of the green wall, including the armature (the supporting modular structure), the substrate medium, and the plants themselves. Typically the wall is constructed on a backing board that lies flat during assembly. The finished wall is relocated to its final position after most of the construction is complete. It should be noted that student manual-skill level, including the wielding of basic hand tools, will vary with the age and experiences of students. While some student groups will be fully capable of accomplishing fabrication with appropriate supervision, younger groups without tool experience may require a greater degree of involvement by adults such as green wall consultants, school staff members, older students, or adult volunteers. The adults could even pre-fabricate the student-designed system, leaving only plant installation to the students. When students are capable, they may be engaged with any or all construction stages, including fastening the frame to the backing board and/or installing the planters as per the design pattern determined during Part II. Also, depending on the number of students, it may be desirable to organize teams to accomplish particular construction stages. The construction is a further stage of collaborative problem solving (Figure 4).
The design template from Part II serves as the basis for the construction of the planter modules. Once the frames and planters are in place, students begin the installation of plants (Figure 5). This phase requires attention to construction “detailing” that ensures the viability of the living system, including proper substrate depth and plant stabilization within the planter modules. During this construction process, students are encouraged to routinely monitor the design as it emerges at actual scale and in three dimensions. Students should also consider whether any adjustments to the pattern are needed so that the constructed assemblage reflects the design intent as originally conceived. This step is crucial as a further-long component of iterative design; it is also an excellent lesson in the shortcomings of visualization and representation of imagined three-dimensional constructions initially in only two dimensions. Once the plant installation is complete, students assist with the clean-up and preparation for the green wall (or walls) to be installed in their respective permanent location(s).
Workshop part IV: green wall maintenance and sustainability

As a living interior landscape, greens walls require regular watering, plant care, and maintenance of the plantings for control of the appearance of the installation. The installation offers a sort of continuing-education opportunity for students, who will learn about plant care and maintenance, but also will gain insights about issues of change over time for living systems. This could conceivably be conducted as an element of a science class. The walls may also require the attention of staff or volunteers, depending on the student involvement, particularly if the green walls are left in place over the summer break.

Maintenance requires teamwork, and these recurring activities afford students the chance to continue their collaborative interactions. It also allows students to take responsibility and ownership for something they created. The participatory involvement in design and construction encourages attachment and direct engagement with the learning environment (Ruiz-Gallardo et al., 2013).

STEAM FIELDS UNDERLYING THE GREEN WALL PROGRAM

The green wall project offers an array of connections to STEAM fields. As living systems, the green wall reveals aspects of biological systems that underlie the study of botany and horticulture. The green wall as interior design and architecture represents an aspect of
environmental design, even to the point of connecting with architectural concepts concerning the relationship of indoor and outdoor environments. The environmental psychological benefits of green walls relate to social science issues that concern disciplines such as sociology, psychology, and behavioral sciences. The modular system that the green wall employs derives from processes that involve digital technologies such as computer-aided drafting and 3-D printing, technologies that are fundamental to contemporary environmental design and engineering professions. Even mathematical and geometrical concepts are essential for green wall pattern design and for estimation of the quantities of plants, the dimensional capacity of each panel, and the number of planters required for the panels. Green walls offer a connection with agriculture; typically the level of available light in classrooms inhibits growing edible plants, but classrooms with good solar access or the utilization of artificial lighting can overcome this limitation. Finally, beyond technical considerations, the creative and artistic process itself is an essential aspect. Students begin with abstract concepts that ultimately become real-world, living, functioning artifacts.

ENSURING A SUSTAINABLE INSTALLATION

As noted, the green wall will require ongoing maintenance throughout the year, so there must be some sort of routine maintenance regimen established for their support. If the green walls are considered part of the school infrastructure, this may potentially fall under the supervision of staff responsible for outdoor landscape maintenance. Most green walls that are built within commercial or institutional settings are maintained by outsourced companies that specialize in interior landscape maintenance. Considering limits on school budgets, it make sense for schools to either engage volunteer community members for this purpose (such as a volunteer or service organization “adopting” a green wall or school), or even fundraising and grant-seeking to attract outside financial support. Strategies such as these were employed by three of the schools that participated in the pilot projects conducted by the authors.

CONCLUSION AND FUTURE DIRECTIONS

Utilizing STEAM-related concepts to effectuate project-based learning, this curriculum provides students with interactive and passive exposure to indoor nature. This classroom-based green wall affords students the opportunity to gain awareness of environmental technologies, build upon their cooperative social skills, and develop design-process abilities when they translate abstract concepts into built form. As a pedagogical strategy, the project is accomplished through directed, active-mode, project-based-learning. This active approach to learning has been associated with improved academic achievement within STEAM fields (Freeman et al., 2014). The students’ introduction to these technologies and processes at the elementary school level could potentially lead to their subsequent involvement in more sophisticated applications of green technologies, or even inspire their interest in educational specialization within academic STEAM programs beyond the secondary education level. Subsequent green wall design/installation workshops could expand upon these pilot projects by including a research and evaluation component that quantitatively and qualitatively measures effects on student learning, engagement, and behavior.

Economical modular green wall systems are a recent innovation and a rapidly-evolving technology. Ongoing research and development of these systems will provide additional opportunities for incorporation of these technologies within classrooms, as both an environmental enhancement and as an educational opportunity for other project-based learning models. Further experimentation with pilot or prototype programs, along with further innovations in the green wall systems themselves, will lead to greater understanding of the potential for building sustainable and dynamic “outdoor-in” classroom environments.
REFERENCES


National Center for Education Statistics. (2008). Average number of hours in the school day and average number of days in the school year for public schools, by state. Retrieved from:


ASSESSING THE VALUE OF OUTDOOR SPACE IN NURSING HOMES: A CASE STUDY FOR ATHENS GERIATRIC HOME (Greece)

VISSILIA, ANNA-MARIA  
North Dakota State University, Annamaria.vissilia@gmail.com

PORFYRAKI, THEODORA  
Agricultural University of Athens, porfyraki.theodora@gmail.com

PAPADOPOULOS, GEORGE  
Agricultural University of Athens, gpapadop@aua.gr

1 ABSTRACT  
This study investigates how the outdoor environment at the Athens Geriatric Home is experienced by its residents and staff. The aim is to raise awareness of the role of the outdoor environment on how it affects the experience and the use of care facilities in Greece by elderly people living in them. Access to green outdoors is widely documented in an increasing number of studies to have multiple physical and psychological benefits on humans in a number of international case studies. However, the evaluation of outdoor space usage as an important component to improve health and quality of life at Greek senior care settings is still given no attention and there is no record of research on environmental preferences of outdoor environments at nursing homes. In Greece, very few of elderly people are privileged enough to access and enjoy an outdoor environment, even if it is not successfully designed. In this context, the authors conducted a pilot research on the Athens Geriatric Home situated in the urban core of Athens, the oldest one in Greece (1873), in order to collect information on size, placement and quality of green spaces, using the Seniors Outdoor Survey. Residents and employees reported their experiences from the gardens, the frequency of their visit and the garden features they prefer. Results revealed the demand for more available seating, mainly in a circular arrangement, properly arranged routes to facilitate their movements, clear views from the routes and open spaces, intense colors and special meeting points.

1.1 Keywords  
Outdoor environment, gerontology, landscape architecture, elderly people, environmental assessment
2 INTRODUCTION

2.1 The value of outdoor space in seniors housing

For thousands of years, spending time in natural surroundings has been assumed to have a positive effect on human health (Stigsdotter & Grahn, 2002). Plants and landscapes can enhance human well-being by causing positive physiological and psychological responses, which affect human behavior (Relf & Lohr, 2003, Cox et al., 2004, Detweiler et al., 2008, Murphy et al., 2010).

Outdoor areas in retirement communities and homes for the elderly have been found to be an important component of elderly’s well-being, satisfaction, improvement of mood and quality of sleep, recovery from illnesses such as blood pressure, heart problems, stress, soreness, dementia, absorption of vitamins, mental fatigue, as well as reduce any possible fall incidents, and increase of life expectancy, especially to those with disabilities or mobility problems (Hernandez, 2007, Calkins et al., 2007, Rappe et al., 2006, Stoneham & Jones, 1997, Takano et al., 2002, Melzack, 1996, Keller & Wetterberg, 1996, Keller & Kuller, 1994, Bramryd & Fransman, 1993, Keller & Lindsten, 1992, Browne, 1992, Grahn, 1991, Talbot and Kaplan, 1991). Moreover, contact with nature causes proneness to recall memory, develops sociality and decreases the perception of loneliness (Oguz et al., 2010, Mimi Mum Yee Tee, 2008, Ulrich, 1999). The visual appeal of nature is important for encouraging the elderly to walk outdoors. Plants trigger social interaction and networking through joint activities and provide themes for conversation (Erja Rappe, 2005).

2.2 Design issues of outdoor space in seniors housing

The main reason why many elderly people rarely visit outdoor spaces in care facilities, despite their inclination, seems to be linked to design issues related to location, accessibility and/or attractiveness of landscape design (Rodiek et al., 2014, Kane et al., 2003, Iwarsson & Ståhl, 2003). In addition, a number of studies have revealed that other obstacles include physical constraints, lack of help by the staff and unpleasant weather conditions (Cohen-Mansfield & Werner, 1999; Cutler et al., 2006). The most concise report on the linkage between various design features of the physical environment and their influence on the elderly’s use of outdoor areas is that of Susan Rodiek in 2003. These features include a multitude of walkways to access outdoor landscaped areas, the substantial shade and seating along the walkways, abundant vegetation, the appearance of a “small park” and access to views looking beyond the facility boundaries, the presence of windows adjacent to outdoor entries and developed areas near them for pre-viewing outdoor spaces (Rodiek, 2003).

2.3 Elderly people in Greek society: role and community programs

The amount of care for elderly people, constitutes one of the criteria of evaluating any society’s culture. Although in recent years there has been an intense concern for this subject worldwide, in Greece, statistics reflect a negative attitude towards aging. The elderly’s social role is shrinking, a phenomenon that is mostly observed in urban environments. This numerically large social group seems to fall aside, and its role is continuously degrading, both in society and within their families. Greece ranks among the lowest places in Western Europe (79th place) between 96 countries, with a percentage of the population being over 60. The percentage of people aged over 65 in Greece is 7.7% and only 61% of these people report that they can rely on friends and relatives in any case of need. 54.6% of Greeks claim that they would not let their parents live in a nursing home, a percentage that is the highest in Europe. Particularly, 35.9% of young people state that they will never leave their parents and relatives, while 34.6% feel that new generations have responsibilities towards the elderly. On the other hand, 21.3% express that state authorities have to take responsibility for the elderly and 5.8% of young people believe they have no obligation towards them (Korkidi, 2011).

In Greece, the elderly care is largely an exclusive family matter. The self-serving incidents constitute a small minority, either because elderly people nowadays contribute to the family budget with their small pension or because this small pension does not cover the cost of their stay even in an affordable unit. Many become members of clubs, organizations and seek community activities and volunteerism. Some of the community programs in Greece consist of Open Seniors Protection Centers, Day Care Centers for the Elderly, Friendship Clubs, Nursing Homes Asylums and Sanatoriums of Chronic Diseases (Korkidi, 2011).
As of nursing homes, 243 care units for the elderly are currently operating in Greece. Most of them are located in Attica (110), followed by Central Macedonia (29) and Crete (20). According to data from the Ministry of Health, Welfare and Social Insurance, 113 nursing homes are running in Greece, including church and charity associations. Additionally, 20 State Chronic Illness Therapeutic centers have been recently established. Therefore, the total capacity of accommodation of elderly people in Greece reaches 15,000 (Korkidi, 2011).

2.4 Outdoor spaces in nursing homes in Athens
The urban street layout in most areas of Athens leaves no room for the construction of nursing homes with extensive green spaces. Therefore, in areas such as the center of Athens, the appearance of nursing homes for the elderly with gardens is limited or non-existent. Scattered through the Athens region, there are approximately 100 nursing homes and facilities for the elderly, of which 20%, including the Athens Geriatric Home, have outdoor green areas and the rest 80% just consist of buildings.

Most units with outdoor spaces are located in the suburbs of Athens or in other areas of Attica, such as Paiania, Glyfada, Koropi or Gerakas, which are still sparsely populated and offer the possibility to develop units on large plots. As for the care facilities found in the city's center, the outdoor spaces, with a few exceptions, are limited to areas around the central building with scarce trees and very few and small sized seating areas. In some cases, an axial green corridor leads to the entrance of the buildings and a swimming pool is centrally located in the outdoor space for the potential exercise of the elderly. More specifically, the second biggest facility is found in Koropi and consists of 16 acres, compared to the Athens Geriatric Home, the largest geriatric unit, which consists of 64 acres.

2.5 The Athens Geriatric Home
Despite the fact that Athens Geriatric Home is located in the neighborhood of Ampelokipoi, which is a densely populated area in the center of Athens, it provides rich outdoor spaces for its residents and remains the only nursing home with the largest outdoor space and gardens in Athens. It is for this reason that this case study was chosen as a prototype to conduct this research.

Athens Geriatric Home was founded in 1864 by a group of philanthropists, the main one being Andreas Syggros. The site of the nursing home is approximately 58883.84 f², of which 18413.05 f² are occupied by the building infrastructure, while the remaining 404253.8 f² include the outdoor areas. The garden area consists of open lawn areas, an olive grove, an orchard, a playground, several seating areas, and a number of trees and bushes scattered all over the place that provide shade, privacy and a buffer against the traffic noise of the nearby streets, which at times is quite heavy. Moreover, each building has a covered terrace near its entrance, serving as a transitional zone between indoors and outdoors (Figure 1, Figure 2, and Figure 3).

The building complex of the Athens Geriatric Home has a great architectural value, dating back to 1873. In the course of the last 110 years, some of the original buildings have been demolished and others are not currently fully operational. Apart from its main function and its charitable services, an aspect of the Athens Geriatric Home that must be ensured, is the ecological one. The Athens Geriatric Home is a precious green zone found within the densely populated neighborhood of Ampelokipoi and has the potential of becoming a green gem in the heart of Athens, in support of the elderly community and the nearby neighborhood, inviting neighbors, parents and children for walks, recreational and social activities.
3 RESEARCH OBJECTIVES
The aim of this study is to use the SOS method to record the views, remarks and evaluation of the particular residents and employees of the Athens Geriatric Home on the subject of their understanding of the value of their outdoor space related to the elder’s well-being. For that reason, no data analysis was performed for statistical inference. This is not an investigation that is intended to lead to a general conclusion about a statistical population from a representative sample, such as conclusions concerning the old-age homes of Greece in their entirety, but rather to carry out descriptive statistics and qualitative analysis of the responses of the specific elderly people on how they perceive their connection to the outdoors in order to design a solid landscape proposal for the improvement of the grounds of Athens Geriatric Home, a case study selected for this research due to its value, which is proven through the extent of its green spaces and its location.

4 METHODS

4.1 Methodology aims
In our study, we focused on the comparison between the elderly’s and the staff’s responses, a parameter addressed in few published studies, focusing on staff's perspective on older people suffering from dementia. The understanding of how different environments are experienced and used is essential for creating attractive, functional and well designed environments. The staff’s view is of particular importance, as they obtain a comprehensive knowledge of the users’ wishes, needs and capabilities in the environment. Many nursing homes accommodate people with diverse diagnoses, and therefore, it is important to elucidate staff’s perspective under these circumstances. Therefore, residents and employees of the Athens Geriatric
4.2 Data collection

The data was collected during the period August-September 2018, a time period during which the elderly visit the outdoors the most. A few days prior to the questionnaire, all residents were invited to participate, and they were reminded again by staff on the morning the research started. It was not easy to find ‘windows of opportunity’ in our participants’ daily schedules. This was due to, for example, often visits to the dining area and coffeehouse, relatives coming for an unexpected visit, and the participants’ routines.

The research was conducted in a manner that the participants found that the time spent to answer the questionnaire was a pleasant diversion in their regular everyday lives. Residents answered the given questionnaires, either by observing the outdoors from the balcony or window in their room, or by visiting the gardens, so that they better capture the outdoors experience. Those who failed to fill in the questionnaire received help from staff the next day, while others failed to be interviewed mainly because of serious health problems (mostly dementia). Many of the elderly experienced difficulties in mobility, concentration and day-to-day activities, while many expressed pain and anxiety/sadness. Additionally, several had weaknesses in sight and hearing.

Studies of this kind are highly dependent on the interest and willingness of the staff’s participation, who are working with the elderly on a day-to-day basis. The selection criteria for the elderly included their physical and cognitive status, so as to have a possibility to participate in the process of the questionnaire or the ability to participate in a personal interview by a person responsible (psychologist or social worker). Also, the choice of the elderly and the suggestion of the appropriate staff was based on the views of the social workers. Generally, when presented with the questionnaire, most of the elderly people were eager to be asked questions and fill in the questionnaire. On the contrary, part of the staff found it more difficult spending time to fill in the questionnaire.

Approximately 80 elderly people and staff are located in the Athenian Geriatric Home. The sample includes seniors aged 60 to 87, males and females, who have been living in the Athens Geriatric Home from one month up to 16 years. 49 questionnaires were successfully completed, 24 were questionnaires answered by elderly people and 25 by staff. This survey included 16 women and 9 men from the sample of staff and 14 women and 10 men from the sample of the elderly. The sample of both elderly and staff was representative of the four main buildings in operation: 1) “Andreas Siggros”, 2) “Estia”, 3) “Konsolio” and 4) “Queen Olga”. The location of these four buildings is shown in Figure 4.

![Figure 4. The Athens Geriatric Home: The four main building in operation. Diagram by the authors based on google maps.](image-url)
4.3 The SOS tool

The SOS (Seniors’ Outdoor Survey) tool, a significant tool in the assessment of living standards and health care in geriatric facilities, enabling for the first time the systematic evaluation of access to nature for the elderly, using reliable and valid means, is used to evaluate 60 different features that are organized into 5 categories. The evaluation form is completed on site at each outdoor space, using a 1 to 7 rating scale for each feature, where 7 is “outstanding” and 1 is “extremely poor.” This allows the tool to sensitively measure the range of support that each feature provides to seniors in a given setting. Collectively, the SOS Tool items are intended to address the most important features relevant to residents’ outdoor usage and satisfaction (Bardenhagen et. al.). The categories are:

1. Access to nature: greenery, views, water, other aesthetic characteristics (14 items)
2. Outdoor comfort and safety: seating, climate control and comfort issues (15 items)
3. Walking and outdoor Activities: safe and accessible walkways, destinations (14 items)
4. Indoor-outdoor connection: doorways, physical and visual outdoor access (11 items)
5. Connection to the world: features providing contact with nearby surroundings (6 items)

The SOS system evaluates the quality of each category from the optical angle of the elderly. It evaluates the functionality of each space and focuses on the advantages it confers on the elderly and does not only examine the existing infrastructure features. Also, the layout of the questionnaire places the respondent in the position of the elderly, who can visualize themselves as an older person (Bardenhagen et. al.).

4.4 Scoring the results

Expecting the increased use of the SOS system in many environments, a differentiated calibration system has been developed for each of the 5 categories with average results reflecting the importance of different items/questions. Although each item is of undisputable value, some items are of greater importance to the use and satisfaction they offer to the elderly in nursing homes. These differences in calibration are determined based on the preferences of the inhabitants, the usefulness of the open spaces and the views of the skilled personnel. Therefore, according to the SOS Tool, the results of the questionnaire were scored with different factors based on the importance of each feature. The rating of each item was multiplied by its specific weighting factor and further converted to a 100-base scale.

After each session, data were manually retrieved from the questionnaires and were analyzed with both Statgraphics and Microsoft Excel. Each item is multiplied by the corresponding weight depending on its importance.

4.5 Testing the validity of the SOS tool results

The validity of the questionnaire is based mainly on past studies that have been carried out on the importance of open-air spaces in nursing homes mainly abroad. In this survey, in order to test the reliability of the questionnaire, we calculated the “Cronbachs Alpha” factor of internal consistency, which assesses whether respondents answers to questions, that concern the same concept, are relevant and consistent. The values of the Cronbachs Alpha factor must be at least ≥0.7 so that the internal consistency of the questionnaire would be “acceptable”, ≥0.8 would be “good” consistency and 0.9-0.94 would be “excellent”.

To test the reliability of the questionnaire, the factor α was calculated for each of the five categories taking into account all internal questions and then overall for the whole questionnaire. Figure 5 presents the internal consistency of the average weighted scores of the overall questionnaire. According to Figure 5, Cronbach’s factor is 0.901822, which shows that the tool is reliable and can be used for this research.
5 RESULTS

The mean of the weighted preference scores were used in Figure 6, which shows a chart created by the comparison of the 5 questionnaire domains. Each one of them includes 3 individual columns corresponded to different groups of participants, which are elderly people, staff and the total number of participants (both elderly and staff) as shown in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>K1</th>
<th>K2</th>
<th>K3</th>
<th>K4</th>
<th>K5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff</td>
<td>81.0008</td>
<td>75.2812</td>
<td>82.63</td>
<td>86.298</td>
<td>82.1064</td>
</tr>
<tr>
<td>Elderly</td>
<td>79.1783</td>
<td>74.5213</td>
<td>80.6629</td>
<td>84.595</td>
<td>78.0046</td>
</tr>
<tr>
<td>Both</td>
<td>80.1082</td>
<td>74.909</td>
<td>81.6665</td>
<td>85.4639</td>
<td>80.0973</td>
</tr>
</tbody>
</table>

Table 1. Collective results of the 5 domains compared to the 3 samples of the population.

Figure 5. Missed variable chart for the average of weighted scores. Diagram by the authors.

Figure 6. Results diagram of the 5 categories compared to the 3 samples of the population. Diagram by the authors.
Figure 7. Illustration mapping of the overall preference of the open-air area. Illustration by the authors.

Table 2. Collective results for the point of view of the outdoor spaces from different buildings.

<table>
<thead>
<tr>
<th></th>
<th>K1</th>
<th>K2</th>
<th>K3</th>
<th>K4</th>
<th>K5</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andreas</td>
<td>81.5139</td>
<td>75.6533</td>
<td>83.0017</td>
<td>85.6778</td>
<td>82.4606</td>
<td>81.6625</td>
</tr>
<tr>
<td>Esla</td>
<td>81.0525</td>
<td>74.355</td>
<td>81.605</td>
<td>85.936</td>
<td>79.415</td>
<td>81.6725</td>
</tr>
<tr>
<td>Konsolio</td>
<td>78.9386</td>
<td>73.9793</td>
<td>80.7021</td>
<td>84.05</td>
<td>77.0593</td>
<td>78.9458</td>
</tr>
<tr>
<td>Vas. Olga</td>
<td>78.5333</td>
<td>74.4511</td>
<td>80.3311</td>
<td>85.1633</td>
<td>79.7544</td>
<td>79.6566</td>
</tr>
<tr>
<td>Workers</td>
<td>80.1967</td>
<td>76.1033</td>
<td>81.7333</td>
<td>91.1633</td>
<td>84.0233</td>
<td>82.6639</td>
</tr>
</tbody>
</table>

Figure 8. Results diagram of the average domain score from different buildings. Diagram by the authors.

Moreover, a total preference chart for the outdoors spaces of the Athens Geriatric Home was created. Specifically, the question included was: "How well does the outdoor area provide a real sense of escape and relief from being indoors?" (a feeling of fresh air, views, sky, sunshine, lush plantings, etc.), Figure 7. This question presents the overall impression of all living and working people for the outdoor spaces of the Athens Geriatric Home, which is not included in the 60 features of the 5 categories of the SOS Tool and
was scored with an arbitrary scale from 1 to 5, with 1 being “none” and 5 being “very well”. Also, due to the large extent of the outdoors areas of the Athens Geriatric Home, it was important to consider separately the views of people living/working in all four buildings in operation (Table 2), based on the assumption that the elderly have different perspectives of the outdoor spaces and experiences of the gardens, from their balconies and windows. Also, the views of the gardeners were taken into consideration separately, due to the fact that they don’t work inside a specific building. The results represented in Figure 8 are based on the mean of the weighted preference scores.

6 CONCLUSIONS

By looking at the diagrams, one concludes that the answers given by staff are more optimistic and positive for the existing outdoor spaces and have generally higher scores than the answers given by the elderly, despite the fact that the standard deviation is also higher. This result can be presented in each of the 5 categories, but it does not apply when they were asked to score their overall experience of the outdoor spaces (Figure 7). Generally, the category 2 has the lowest scores, both by elderly people and by staff, indicating that the outdoor seating areas do not have the appropriate specifications and are not used to a large extent. Observing the unweighted scores given by the elderly, in many questions of this category, which includes questions about the comfort of outdoor seating areas, outdoor toilets, tables, air quality and climatic conditions, it is noted that the majority of them is the lowest possible. Mostly, it was assessed that there was a shortage in the seating areas (Figure 6) and that many of them were poorly preserved, being rusty, without cushions and the ones made of stone were impossible to seat at. Also, in categories 1 and 5, the scores show a concern in the respondents answers, without indicating such a big difference from category 3. On the other hand, category 4 presents the highest scores showing a satisfaction with the current design and existence of features such as doors, doorways and outdoor spaces, including the 2 main entrances and every building entrance, showing that the transition between the areas is sufficient. When evaluating the total experience that elderly people and staff receive from the outdoors areas of the Athens Geriatric Home, it seems that, with few exceptions, most respondents ranked the surrounding areas with score such as 4 or 5, which are the highest ones. Finally, Figure 8 shows no significant differences between the five remaining residential buildings of the nursing home, with a small exception of the “Estia” building. This result can be attributed to the fact that this building is located in the northwestern part of the nursing home and is relatively detached from the rest of the premises, thus giving a distance to the entrances and central outdoor spaces that the other buildings enjoy. It should be noted that, this building was constructed in recent years, not being in the original design of the plot and remains autonomous to this day. In conclusion, it is important to emphasize the demand for more available seating, mainly in a circular arrangement, which gives the elderly the sense of a “hug”. Also, properly arranged routes seem to facilitate their movements, and clear views from the routes and open spaces, seem to abolish the sense of encapsulation, intense colors and special meeting points, seem to help the development of sociability and encourage them to visit the outdoors facilities more.

7 DISCUSSION

The main limitation of our research was that in Greece no similar research has been conducted in the past years, which means that there was no measure to which we could compare our results and borrow guidelines for a possible landscape design. Also the research took place around autumn, which means that the answers given by the participants were mostly based on the outdoor environment they encountered only during this period of time. A more completed research could include the completion of the same questionnaire at different times of the year, in which trees, bushes and flowers offer a different sense and create multiple environments, which elderly people would face with a different attitude and point of view. Finally, other nursing homes in the region of Attica can also be used for future researches, despite the fact that they don’t necessarily have such extensive outdoor areas as the Athens Geriatric Home in order to
better understand elderly people’s perspective concerning outdoor green spaces in Attica. A usable and attractive environment increases the possibilities and the drive to go outdoors both from the staffs point of view and from the elderly according to this research. It attempts to expand and reinforce previous research into the interaction of outdoor green spaces in elderly facilities and the impact on their health and everyday life. Further research will make a positive contribution to informing about the role well designed outdoor green areas and the experience of the elderly when visiting these open spaces more often.

8 REFERENCES


Korkidi E., (2011) Psycological and social needs of elderly peo ple. A first record attempt in nursing homes in Chania, Crete.(Postgraduate study, National Public Health School, Public Health Department, Sociology and Epidemiology, University of Crete), Retrieved February 1 2019 from: http://hypatia.teiath.gr/xmlui/bitstream/handle/11400/6005/%CE%9A%CE%BF%CF%81%CE%BA%CE%AF%CE%B4%CE%B7%20%CE%95%CE%B9%CF%81%CE%AE%CE%BD%CE%B7.docx?sequence=1.


PARK PERCEPTION IN BROOKINGS, SOUTH DAKOTA:
INVESTIGATING THE ROLE OF LANDSCAPE ARCHITECTURE IN
COGNITIVE MAPPING

Goeden, Joshua
South Dakota State University, joshua.goeden@jacks.sdstate.edu

Burger, Don
South Dakota State University, donald.burger@sdstate.edu

1 ABSTRACT
The Image of the City (Lynch, 1960) provides a theory of how people perceive the built environment through cognitive mapping. According to Lynch, five major feature classes help to construct these mental maps: paths, edges, districts, nodes, and landmarks. The mind organizes city features into these classes to simplify the encoding process. However, the role of parks and public spaces within this theory is largely undefined. This paper aims to identify this role. Initial research conducted by landscape architecture students at South Dakota State University showed that landscape features were largely absent from participants’ cognitive maps of the university campus (Burger, 2018). This paper changes the scale of the SDSU study to examine whether this holds true for the cognitive maps of residents in Brookings, South Dakota. Participants were interviewed using a similar method to Lynch’s study consisting of a mapping exercise, an oral description of their daily commute, an inquiry on their favorite place in Brookings, and follow-up demographic questions. The data was analyzed to indicate how many times parks were mentioned on individual surveys as compared to other mapped features. A content analysis of this data revealed that parks are fairly prevalent in cognitive perception, but the role they play within Lynch’s theory varies greatly depending on the method of recall. Our hope is that the results of this study will open a discussion on the role of parks with regards to city perception and promote further research on the relationship between cognitive mapping and park design.

1.1 Keywords
Cognitive Mapping, Lynch, Parks, Wayfinding, People-Environment Relationships
2 INTRODUCTION

The human brain is constantly at work, ceaselessly laboring to collect, encode, and store data about our environment in an attempt to make sense of the world around us. The study of how the brain organizes this spatial data is dubbed cognitive mapping. Psychologists have long had their hands on this topic, but perhaps its most direct application came from an urban planner named Kevin Lynch. In 1960, Lynch published *The Image of the City* in which he details his findings from a hands-on cognitive mapping study he led in three major US cities. In that study, Lynch had participants draw, from memory, a map of their local neighborhood in his attempt to simplify the complex fabric of the urban environment into a standard set of repeated elements. In the end, Lynch defined the city using five distinct elements—paths, edges, districts, nodes, and landmarks (Lynch, 1960). Today, his work has become key to our understanding of the urban environment and how it is perceived by the people living in it.

In 1981, Jerry Weisman published *Evaluating Architectural Legibility: Way-finding in the Built Environment*. In his paper, he attempted to determine how cognitive mapping influences navigation within an architectural setting. In the end, he came to the conclusion that in both architectural settings and the large-scale environment, the brain is not able to store the entirety of what is perceived. Rather, the brain focuses on the relationships between specific locations in the environment (Weisman, 1981). This solidified the concept of environmental legibility—the degree of difficulty the brain has in encoding a feature into the cognitive map. Other studies have built on this work, looking both at the psychology behind cognitive mapping and wayfinding (Tversky, 1993) as well as the attributes that contribute to the architectural legibility of a feature in the urban environment (Chan et al., 2012).

Though legibility is key in environmental navigation, it is only one element that determines the formation of cognitive maps. Lynch also stressed the importance of imageability—a concept that accounts for the impact of sociocultural differences in terms of cognitive salience (Lynch, 1960). Imageability is determined by not only the built form but also by usage and societal meaning within a place. Though included in Lynch’s original works, the importance of imageability was largely overlooked by urban planners of the time. This prompted Lynch to rehash the point in his follow-up work “Reconsidering The Image of the City” in which he attempted to further explain the link between imageability and legibility (Mondschein and Moga, 2019). More recent studies have now began to expand upon his model, relating imageability to other concepts such as sense of place (McCunn and Gifford, 2018), livability (Ruggeri et al., 2018), and digital navigation (Park and Evans, 2018).

The foundation set by Lynch and the research he inspired has truly had a powerful impact on the field of landscape architecture. However, there is still a gap when it comes to determining the role and importance of traditional landscape architecture projects (parks, plazas, gardens, etc.) on cognitive mapping. These sites make up a large portion of public space within the city, and thus can be assumed to have a measurable impact on an individual’s cognitive perception. Some studies have looked at the impacts of green space (Lui et al., 2016) or at cognitive mapping within a specific garden space (Mikaeili, 2016), but few have looked at the impact of the sites as a whole.

3 METHODS

Over the past seven years, students at South Dakota State University have worked on a cognitive mapping exercise focusing on how SDSU students generally perceive the university campus. By and large, campus green spaces and other landscape features were absent from participants’ cognitive maps (Burger, 2018). This led to the question—does this hold true at the city scale? To answer this question, the research team decided to repeat the previous exercise at the scale of the city of Brookings, the home of SDSU.

An individually-administered interview process modeled after Kevin Lynch’s original methodology was used to collect the data for this study. The interview began with a mapping exercise in which participants were asked to draw from memory a quick map of the city of Brookings, detailing and labeling all key features of the city. Participants were given roughly 10 minutes to complete this mapping exercise. The process and strategy the participants used while drawing the map was observed and noted by the interviewer, paying particular attention to the order in which features were drawn, the scale and page orientation of the maps, the symbology used on the maps, and the overall strategy the participants employed.

After completing the mapping exercise, the participants were then given a second sheet with a set of further questions to answer. First, the participants were asked to identify north on their completed maps. Then they were asked to draw a star to indicate where they lived within the community. Next, they were asked their occupation and to provide a verbal description of the route they take to get to work, including...
their mode of transportation, key places and features along the way, and directional aids they use. This question tested how they recalled the city without an evolving drawing to prompt them, and aimed to uncover any differences between the visual and verbal processes.

Following the verbal process, participants were asked to name their favorite place in Brookings. Finally, participants were asked their age and how long they had lived in Brookings in order to facilitate demographic comparison. After the interview concluded, participants were briefed on the purpose of the study and were given the opportunity to ask further questions.

The survey process was conducted over a six-week period in the fall of 2018. Due to time constraints and limited initial participation, 30 participants were ultimately identified by the research team from among community members and researchers’ circle of acquaintances.

4 Results

The following data was collected from the 30 survey responses. For our study, we focused on the presence of parks in the maps and responses, as parks are the only major public spaces in the City of Brookings. These parks were verified using the information on the city’s parks and recreation website (City of Brookings, 2019). The locations of each park are shown on Figure 1. The survey information was sorted using two methods. The first compared the demographic data and park mentions of the survey. These results are included in the demographic analysis, individual park data, and park correlation to major paths. The second method was a comprehensive summary of all of the included map and response features by land use. This chart was used to produce the results included under the land use comparison, land use impact factors, and feature prevalence.

Figure 1. Locations of parks in Brookings. Map by the author.

4.1 Demographic Analysis

The ages of the survey participants ranged from 19 to 67 with an average age of 34.2. Of the 30 participants, 10 were college students at South Dakota State University, 15 were residents not attending college, and 5 currently lived outside of Brookings. The average number of years lived in Brookings was 8.6, ranging from 0 to 27 years. The 30-40 age group had the greatest number of parks mapped with an average of 5.5 parks per map. The 50-60 age group had the least with an average of 1.4. However, as seen in Table 1, the number of parks mapped by age group does not reveal any obvious trend. This was also true regarding the most commonly mapped park by age group. McCrory Gardens was a top response...
by each age group. Hillcrest Park was more common between the ages of 23 and 50. However, there was no definitive trend regarding the relationship between age and parks in the cognitive map. There was also no obvious trend linking number of years lived in Brookings with the number of parks mapped, as shown in Table 2. The highest average came from those living in Brookings 10-14 years at 6, and the lowest from participants residing outside of Brookings at an average of 1.33 parks per map.

Table 1. Park mapping data by age group.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Number in Group</th>
<th>Average Parks Mapped</th>
<th>Most Commonly Mapped Park</th>
<th>Times Mapped</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-23</td>
<td>13</td>
<td>2</td>
<td>McCrory Gardens</td>
<td>7</td>
</tr>
<tr>
<td>23-30</td>
<td>4</td>
<td>1.75</td>
<td>Hillcrest Park &amp; McCrory Gardens</td>
<td>2</td>
</tr>
<tr>
<td>30-40</td>
<td>2</td>
<td>5.5</td>
<td>Hillcrest Park &amp; McCrory Gardens</td>
<td>2</td>
</tr>
<tr>
<td>40-50</td>
<td>4</td>
<td>2.5</td>
<td>Hillcrest Park &amp; McCrory Gardens</td>
<td>3</td>
</tr>
<tr>
<td>50-60</td>
<td>5</td>
<td>1.4</td>
<td>McCrory Gardens</td>
<td>3</td>
</tr>
<tr>
<td>60+</td>
<td>2</td>
<td>2.5</td>
<td>McCrory Gardens, Hillcrest Park, Dakota Nature Park, Veterans Memorial Park, &amp; Pioneer Park</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2. Park mapping data by by years lived in Brookings.

<table>
<thead>
<tr>
<th>Years Lived in Brookings</th>
<th>Number in Group</th>
<th>Average Parks Mapped</th>
<th>Most Commonly Mapped Park</th>
<th>Times Mapped</th>
</tr>
</thead>
<tbody>
<tr>
<td>under 1 year</td>
<td>3</td>
<td>2.67</td>
<td>McCrory Gardens &amp; Pioneer Park</td>
<td>2</td>
</tr>
<tr>
<td>1-4 years</td>
<td>11</td>
<td>1.63</td>
<td>McCrory Gardens</td>
<td>6</td>
</tr>
<tr>
<td>5-9 years</td>
<td>4</td>
<td>2</td>
<td>McCrory Gardens</td>
<td>3</td>
</tr>
<tr>
<td>10-14 years</td>
<td>1</td>
<td>6</td>
<td>McCrory Gardens, Hillcrest Park, Dakota Nature Park, Fishback Soccer Complex, Edgebrook Golf Course, Veterans Memorial Park, Dwiggins-Medary Park, and Pump Park</td>
<td>1</td>
</tr>
<tr>
<td>15-19 years</td>
<td>5</td>
<td>2.2</td>
<td>Hillcrest Park</td>
<td>3</td>
</tr>
<tr>
<td>20+ years</td>
<td>3</td>
<td>3.67</td>
<td>Hillcrest Park</td>
<td>3</td>
</tr>
<tr>
<td>live elsewhere</td>
<td>3</td>
<td>1.33</td>
<td>McCrory Gardens</td>
<td>3</td>
</tr>
</tbody>
</table>

4.2 Individual Park Data

The individual park data includes information on the parks that were included on the maps, in route recall, and as favorite places. It also looks at the breakdown of park inclusion on each individual survey and provides averages for each of the categories mentioned above. In total, 13 different parks showed up across the surveys: Hillcrest Park, Rotary Park, Larson Park, Dakota Nature Park, Sexauer Park, McCrory Gardens, Pioneer Park, Southbrook Softball Complex, Fishback Soccer Complex, Edgebrook Golf Course, Veterans Memorial Park, Dwiggins-Medary Park, and Pump Park. Overall, these parks represent 52% of the total number of parks in the Brookings. The most commonly mapped parks, in order, were McCrory Gardens (mapped 18 times), Hillcrest Park (13), Dakota Nature Park (8), and Larson Park (7). The number of parks included on individual maps ranged from 0 to 6, with an average of 2.2 parks per map. Parks were mentioned during the verbal route recall by only 5 participants (16.7%), with Larson Park being the most commonly mentioned. Parks were mentioned as participants’ favorite place in Brookings by 13 participants (43.3%), with McCrory Gardens having 5 mentions and the Dakota Nature Park having 4. Three of the participants who mentioned a park in their verbal route recall also included that park on their map, while two
only had the park in the verbal recall. Ten participants mentioned a park as their favorite place and included it on their map, while three had a park as their favorite place without showing it on their map. The overall data for each park is shown in Table 3.

### Table 3. Overall data for individual parks (2019).

<table>
<thead>
<tr>
<th>Name</th>
<th>Times Mapped</th>
<th>Times in Route Description</th>
<th>Times as Favorite</th>
<th>Total in Responses</th>
<th>Total Mentions</th>
</tr>
</thead>
<tbody>
<tr>
<td>McCrory Gardens</td>
<td>18</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Hillcrest Park</td>
<td>13</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Dakota Nature Park</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Larson Park</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Edgebrook Golf Course</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Pioneer Park</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Fishback Soccer Complex</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Veterans Memorial Park</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Pump Park</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Dwiggins-Medary Park</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Southbrook Softball Complex</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rotary Park</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sexaur Park</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

### 4.3 Park Correlation to Major Paths

An interesting trend in the data was the correlation between parks and major path features on the maps. The major streets in Brookings are 6th Street/Highway 14 (east/west connector) and 22nd Avenue (north-south connector), and a majority of the parks mentioned during the survey are located along these two routes. Only two (Fishback Soccer Complex and Dwiggins-Medary Park) are not located along these major streets. In total, 24 (80%) of the maps included at least one park along 22nd Avenue compared to only 16 (53%) containing a park not located on 22nd Avenue. In the responses, the parks on 22nd Avenue were mentioned a total of 13 times (43.3%) compared to 2 times (6.7%) for all other parks. Table 4 shows the cumulative results for this data.

### Table 4. Cumulative results for parks on 22nd Avenue.

<table>
<thead>
<tr>
<th>Name</th>
<th>Times Mapped</th>
<th>Times in Route Description</th>
<th>Times as Favorite</th>
<th>Times in Responses</th>
<th>Times Mentioned*</th>
</tr>
</thead>
<tbody>
<tr>
<td>McCrory Gardens</td>
<td>18</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Dakota Nature Park</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Larson Park</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Edgebrook Golf Course</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Pump Park</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rotary Park</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Southbrook Softball Complex</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>At least one park on 22nd Avenue</td>
<td>24</td>
<td>5</td>
<td>11</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>At least one other park</td>
<td>16</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>16</td>
</tr>
</tbody>
</table>

* Participants listing parks both in route description and as favorites count as one response for this table

** Total 22nd Avenue Park Mentions Percentage 66.5%

** One participant included parks in general as a favorite place. This was added for the total mentions calculation

** Total Park Mentions 84

** Total Other Park Mentions 28

** Ratio 22nd Avenue Parks to Other Parks 1.96
4.4 Land Use Comparison

Some of the most interesting data came from breaking down all of the mentioned features into 11 categories: agricultural, commercial, dining, education, entertainment, industrial, institutional, parkland, non-park recreational, residential, and other (all features not fitting into an aforementioned land use). In total, there were 161 distinct features included on the maps. The top three categories were commercial with 43 individual features, dining with 33, and institutional with 22. Parkland came in 5th with 13 features. For mapping, commercial had the most total features mapped at 100, or 3.33 features per participant (fpp). Dining came in second at 81 (2.70 fpp) and parkland third at 66 (2.20 fpp). During the verbal route recall exercise, commercial had the most mentions at 16 (53% of participants) followed by education at 12 (40%) and other at 11 (37%). Parkland was tied for 6th with 5 (17%). For favorites, parkland had the most total mentions at 13 (43%), and commercial, residential, and other tied for next closest at 5 each (17%). For total verbal responses (route recall and favorite place), commercial had the most mentions at 21 (70%) with parkland in second at 18 (60%). For overall total responses, commercial had the highest mentions at 121 (4.03 mentions per participant) followed by dining at 92 (3.07) and parkland at 84 (2.8).

4.5 Land Use Impact Factors

In order to better understand the cognitive prevalence of any individual feature within each land use category, the number of times a feature is mentioned is given as a ratio to the number of features within the category. For this study, this ratio is referred to as the impact factor and is derived by dividing the number of times any features from a given land use category was mentioned (total mentions) by the number of features in that category. The impact factors compare as standard linear data, such that an impact factor of 2 has twice the impact of a factor of 1. Figure 2 shows the comparison between the total mentions and total impact factors for each land use.

For the mapping category, education had the greatest impact factor at 6.00 (54 mentions/9 features in the category) followed by parkland at 5.08. Commercial, which had the most total mapped inclusions, only had an impact factor of 2.33. For route recall, agricultural had the greatest impact factor at 2.00 followed by education at 1.33. Parkland was 6th in this category with an impact factor of 0.38. In the favorite place category, parkland had the greatest impact factor at 1.00 followed by residential at 0.83. For total verbal responses (route recall and favorites), agricultural had the greatest impact factor at 2.00 followed by education at 1.56 and parkland at 1.38. For overall total responses (mapping, route recall, and favorite place), education had the greatest impact factor at 7.56 followed by parkland at 6.46.
4.6 Feature Prevalence

Many features stood out on the maps regardless of land use due to their size and usage, as well as their location along major paths and circulation nodes within the city. The most commonly mapped feature was the SDSU Campus, showing up in 29 of the 30 maps. Walmart was the next most commonly mapped by 20 (24 total mentions), followed by McCrory Gardens at 18 (24 total mentions). Out of the top ten features, four were parks and three were commercial. During the verbal route recall, the SDSU Campus was mentioned eight times, HyVee six times, and Walmart four times. McCrory Gardens was five participants’ favorite place, while four identified Dakota Nature Park, and three said Downtown. Overall, the SDSU Campus was verbally identified ten times, while both HyVee and McCrory Gardens were mentioned six times. Table 5 shows the overall data for the ten most prevalent features.

Table 5. Overall data for the top ten most prevalent features.

<table>
<thead>
<tr>
<th>Name</th>
<th>Land Use</th>
<th>Times Mapped</th>
<th>Times in Route Description</th>
<th>Times as Favorite</th>
<th>Total In Responses</th>
<th>Total Mentions</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDSU Campus</td>
<td>Education</td>
<td>29</td>
<td>8</td>
<td>2</td>
<td>10</td>
<td>39</td>
</tr>
<tr>
<td>Wal-Mart</td>
<td>Commercial</td>
<td>20</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>McCrory Gardens</td>
<td>Parkland</td>
<td>18</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>HyVee</td>
<td>Commercial</td>
<td>14</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>the Downtown</td>
<td>Other</td>
<td>16</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Hillcrest Park</td>
<td>Parkland</td>
<td>13</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Dakota Nature Park</td>
<td>Parkland</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>the Campanile</td>
<td>Other</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Larson Park</td>
<td>Parkland</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

5 ANALYSIS

Looking at the maps in a general sense, the parks do not stand out as a dominant feature. The average map only included around 2 parks out of the nearly 30 in Brookings. Commercial and dining land uses seem to dominate the cognitive perception of Brookings. However, the results from a further breakdown of the data showed that parks are quite prevalent, especially compared to other land use types. The number of times a park was included on a map (66) was quite high compared to the number of parks within the category (13), suggesting that the cognitive impact of each individual park is greater than many other land use categories. This also held true for the favorite places responses. Parkland had the highest impact factor (1.00), and 43% of participants mentioned a park as their favorite place in Brookings. Parkland also had the second highest impact factor for the mapping (5.08) and overall mentions (6.46) categories, and had the highest percentage of features ranked in the top 10 for individual mentions. These results are contrary to those seen in the campus study, showing instead that parks have a high impact on the cognitive maps of Brookings residents.

Another interesting result that deals with Lynch’s original theory is the method by which the maps were drawn. Most participants began their map with the major streets of the city, which would be classified as paths or perhaps edges in the Lynch vernacular. The majority of participants then began filling in features along these paths that stood out boldly in their memory. Many of these such as Wal-Mart, McCrory Gardens, HyVee, and the Campanile would be classified as landmarks. Finally, participants filled in the gaps between these locations, drawing features in clusters around previously mapped elements and generalizing large areas of similar uses, such as residential, downtown, and industrial zones. The features that fill in around the landmarks make up nodes, whereas those left independent serve as minor landmarks. The generalized areas serve as districts. This mapping strategy suggests that paths and edges are the most prevalent elements in our cognitive maps as they form the framework for every other included feature. Landmarks hold the second most weight, and nodes and districts are the least present in the cognitive map. However, this only looks at these features from a navigational standpoint. When drawing out a cognitive map, the participant is mainly focused on laying features consistent with how they perceive the city from the air, as if looking at a street map. This can explain why parks are not as directly evident on most maps. In terms of wayfinding, parks are not as useful. This has to do with the difference between perception and encoding of environmental information.
According to the study *C-Image: city cognitive mapping through geo-tagged photos*, “green perception” was the most dominant city feature (Liu et al., 2016). This data matches the results of our study, as the highest percentage of participants’ favorite places were parks. However, the Liu study was based on a photographic representation of the city, so the data is based largely on our attraction to natural scenery. In contrast, in terms of wayfinding, landmarks or “environmental cues” are key. Parks offer fewer of these cues and thus require a sequence of memorized images to be useful in wayfinding. Comparatively, landmarks reduce the need for this memorization by offering a single defining feature that can be readily used when making a navigational decision (Strickrodt et al., 2015). The perception of parks as navigation aids is further impaired by the vehicular culture in Brookings. Driving is a cognitively-passive mode of travel compared to walking or biking and thus less information is recorded along the route except for at decision points such as intersections and turns (Mondschein et al., 2013). Though Brookings has average overall walkability, research has shown that walking behavior is still limited (Schmunk and Spinney, 2018). Thus the standard transportation mode is driving, which limits the number of features encoded. Park features tend to blend in with the surrounding streetscape at higher speeds of travel, further reducing their legibility. This is evident in the results of the route recall, where parks scored far lower than other land uses. Instead, destinations and decision points become the major recalled features. The parks that did appear in the mapping exercise were those seen as popular destinations due to usage and larger parks that take up space in plan view. In summary, parks were most prevalent as favorite places due to their aesthetics and usage, but in terms of wayfinding they were far less prevalent.

This leads us to question why parks were more prevalent in this study than green spaces were during the campus studies? The potential answer has to do with how these spaces function within Lynch’s theory. The simple answer to this is that parks and greenspaces do not fit into any one category. Rather, their status changes depending on the park type, location, size, and functionality. On campus, green spaces are generally very large compared to the surrounding buildings. Functionally, they are rarely seen as a destination but are rather the space one moves through to reach other destinations. Therefore, these spaces could be classified as districts, putting them near the bottom of general cognitive perception. Also, with the majority of campus circulation taking place on sidewalks which crisscross these green spaces, it is common for the paths to take precedence and the green spaces to be overlooked. In the City of Brookings parks can fall into a number of different categories and thus many are more prevalent in cognitive maps. Most parks still showed up as districts, but some maps did show parks as landmarks. These were represented using different shapes, mirroring the strategy used for many of the other landmarks on the maps. Many were also defined by their use rather than the actual park name, suggesting that parks with unique uses were more prominent in the cognitive map. Overall, each park had a different value to each participant, but they were all seen as an important part of the city. Therefore, they had more prominence within the cognitive map than the less-defined green spaces on campus.

6 DISCUSSION

After analyzing the results of this study, it becomes clear that the role of parks on the cognitive map is still inconclusive. There are many variables (park location, size, type, and usage) that change how a park fits within Lynch’s cognitive mapping theory, and thus the role is dependent on the method employed. However, this is not an exhaustive list, and further research could reveal more variables that could further define how parks are encoded in cognitive mapping. For the sake of this study, perhaps a better approach is looking at the general role of parks within the community. By definition, a park is “a large public green area in a town used for recreation”. This definition fits well with the usage definition from this study. Many parks were included based on their recreational opportunities with many being labeled by the activities they offer and many others being mentioned as favorite places. As discussed in the analysis, the associated activities with these parks create a mental link that lends them greater prevalence in the cognitive map.

Usage is a key component of the role of parks within Brookings, but not all of the parks present (or those missing) in the study can be explained by this approach. First, many of the parks not present on the maps offer just as many recreational opportunities and are used by many residents. Their absence could possibly be explained by the park type breakdown. Most of the parks included on the maps were community parks- large and easily accessible by everyone. Many of the missing parks were residential parks, mainly used by the surrounding neighborhood. This disparity could potentially be explained by a bias in the home locations of the participants, as a majority were taken near the SDSU campus and far from the residential districts. However, there is still the question of why these residential parks do not show up along the major
pathways where they would have a greater chance of being noticed. This would require more directed research to answer properly, but one reason could be the prominence of these parks. This would be based less on usage and park type and more on size, location, and visibility. Using these indicators would help to solidify why the community parks are much more likely to be mapped. They often have a greater presence based on size, are located along major circulation paths, and are much more visible to the average person.

The topic of prominence also leads the question of a parks role in wayfinding. The results of this study showed that parks do not play a major role in wayfinding for Brookings residents. Though other factors impact wayfinding potential (discussed in the analysis), park prominence plays a major role in its cognitive presence and thus its ability to be encoded in our cognitive maps. Thus, it could be assumed that the design of a park could play a key role in its perception not only for recreational purposes but also for wayfinding. Designing parks to serve as landmark locations in terms of wayfinding could help define not only the parks as important city features but could also increase the perception of other businesses and locations around the park. This could be especially true along major streets where increased density of features could lead to legibility issues. The results of this study showed a strong correlation between major streets and cognitive recall of city features, and this was especially true for parks. Strengthening the connection of park features adjacent to major streets, framing impactful viewsheds into the park, and creating a change of density from the surrounding urban fabric are all design solutions that could increase the overall prominence of a park. These changes, combined with the already diverse selection of activities within parks, could potentially lead to greater park usage and make these parks more prevalent in the cognitive maps of the residents.

Amongst all of these inquiries, there is one overarching question: should the practice of park design change to accommodate these conditions? The easy answer is that there is still a lot to be considered both on the side of designers and city governments. There are many benefits that could come from an increased emphasis on park prominence within cities, but there are also other issues that need further research before any changes are made. The first is whether or not parks should be planned and located along major streets. Though this study shows that parks have a much higher cognitive presence when located along these paths, the same could be true of other land uses. Thus, there is a question as to what land uses should take precedence in these locations. Due to zoning regulations, some land uses (such as large retail stores) are required to be in these locations whereas parks can be more versatile in their placement. Safety also becomes an issue with parks located along major streets. Thus, it is more of a decision based on a city’s needs rather than park design in this case.

Another consideration is whether all parks should be located in prominent locations. Though community parks provide many benefits to a community, the smaller residential parks also have a place. Thus, solely designing parks based on prominence may not be the best solution for all situations. Not all parks are meant to be highly visible- many are meant to be private retreats for the surrounding neighborhood. Park types and locations are generally fairly strategic within a city master plan, and the balance of community and residential parks is key to creating a healthy city environment. With that, this same strategic planning can be used to determine which parks would benefit from more prominent designs. By working to increase the cognitive perception of key parks, a community can ensure more efficient use of funding for these design changes and get the maximum benefit. As mentioned above, these design changes could lead to cognitive perception of these key parks and result in greater park usage, increased cognition of nearby city features, and an overall increase in city legibility through perception and wayfinding.

7 CONCLUSION

The role of parks within both communities and the cognitive maps of the people living in these communities largely depends upon the context in which they are presented. In terms of Lynch’s theory, parks were potentially seen as landmarks, districts, or nodes based on their location, size, type, and sub-features. These criteria, along with the design of the park relate to its prominence and determine its ability to be encoded into the cognitive map. Though feature prominence plays an important role in city legibility and wayfinding, it is important to remember that not all parks are meant to meet these objectives. Thus, it takes the cooperation of city governments and designers to determine the best course of action when analyzing the parkland environment of a city.

Since Brookings is not a perfect representation of all cities of the world, it is important to keep in mind the limitations of this study. There is still further research to be done to determine how these results change at different scales and areas with different societal habits and values, and related studies would.
need to be conducted to determine the role of other landscape features such as plazas or streetscapes. Further investigation into these topics would help to validate the role of landscape architecture within Lynch’s theory and the other context areas mentioned in this paper. It is our hope that this study will help to set a precedence for these future studies and will open up broader discussion on the relationship between landscape architecture and cognitive mapping. By continuing the work that was started by Lynch, we will be able to get a better understanding of the purpose of public spaces within the urban environment and find even more applications for these spaces for both landscape architects, city governments, and the general public.

8 REFERENCES
Stefanidis, A. (2005). Mental mapping, Viewing the urban landscapes of the mind. In (pp. 5).
HOW VARIABLES OF SOCIAL CAPITAL IN THREE HISPANIC NEIGHBORHOODS RELATE TO AN INDIVIDUAL’S ACTIVITY SPACE

SMILOVSKY, NIKOLAS
Arizona State University, nikolas.smilovsky@asu.edu

LUKINBEAL, CHRIS
University of Arizona, chris.lukinbeal@arizona.edu

1. ABSTRACT
Inner-ring ethnic enclave neighborhoods are often subjects of debate concerning immigration, civic engagement, urban development, and citizenship. How different socio-demographic groups engage and perceive urban space can shape their physical and political environment, foster or hinder community capacity building, and foster feelings of belonging and exclusion. This case study focused on three inner-ring Latino enclave neighborhoods: Pilsen in Chicago, Garfield in Phoenix, and Little Havana in Miami. All three have a history of civic engagement and are dealing with a range of social urban prospects and challenges whether in the form of newly arriving immigrants, or gentrification. With this paper, we take up the idea that there is a spatial aspect of social capital that remains largely unexamined. Using geographic information systems along with mental mapping techniques, and survey data related to civic and place engagement, we query the extent to which gender, ethnicity, educational achievement, income level, voter registration status, and the spatial perception of safety and trust predict a person’s aggregate activity space. Activity space, in this context, reflects a person’s social and spatial mobility in a city and their perception of that city. Data derived from an extensive residential survey done (n=1,200) in the neighborhoods and a mental map exercise (n=120). Our findings show that ethnicity and the spatial perceptions of trust and safety when used in combination, predicted the size of an individual's activity space.

1.1. Keywords
Social Capital, Activity Space, Environmental Perception, Mental Maps, Civic Engagement.
2. INTRODUCTION

Global changes have set in motion new human diasporas, shaped new geographies of wealth and power, and reworked the social and spatial landscape of large cities. Understanding the human and spatial dimensions of these reorganizations, and how people engage with and actively shape them, constitutes the broader impact of this research. Inner-ring ethnic enclave neighborhoods distill broader contentions over immigration, urban redevelopment, political participation, and citizenship. How these issues are addressed is seen by some to shape the very identity of the U.S.. Negative or reactionary policy toward Latino immigration as well as anxiety over the perceived ‘Latinization’ of the U.S. might be understood in part as a consequence of insufficiently nuanced knowledge.

This research is based on extensive research in three inner-ring Latino enclave neighborhoods in Chicago (Pilsen, figure 1), Phoenix (Garfield, figure 2), and Miami (Little Havana, figure 3). In all three neighborhoods, established Latino groups face challenges both from new Hispanic immigrants and from relatively wealthy gentrifiers who create an income disparity in the neighborhood. The research presented in this paper is an outgrowth of a large systematic, comparative assessment of how individuals and groups interact with one another civically through organizations to shape their physical surroundings, and how these surroundings in turn foster or hinder belonging and exclusion (Lukinbeal et al. 2012; Price et al. 2011; Lopez and Lukinbeal 2010; Artiles et al. 2011). Because the majority of Hispanics in the U.S. reside in urban areas, Phoenix, Chicago, and Miami—with their vast and growing Latino populations, their diverse regional locations, and their historical and contemporary roles as gateway cities for Latino immigrants—were selected as case study sites. Further, each of these three neighborhoods has a rich history of civic and place engagement and community capacity building. According to Chaskin (2001, 295), community capacity is “the interaction of human capital, organizational resources, and social capital existing within a given community that can be leveraged to solve collective problems and improve or maintain the well-being of a given community.”

Figure 1. Pilsen, Chicago Neighborhood Map
With this study, we elaborate on the findings of a larger National Science Foundation project on “Comparative Civic and Place Engagement in Three Latino Enclave Neighborhoods in Transition” (Price et al. 2011). More specifically, this research queries how spatial perception and behavior relate to variables commonly associated with social capital and the building of community capacity, and to what extent those
variables could predict a person’s activity space (Smilovsky 2019). Work done by Lynch (1960) on mental mapping holds that more impoverished and racialized minorities have smaller activity spaces and less-complete perceptions of place. The variables used in this study come from a residential survey performed in each of the neighborhoods which achieved confidence intervals of 95% for their total population. Data was also drawn from a subsample of the surveyed population, which queried 120 residents in more depth on civic and place engagement as well as their spatial perceptions about safety and trust using a mental map exercise. The variables leveraged in this study from the survey were gender, ethnicity, educational achievement (GED or not), income level, voter registration status, and the spatial perception of neighborhood areas associated with safety and trust. This data was statistically compared with an individual’s activity space within the broader metropolitan region, which was derived from location-based questions in the survey. With this in mind, our central research question was to what extent do the combined research variables, or any combination of the research variables significantly predict a person’s activity space? In what follows, we address this question by first discussing social capital and community capacity building, as well as cognitive mapping and activity spaces. We then review the underlying methodology used to conduct this research, including data capture and manipulation, spatial analysis using a geographic information system, and the statistical test done to address the question. Finally, we turn to a discussion of our results and conclusions.

2.1. Literature Review of Social Capital and Behavioral Geography

Social capital consists of personal connections and interpersonal interaction, along with a shared set of values that are linked with these contacts (Field 2003). Bourdieu developed the concept of social capital during the 1970s and 80s with a focus on social hierarchy. He treated the concept of social capital as a part of cultural capital, where individuals acquired social status through cultural practices, and noted that individuals had to work at social capital in order for it to maintain its value (Bourdieu and Wacquant 1992; Robbins 2000; Field 2003). Coleman (1994), however, was interested in the interconnection of social and human capital at all socio-economic levels, proving that social capital had real benefits to the poor as well as the rich.

Putnam (2000) attracted the greatest publicity on social capital with his central idea that social networks have value and affect individual and group productivity. He extends Coleman’s idea of social capital and argues that it is an asset operating at the societal level. Social capital includes networks, trust, and norms that allow people to come together to pursue shared goals. Social capital, and by proxy social networks, are central components of community-building through the development of partnerships (Fraser and Lepofsky 2004). Social capital is a barometer of the degree to which social networks, norms, and trust allow people to unify and effectively pursue shared objectives (Putnam 2000). Social networks are essential to measure because they are an indicator of a community’s potential to be successful in revitalization efforts. This is a difficult task, because “network[s] and trust are too imprecise to be imported into a neat formula and their meaning for people often depends on their context” (Field 2003, 57). Rather than focus on the imprecise nature of trust within social networks, we use the spatial perception of safety and trust within one’s own neighborhood as a means to measure this aspect of social capital.

People form relationships with others based on friendship, work, school, or common interests and maintain these social contacts and networks over time. Geographically bounded places, such as neighborhoods, are familiar places for people to interact with one another and establish social networks. While these social networks change and are not restricted to neighborhood boundaries, they do allow people to bond and accomplish things that they would not be able to do alone, which can be beneficial in neighborhood change. Putnam (2000, 18-19) argues that “the core idea of social capital theory is that social networks have value… [and] social contacts affect the productivity of individuals and groups.” Social capital has several benefits that flow from the trust, information, and cooperation associated with social networks which are valuable to all levels of social agency. Social capital facilitates action through the productivity of social networks and is crucial for a community to come together.

According to Chaskin (2001, 295), community capacity is “the interaction of human capital, organizational resources, and social capital existing within a given community that can be leveraged to solve collective problems and improve or maintain the well-being of a given community.” Among individuals, social capital refers to “networks of positive social relations that provide a context of trust and support and that represent access to resources (information, connections, money)” (Chaskin et al. 2001, 20). Human capital, however, is a person’s attributes that are productive in an economic context often measured and thought of...
as private returns to the individual, though they can also be seen as social returns (Field 2003). One such aspect of human capital is mobility, which is directly related to the size of one’s activity space. Larger activity spaces allow individuals to have great opportunities, affords access to more resources, and is often associated with great wealth because the cost of mobility increases with distance from one’s home neighborhood. However, this is not always the case as we found in Little Havana, where household income was negatively related to activity space. In other words, in Little Havana activity space shrank with increased household income. Putnam’s (2007) referred to this as “hunkering down” while Davis (1990) describes it as a “fortress” mentality, where wealthier populations in racially plural postmodern cities become progressively more spatially isolated.

The building of social capital and community capacity require the ongoing engagement of people with a place. Although there has been much attention given to social relations in social capital theory, little emphasis has been placed on the spatial dimension of social capital (though see Rutten, Westlund, Boekema 2010). There is a need to look at the underlying geographies of these social relations and networks and identify how social and demographic variables have differing spatial domains and networked patterns. The idea behind social propinquity begins to get at these relations where higher degrees of bonding is associated with less spatial distance which is central to urban social networks, as well as regional agglomerations of the creative class (Backstrom, Sun, Marlow 2010). As Scott (2000, 33) notes, transactional networked density is not just a resource of skilled labor but also is the foundation of “active hubs of social reproduction in which crucial cultural competencies are maintained and circulated.” Denser networks of social relations lead to higher levels of social capital and community capacity. The spatial dimensions of social capital, however, may operate quite differently depending on the location within which they are studied (Rutten, Westlund, Boekema 2010). Also, as Lynch (1960) has shown in his work on mental maps, more affluent communities that have higher mobility create large urban imaginaries within which social capital can be built.

Research related to activity space goes back to the 1950-60s and space-time analysis of daily activities (Meier 1962; Chapin 1965; Hagerstand 1970), and travel diaries (Marble 1967; Nysteun 1967). Rather than being a theoretical construct, activity space is more of a practical unit or analysis that can easily be given a quantitative areal measurement and applied to people’s values, constraints in the urban environment, and patterns of social clustering, and spatial movement (Kwan 2000a, 2000b; Mennis, Mason, & Cao, 2013; Curtis, 2016; Perchoux et al., 2016). Mapping activity space reveals where place engagement is concentrated for individual’s surveyed within study areas. It also can provide a practical computational means by which to assess the territoriality of individuals and groups and effectively show one form of place engagement. Activity space analysis, however, differs from space-time analysis in that the spatial organization of the data is explicated, while the temporal patterns are of less importance. Such is the case with our research, where we sought to understand the macro spatial domain that encompassed residential patterns of activity and not the micro spatial-temporal patterns of daily life.

Where activity space focuses on the behaviors one exhibits in their daily activities, individuals also carry around with them an overall impression of the city within which they live, called one’s urban image (Stern and Krakover 1993). These images are always partial, distorted, idiosyncratic, and impact how people go about their daily activities and influence their choices of those activities. In a broad sense these maps within our mind, called mental and cognitive maps, are not only used to guide us through space but also relate to our preference, evaluation, and assessment of spaces and places (Lopez and Lukinbeal 2010). Further, cognitive mapping research makes the distinction between designative and appraisive images where the former deals with variations between the actual mapped environment and our image of it in terms of distance, directions, and orientation (Walmsley 1988; Pock and Hudson 1978). With designative image analysis (made famous by Kevin Lynch) we are looking at how well one’s urban image is developed, physical and perceptual barriers that preclude that development, and distortions that resonant not only with individuals but commonalities of designative urban images amongst groups. Though a useful line of inquiry, our research does not use designative images but instead relies on appraisive image analysis.

In contrast, appraisive images “incorporates both evaluation and preference, the former including some general or external standard, the latter reflecting a more personal type of appraisal, and affection, which is the emotional response concerned with feeling, value, and meaning attached to the perceived” (Pocock and Hudson 1978, 30). Drawing upon appraisive urban images can be a compelling way to get at how people project their evaluation of space onto the urban environment. It also allows us to access and apply the social capital variable of trust and safety to a spatial domain. This can be done by having
participants draw polygons around areas they perceive as being safe and trustworthy, and those they do not.

3. METHODS

A modified area probability random sampling frame for the personal interview survey was done at a respondent’s home in each of the respective study areas. The survey data accounted for all but one of the variables used in this study. The only data not derived from the survey was the mental mapping data associated with trust and safety, which will be discussed later. The surveys were done with residents 18 years or old in English or Spanish, depending on the respondent’s preference. The survey followed Yamane’s (1967) formula for proportions to calculate the needed sample size for each of the three study areas (Figure 4, Table 1). In the formula, ‘n’ reflects the sample size needed, ‘N’ reflects the total population to be sampled, and ‘e’ is the level of precision. The level of precision is expressed as a percentage (e.g., +/- 5%) that reflects the sampling error and is inversely related to the level of confidence.

The neighborhoods were defined by Census tracts so that a baseline population (N) could be obtained. For our probability sampling technique we allocated the number of surveys needed based on a total percent of the population within an aggregated census tract. By using census tracts, we were able to draw from predetermined spatial extents, which provided a means to cross-compare study sites findings with census data. The Garfield study area consists of 3 census tracts (1132.01, 1132.02, 1132.03), the Pilsen study area constitutes 9 census tracts (3103, 3104, 3105, 3106, 3107, 3108, 3109, 3113, 3114) and Little Havana comprises 9 census tracts (5201, 5202, 5301, 5302, 5401, 5402, 6401, 6402, 6403). Because the total number of surveys needed would increase exponentially to maintain a confidence interval of 95% within each tract, calculations for the level of precision reflect the total populations of people 18 years or over for the entire study area(s). Survey findings, therefore, are reflective of the entire study area, and confidence intervals do not correspond to the individual census tract.

\[ n = \frac{N}{1 - N \cdot (e)^2} \]

Figure 4. Yamane’s Formula for Proportions

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Population 18 and Over</th>
<th>Confidence Interval</th>
<th>Surveys Completed</th>
<th>Survey Size with 5% Level of Precision</th>
<th>Mental Maps Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garfield</td>
<td>6,219</td>
<td>95.087%</td>
<td>388</td>
<td>376</td>
<td>39</td>
</tr>
<tr>
<td>Pilsen</td>
<td>23,621</td>
<td>95.052%</td>
<td>402</td>
<td>394</td>
<td>41</td>
</tr>
<tr>
<td>Little Havana</td>
<td>42,695</td>
<td>95.025%</td>
<td>400</td>
<td>396</td>
<td></td>
</tr>
</tbody>
</table>

One drawback to probability sampling through personal interview surveys deals with spatial coverage and sampling design. As Golledge and Stimpson (1996, 20 emphases in original) note, “it is essential to use probability random sampling designs where the intention is to use sample statistics to make inferences about the parameters of the population from which the sample is drawn.” Probability random sampling requires that each discrete sampling unit must have the same chance to be picked. Sheskin (1985) points out that such a method runs the risk of samples being drawn from highly localized or clustered areas within study sites which have the potential to skew data results because people living in very close proximity (for instance, on the same block) tend to share similar beliefs, values, and attitudes. To alleviate issues of data being skewed by spatial propinquity, we used geographic information systems (GIS) and Microsoft’s Excel to randomized respondents demographically as well as spatial. To accomplish this parcel data was obtained from the three different county assessors’ offices. Each parcel has a unique number assigned by
the County. Unique parcel numbers were imputed into an Excel spreadsheet, and a randomization algorithm was run to determine which parcels would be used in the survey.

For this research, data for a person’s activity space came from a series of questions in the survey that asked where one conducts their daily activities associated with their home, shopping, haircut, restaurants, children’s school, playground, and where they visited with friends and family. Respondents would note the address or relative location which would be geocoded and attributed with the unique identifier that provided the link between the spatial location and the respondent’s survey data. Following Shareck, Krestens, and Gauvin (2013) example in which they utilized convex hulls to examine the spatial congruence between spatially obtained data from questionnaires, this study leveraged convex hulls to calculate a person’s activity space. A convex hull is a mathematical envelope that circumnavigates a set of points on a Euclidean plane, which is defined as the smallest convex polygons. Convex hulls are indicators of the spatial extent and spatial dispersions of an activity (Shareck, Kestens, and Gauvin 2013). All data were projected to the study area’s State Planes Coordinate System NAD83 (SPCS), and the areal geometry (area size) was recorded for each convex hull (Figure 5).

![Figure 5. Garfield, Aggregated Activity Space Map](image)

Activity Locations of Garfield Residents
- Activity Spots
- Activity Spaces
- Garfield Tracts
- Phoenix
- Metro Phoenix Cities

0  5  10 Miles

N
Along with the more extensive neighborhood survey, a sub-sample of 10% of respondents were selected for in-depth interviews (N=120). Because our focus was on the combination of variables that were demographic, behavioral, and perceptual, our overall population (N) for analysis was reduced to this sub-sample. Participants for the in-depth interviews were not intended to be a random sample but rather focused on finding and eliciting information from interesting and engaging residents. Interview questions sought to elicit the resident’s opinions about life in the neighborhood changes happening there, and the level of connection that residents feel with neighbors and the City. Each interviewee was asked to complete a mental map exercise where they were given a standardized printed map of their neighborhood with landmarks and streets labeled. Individuals were asked to locate their home (black point), their neighborhood (black polygon), locations and areas they deemed friendly, trusting, and safe (blue points and polygons), and locations and areas they deemed problematic or unsafe (red points and polygons) (Figure 6).

![Figure 6. Pilsen, Participant’s Cognitive Map](image)

All of the printed mental maps were scanned and georeferenced to match the existing projected coordinates system (SPCS) of study area’s geodatabase. Following this, each of the mental map features was digitized into point and polygon layers and attributed by the respondent’s unique identifier that provided the link between the survey and mental map data. Although area size calculations were created for all of the mental map data, for this study only the areal size of polygons associated with friendly, trusting, and safe areas was used. Of the 120 respondents, 13 had not recorded any friendly, trusting, and safe areas leaving our final population size for analysis at 107, which was an adequate population size to confidently predict activity space using multiple linear regression.

### 3.1. Data Analysis

Descriptive statistics and multiple linear regression (MLR) were leveraged to answer the research question. Results of the descriptive statistics are found in table 2 and table 3. Figure 7 is a graphical representation of how the six individual predictor variables were used to determine whether they could confidently predict the outcome variable activity space.

#### Table 2. Descriptive Findings for Categorical Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>#</th>
<th>Max</th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>StdDv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male (1)</td>
<td>44</td>
<td>78.42</td>
<td>0.0237</td>
<td>12.78</td>
<td>3.92</td>
<td>19.09</td>
</tr>
</tbody>
</table>
### Table 3. Descriptive Findings for Continuous Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>#</th>
<th>Max</th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>StdDv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Int. Var. (sqmi)</td>
<td>107</td>
<td>10.33</td>
<td>0.09</td>
<td>2.02</td>
<td>1.24</td>
<td>0.79</td>
<td>2.08</td>
</tr>
<tr>
<td>ActSpace</td>
<td>Int. Var. (sqmi)</td>
<td>107</td>
<td>80.46</td>
<td>0.0003</td>
<td>11.53</td>
<td>3.25</td>
<td>Null</td>
<td>18.39</td>
</tr>
</tbody>
</table>

**Figure 7. Methodology Flow Chart**
Using IBM’s SPSS software, the MLR analysis was performed on the data. Following strict statistical guidelines from Statistic Solutions (2018) and Laerd (Laerd Statistics 2015), eight assumptions were tested to make sure the MLR was an appropriate statistical measure to predict activity space. These included:

A1: You have a continuous dependent variable (outcome variable).
A2: You have two or more independent variables (predictor variables) which are either continuous (interval or ratio) or categorical (ordinal or nominal).
A3: You should have the independence of observations.
A4: There needs to be a linear relationship between the dependent variable and all the independent variables.
A5: The data needs to show homoscedasticity of residuals.
A6: The data must not show the multicollinearity of independent variables.
A7: There should be no significant outliers in the data.
A8: The residuals (errors) are approximately normally distributed.

4. RESULTS

We first tested whether the conjunction of the research variables predicts a person’s activity space. The results from this study found that in conjunction, gender, ethnicity, educational achievement, income level, voter registration status, and the spatial perception of neighborhood areas associated with safety and trust do not predict the size of an individual’s activity space. After analyzing the eight assumptions needing to be met for MLR, the final model was produced. The final model used to test this research question was ActivitySpace = β0 + β1(Ethnicity) + β2(Gender) + β3(Education) + β4(Voter Registration) + β5(Income) + β6(Safety/Trust). This outcome was due to the fact that the predictor variables were not all significantly related to the dependent variable (activity space). Next, we tested whether any of the research variables in combination predicted a person’s activity space. The results reveal that the environmental perception variable of safety/trust as well as ethnicity were significant predictors for activity space. The final model which represented this relationship was log(ActivitySpace) = β0 + β1(Ethnicity) + β2*log(Safety/Trust).

4.1. Discussion

The final MLR model produced significantly predicted an individual’s activity space based on two of the six variables selected in this study. By plugging in different values for the ethnicity and safety/trust variables, the equation was able to predict a person’s activity space. For example, if you assume the variable of environmental perception of safety/trust equals one square mile and the variable ethnicity equals non-Hispanic, then:

\[
\log_{10}(\text{ActivitySpace}) = 1.07 + 0.502 \log_{10}(1) - 0.508 \cdot (1)
\]
\[
\log_{10}(\text{ActivitySpace}) = 1.07 + 0 - 0.508 = 0.57
\]
\[
\text{ActivitySpace} = 10^{0.57} = 3.72 \text{ square miles}
\]
\[
\text{Activity Space is 3.72 square miles}
\]

In contrast, if we assume the variable safety/trust equals one square mile and ethnicity equals Hispanic, then:

\[
\log_{10}(\text{ActivitySpace}) = 1.07 + 0.502 \log_{10}(1) + 0.508 \cdot (2)
\]
\[
\log_{10}(\text{ActivitySpace}) = 1.07 + 0 - 1 = 0.07
\]
\[
\text{ActivitySpace} = 10^{0.07} = 1.17 \text{ square miles}
\]
\[
\text{Activity Space is 1.17 square miles}
\]

This example shows that the activity spaces of non-Hispanics are higher than Hispanics when the environmental perception of safety/trust variable stays constant. This interpretation was supported by analyzing the median value of activity space for ethnicity, where the median value of non-Hispanics was higher than Hispanics. Another result from the final model is when you assume the variable of environmental perception of safety/trust equals two square miles, and the variable ethnicity equals non-Hispanic, then:

\[
\log_{10}(\text{ActivitySpace}) = 1.07 + 0.5(0.301) - .508 = .713
\]
ActivitySpace = 10^.713 = 5.164 square miles
Activity Space is 5.164 square miles

This demonstrated that non-Hispanic’s activity space was spatially larger when they had a higher environmental perception of safety/trust in their neighborhood. This was shown when the variable of environmental perception of safety/trust was set to one square mile, compared to two square miles, and ethnicity was set to non-Hispanic. In this example, the calculated activity space was 3.72 square miles, which was less than the 5.164 square miles reported previously. Finally, this same trend was seen with Hispanics. When the variable environmental perception of safety/trust was set to two square miles, and ethnicity was set to Hispanic, then:

\[
\log_{10}(\text{ActivitySpace}) = 1.07 + 0.5(0.301) - 1 = 1.07 + 0.151 - 1 = 0.221 \\
\text{ActivitySpace} = 10^{0.221} = 1.93 \text{ square miles} \\
\text{Activity Space is} 1.93 \text{ square miles}
\]

This depicts that Hispanics similarly have larger activity spaces when they perceive their neighborhoods to be safer and more trustworthy.

A few limitations were identified in this research. First, the location of the participant’s place of work was not asked in the original survey which could not be corrected at a later date and may have improved the activity space calculations. Second, only a small sub-sample of 107 people were used to test the relationships between specific variables and urban behavior. Third, the study focused on a Hispanic inner-ring neighborhoods and the results may not be generalizable to other populations. For future studies, researchers may wish to broaden the study area or increase the sample size. Second, increasing the number of locations that go into calculating the size of one’s activity space would make the analysis more robust but would also make the research more labor intensive.

5. CONCLUSION

The purpose of mapping perception and behavior is to provide a means to examine how residents engage with and perceive their neighborhood and city (Lynch 1960; Lee 1968; Johnston 1971; Carp, Zawadski, and Hossein 1976; Kwan 2000a, 2000b). Spatial analysis provides a practical computational means by which to assess an individual’s spatial behavior and show how people engage with, produce, and re-produce place. Appraisive images are what people draw upon when they evaluated the quality of places and when combined with ethnicity is a predictor of one’s behavioral patterns in the urban environment. Assessment of appraisive imagery through the use of mental maps provides a means to document and assess the qualitative judgement of an individual. Aggregating mental map data to perform statistical analysis helps to reveal trends in how subgroups engage differently with place and community.

Positive social capital building and civic engagement are essential for society because they help create collective efficacy in the community (Putnam, 2000) and because they are a vehicle for positive change (Scandahl, 2013). People’s behaviors have been the focus of many studies since the conception of psychology, yet studying behavior in conjunction with social capital building and civic engagement is a relatively new area of research. A person’s behavior and perception influence how one interacts with their community, neighborhood, and urban environment. The results of this study indicate that there are specific variables associated with social capital that have significant relationships with a person’s ethnicity, spatial behavior (activity space), and spatial perception (safety and trust). By combining measures of spatial perception and behavior with demographic information, we can begin to tease out the underlying relationship between urban social geography and social capital. Understanding that people’s spatial behavior is predicated on environmental perception of safety/trust and ethnicity may aid designers, architects, urban planners, and engineers make better decisions about their projects.
6. REFERENCES


SUSTAINABLE SOLUTIONS FOR VISITOR ACCESS AT YELLOWSTONE NATIONAL PARK: EXPLORING TRANSIT OPTIONS FOR THE PARK’S MOST POPULAR DESTINATIONS

Roberts, Mandi
MLA Candidate, University of Idaho, robe1151@vandals.uidaho.edu

Scott, Elizabeth
University of Idaho, Department of Landscape Architecture, Urban Design Center, bscott@uidaho.edu

1 ABSTRACT

Yellowstone National Park is experiencing unprecedented congestion levels, particularly in the heavily-visited Geyser Basin from West Yellowstone to Old Faithful. Congestion threatens unique geothermal features, rivers, natural vegetation, and habitat due to off-trail foot traffic and parking outside designated areas. Park visitor surveys indicate congestion levels are detrimentally effecting the quality of the visitor experience. Because vehicle volumes are frequently above the capacity of parking areas in the Geyser Basin in summer, this study investigates the potential to introduce a shuttle system to this area. Research methods include case studies of shuttle systems at other national parks, secondary analysis of visitor surveys and studies of visitor impacts in the Geyser Basin, and interviews with National Park Service (NPS) experts who plan and manage shuttle systems at other parks. The case studies examine visitation levels, system capacity, scheduling, parking, and operations. Research findings suggest that capping private vehicle use to existing parking lot capacities and delivering additional visitors via shuttle could be a more sustainable means for access to the park. Key findings include: shuttle systems should connect heavily visited areas, rather than serving the entire park; convenient, attractive park-and-rides are critical for encouraging ridership; and opportunities to promote bicycling and sight-seeing with the shuttle program can enhance visitor experience. A conceptual transit system plan proposes three services between West Yellowstone and Old Faithful (Express, Explorer, and Trekker) with synchronized timetables. This plan could remove up to approximately 45 percent of private vehicles from the congested corridor during summer peak months.

1.1 Keywords
- National parks shuttle
- Parks overcrowding
- Visitor use management
- Alternative transportation systems
- Sustainable visitor access

The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the Council of Educators in Landscape Architecture (CELA), and its printing and distribution does not constitute an endorsement of views which may be expressed. Citation of this work should state that it is from a CELA conference paper. EXAMPLE: Author's Last Name, Initials. 2018. Title of Paper. Blacksburg, Virginia: CELA. For information about securing permission to reprint or reproduce this paper, please contact CELA at staff@thecela.org
2 INTRODUCTION

America’s national parks continue to experience increasing levels of visitation as our nation’s population grows, and as international tourism levels continue to spike across the western U.S. In 2018, the Park Service recorded nearly 320 million visitors at all of its facilities, up from about 275 million in 2008 (NPS, 2019). Increasing levels of visitation are difficult to manage given limitations on funding and staffing. Increased visitation can affect the National Park Service (NPS) mission to protect natural and cultural resources and provide a positive visitor experience. Yellowstone National Park (Yellowstone) is one of the most visited places in the United States. With increasing visitation, private automobile use is also reaching levels never seen before at Yellowstone. Roads and parking areas are highly congested, particularly in the Geyser Basin corridor from West Yellowstone to Old Faithful. Traffic congestion and high levels of private vehicle use bring increases in greenhouse gas emissions and air pollution, as well as degradation of resources and impacts to wildlife. Potential effects on visitor experience continue to be studied, but a 2016 survey of visitors by the NPS (NPS, 2017a) found that:

- Over half the visitors think there are too many people in the park.
- Two thirds of visitors think that parking is a problem and over half think that the amount of roadway traffic and congestion are problems (“finding a parking space” was the highest ranking of all problems).
- Many visitors would like to see these challenges addressed through voluntary public transportation and expansion of parking options.
- Most visitors coming through West and South gates are going to see Old Faithful.

With continued growing visitation, NPS staff at Yellowstone face the question of how to manage visitor usage to best minimize effects to the park’s resources while providing the best possible visitor experience. This paper highlights work done by the authors to define relevant best practices applicable for introducing alternative transportation systems (ATS) to Yellowstone; identify potential options for implementation through descriptive case studies of ATS at other national parks; and develop a proposed transit system to help manage visitor use in heavily congested areas of the park. Investigation of options for introducing ATS to Yellowstone began with discussions with park staff who identified the need to explore the options for managing the park’s traffic and high visitation levels during peak summer months. The work presented here reflects work sessions with NPS staff and stakeholders, and thorough review of NPS data, reports and other literature regarding the use of transit in national parks. The results of this work have informed the development of a potential shuttle system for the park’s most congested corridor in the Geyser Basin. Further work exploring design options, implementation guidelines, operational frameworks, and funding and financing options is not included here.

2.1 The Use of Transit in National Parks

Transit systems in parks vary widely in many aspects, including the types of vehicles used, service timeframes, length of routes, operational approaches, and level of visitor facilities and improvements in place to serve the public. (E. Cole, personal communication, April 17, 2018; Manning, 2014; Taff et al, 2013). Transit systems in parks face challenges of having to deliver visitors efficiently while also offering a positive user experience and protecting natural and cultural resources. For example, at Zion National Park (Zion NP), the NPS found that pulsing of shuttle visitor loads led to the unintended consequences of overcrowding at bus stops and trailheads. Zion NP had to adjust the service and improve certain areas to address these concerns. (J. Burns, personal communication, April 17, 2018).

Some park shuttle systems are designed to provide access to special experiences, while others provide general transportation and delivery of visitors. Partnerships are often crucial to successful implementation of park shuttle programs. Because of the high capital costs in starting a shuttle system and ongoing operations costs, the NPS carefully studies each system opportunity, generally conducting a detailed feasibility study followed by a two- to three-year pilot program (e.g., Nelson et al, 2008). Ongoing operations can be funded through various methods such as a portion of entrance fees allocated to transportation. In some cases, the NPS owns and operates shuttles in parks, while in other locations it may manage concession or service contracts to operate the systems (Begley, 2012). Feasibility studies involve cost/benefit analysis and examining the potential advantages a shuttle system may offer in enhancing the visitor experience, minimizing congestion and crowding, and reducing potential detrimental effects to natural and cultural resources. “Sustainable transportation in national parks makes good, common sense” according to the authors of Sustainable Transportation in the National Parks: from Acadia to Zion (Manning et al, 2014). Manning et al explored the history of transportation in national parks and identified best management practices in place throughout the NPS that can help guide planning and management of sustainable transportation systems. They emphasize that there is growing use and support for ATS in the national parks. Table 1 summarizes some of
these key best practices and identifies the advantages they offer related to park operations, visitor experience, and resource protection.


<table>
<thead>
<tr>
<th>Best Management Practices (BMPs)</th>
<th>Advantages of BMPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation in national parks should include important experiential implications.</td>
<td>X</td>
</tr>
<tr>
<td>Transportation should be utilized as an effective management tool in national parks.</td>
<td>X</td>
</tr>
<tr>
<td>Transportation should be an important form of recreation.</td>
<td>X</td>
</tr>
<tr>
<td>Transportation systems should deliver information, education, and interpretation to park visitors.</td>
<td>X</td>
</tr>
<tr>
<td>Transportation management in the national parks should be based on partnerships with important stakeholders.</td>
<td>X</td>
</tr>
<tr>
<td>Transportation management in the national parks needs strong leadership.</td>
<td>X</td>
</tr>
</tbody>
</table>

3 METHODS

A complex descriptive strategy used for investigating the potential to introduce transit to the Geyser Basin corridor consisted of case studies of shuttle system use at Zion, Rocky Mountain, Yosemite, and Acadia National Parks, NPS staff interviews, review of internal NPS reports, and review of visitor data collected at Yellowstone beginning in 2016. Interviews with twelve NPS transportation experts stationed at the Denver Service Center, Intermountain Region, the Washington Support Office, and at other national parks provided insights into the challenges and opportunities presented by transit systems in national parks. These approximately one hour interviews consisted of open-ended questions about the planning, design and operations of transit systems, and were necessarily contextual based on the interviewee’s experience. The case studies evaluate how other national parks have implemented transportation demand management techniques, shuttling systems, trail access, and other actions to help manage visitor congestion and improve visitor experience. Key concerns and other information gathered from interviews and workshops with NPS staff are discussed in Section 2.1 above. In addition, visitor demographics and visitation statistics gathered by the NPS at Yellowstone (NPS, 2017a) were reviewed to better understand visitor use patterns and demand. Key ideas from this data are presented in Section 5, Geyser Basin Analysis. Case studies of shuttle systems at Zion, Rocky Mountain, Yosemite, and Acadia National Parks posed the following questions:

- How have alternative transportation systems been successfully designed and implemented in other national parks? What features contribute to their sustainability?
- What components do the case study systems include?
- In what ways do the case study systems enhance the visitor experience (such as by reducing traffic congestion) and protect natural and cultural resources (such as by reducing air pollution and traffic noise)?
- Do the system design features fit well within the park context and what are the specific design features that support context sensitive design?

This paper presents a synopsis of the Zion NP shuttle system to best represent operational and visitor experience characteristics of the four shuttle systems studied as part of this work. A summary of key findings of the other case studies is presented here, but a detailed discussion of these is beyond the scope of this paper. The Zion Canyon shuttle system is emphasized here because it is widely viewed as a successful example, and because it is a good illustration of the best practices applied to ATS in national parks.

4 National Park Shuttle System Case Studies

ATS in national parks have different operational and user considerations than those operating in urban environments (e.g., Orsi, 2015; Taff et al, 2013; White and Aquino, 2008). Primary among these is the need to protect the park’s natural and cultural resources while providing a high-quality visitor experience. In short, the
shuttle systems must support the overall mission of the National Park Service to preserve “unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations” (NPS, 2016).

4.1 Zion National Park Shuttle

Zion National Park, near Springdale, UT, introduced its 6.5-mile shuttle system in 2000, after visitation topped 2.4 million visitors in 1999. At that time, on an average day during the peak season, more than 5000 cars and tour buses were using the scenic drive with only 400 parking spots available (J. Burns, personal communication, April 17, 2018). The congestion led to erosion and destruction of vegetation in the sensitive Virgin River Canyon, as well as frustration among park visitors. A range of alternatives to protect resources in the canyon while also continuing to provide visitor access and enhance visitor experience was explored through a public and internal review process before deciding to implement a mandatory shuttle system to Zion Canyon destinations during the peak tourist season (J. Burns, personal communication, April 17, 2018). The shuttle provides convenient, frequent access to hiking trails, scenic points, picnicking, horseback riding, and the Upper Lodge. After nearly 20 years of operation, the Zion shuttle system has proven to be an outstanding exemplar of the BMPs highlighted in Table 1.

The system was planned and funded through cooperative efforts between Zion National Park, the Town of Springdale, the National Park Service’s Denver Service Center, the Utah Department of Transportation, the Federal Highway Administration, the Zion National History Association (ZNHA), and other organizations. The park purchased the shuttle buses and received funding for capital construction of the shuttle maintenance barn and storage area in the park. Federal transportation funding helped cover the cost of shuttle stop improvements in Springdale, supported by matching funds from the town and ZNHA. The shuttle system is operated and maintained by a private contractor through a service contract between the contractor and the National Park Service that is renewed every five to ten years.

To support ongoing operation costs, the park charges a transportation fee that is part of the park entrance fees. Entrance fees were formerly $10 per vehicle or group of visitors, of which the park kept 80 percent and sent 20 percent to the National Park Service in Washington, D.C. Special legislation (public law 102.03) allowed the Park to add a $10 transportation fee on top of the $10 entrance fee, and allowed the park to keep 100 percent of the transportation fee to pay for the shuttle. The park could thus keep $18 for every $20 paid by visitors. Because Zion National Park is close to several other parks, many visitors started appearing to keep 100 percent of the transportation fee to pay for the shuttle. The park could thus keep $18 for every $20 paid by visitors. Because Zion National Park is close to several other parks, many visitors started appearing

The shuttle system includes the vehicles, shuttle stops with shelters, seating areas and other amenities (in the park and in Springdale), an in-park maintenance and storage area, and a wayfinding/signing system that helps visitors determine where to park and ride the shuttle either from locations in Springdale or from the visitor center where parking is available. The system operates with 30 propane-powered buses. Inside the park, passenger-carrying trailers are connected to the buses to increase visitor capacity along the route. When combined with the trailer, the double length shuttle has the capacity for 66 passengers. Shuttle buses are also designed and branded with an attractive graphic template that blends with the park scenery and enhance the visual connectivity between the shuttle system and the park experience.

Pulsing patterns of visitors deboarding the shuttle at trailhead stops in the canyon was closely monitored, and while the park had carefully designed most shuttle stops and trailheads to accommodate the full capacity of the vehicles, some locations had to be improved to handle a greater number of visitors after the shuttle system was in operation. Design also integrated features such as low walls and curbs to contain visitor traffic and protect adjacent resources as visitors travel to trails and other park destinations. Shuttle stops are constructed of natural materials including timber and quarried rock from local sources. The bus stop shelters are simple structures designed in materials and colors that blend well with the park setting.

The shuttle system operates from April through October or November (park loop only). During the summer months, visitors may not drive their private vehicles on the scenic drive in upper Zion Canyon unless they are guests at the Upper Lodge. Buses run at six-minute intervals during the middle of the day, which provides convenient and frequent access to destinations. Shuttles generally operate from 6:30 a.m. to 11:00 p.m. daily during the summer months, allowing visitors a variety of time options during the day, and a variety of visit durations.

The park has documented that resource conditions have improved and that visitors report a high level of satisfaction with the shuttle system. One double length shuttle carrying 66 passengers replaces approximately 25 private vehicles that without the shuttle system would be competing for parking and adding to congestion in the upper canyon. The vehicles have excellent ventilation with a top-opening window system, so
no air conditioning is required (reducing energy use). They also have large windows so visitors have excellent views of the park scenery during their trip. The park offers multiple sources of information about the shuttle system, including website, the park visitors guide and brochure, and information posted on signs in Springdale and at the visitor center. Visitors are made aware through multiple sources that they may drive their vehicles through the park year-round, but during the summer season, the Zion Canyon Scenic Drive is accessible by shuttle only.

The Zion Canyon shuttle system has been effective in reducing traffic congestion in the upper canyon portion of the park. Studies have documented that the visitor experience is enhanced by the shuttle system, which provides onboard interpretation and excellent scenic viewing opportunities. The park reports that visitor surveys show a positive relationship between the shuttle and overall park experience (NPS, 2009; Mace et al, 2013). A greater degree of solitude and tranquility were reported by visitors in the canyon after the shuttle system was implemented compared to the years preceding the shuttle, and noise readings taken by park staff confirm these perceptions. In addition, park studies of natural resources in the canyon including vegetation, wildlife habitat, water quality, and other elements show that conditions improved with implementation of the shuttle system. Even though the shuttle has been successful, ongoing operation of the system encounters periodic challenges. The visitor center becomes crowded on peak visitation days and at times, visitors have to wait in line for the shuttle. The lack of available space for parking in town becomes a concern during peak visitation as well. Financial constraints have been reported related to the park’s ownership of the bus vehicles, which are due for major repairs and some replacements as they approach 20 years in service. These issues aside, the Zion Canyon shuttle system is known throughout the National Park Service as a highly effective and successful example of an alternative transportation system that has been effective in helping the park manage congestion and protect sensitive resources while also enhancing visitor experience.

4.2 Case Studies Summary

A review of ATS at other national parks shows that a wide variety of approaches and systems are in place in national parks across the country. Each system is tailored to the context of the park, and there are varying structures of funding and operations. Key characteristics of shuttle systems in operation at Zion, Rocky Mountain, Yosemite, and Acadia National Parks included the size of the shuttle fleet, who operates the fleet, the strategic system approach (e.g., reduce environmental impact, provide better backcountry access) and other distinctive elements of each system. While the case studies are not discussed in detail here, they provide insights to the variety of operational and implementation challenges that arise with shuttle systems in national parks, including:

- Initial capital costs associated with improvements, such as the need to create a bus maintenance and staging/storage facility; purchase of the rolling stock; improvements for park and ride and bus stop locations.
- Funding of ongoing operational and maintenance costs, including development of maintenance facilities, and replacement of vehicles.
- For seasonal systems, the challenge of finding / keeping qualified employees to operate the system.
- A wide range of options for covering costs of shuttle systems, including allocating a portion of park fees, working with partners such as private corporations and non-profit groups, obtaining grants and donations, and leveraging services through regional and local transit agencies.

Yellowstone faces all of these challenges as well as degradation of its unique geothermal resources. Transit solutions aimed at reducing congestion and other impacts from personal vehicle use need to be multifaceted, such as ATS coupled with trail and multi-use path development that could connect key features, and/or ATS coupled with metering of traffic at key gates into the park that could have nearby park-and-ride facilities. There is much interest in and support for this work from Yellowstone staff, as well as staff at the NPS Intermountain Region and the NPS Denver Service Center. Partners to Yellowstone are also interested and engaged. Ongoing work on this project will continue engagement with these stakeholders to help guide the development of the proposed system.

5 GEYSER BASIN CORRIDOR ANALYSIS

As visitation to Yellowstone continues to surpass record numbers, concerns intensify regarding how to provide public access while maintaining a positive visitor experience and preserving Yellowstone’s iconic natural and cultural resources. The primary challenges with intensifying visitation are:

- Visitor Experience — congestion and overcrowding at entrances, roads, parking areas, trailheads, trails, attraction sites, visitor centers, restrooms, and other facilities.
• Environmental — air pollution, noise pollution, light pollution, wildlife impacts, damage to resources, including critical natural and cultural features, especially the iconic geothermal features.

Figure 1 Map of congested areas throughout Yellowstone National Park (2018). Diagram by authors.

In determining potential shuttle routes in Yellowstone, it was evident from visitor statistics and survey information collected by the park staff beginning in 2016 (NPS, 2017a) that the Geyser Basin corridor between the west park entrance at West Yellowstone, MT and Old Faithful (Figure 1) was the principal route that could contribute the greatest benefits in terms of reducing vehicle congestion and managing visitor impacts to the park’s resources. Most visitors arriving through the west and south entrances are coming to see Old Faithful. Traffic volumes from the west entrance are roughly 30 percent higher than the design capacity of the roads and parking lots. Figure 1 shows the main features in the park and the location and types of conflicts that have been observed by NPS staff and visitors. The Geyser Basin stands out as the most congested area, with a high concentration of geothermal features including Old Faithful, the Grand Prismatic Spring, and other popular geothermal features. There is also a high concentration of “wildlife jams” along the Yellowstone River, that is, traffic jams caused by visitors stopping to view and photograph wildlife. Wildlife jams are also concentrated along the Madison River near the intersection of Highway 20 and Highway 89.

The concentration of geothermal features in the Geyser Basin is clearly a major reason for visitors to come to Yellowstone. Figure 2 is a bird’s-eye view of the Grand Prismatic Spring, one of the park’s most iconic features. The other-worldly beauty of Grand Prismatic and so many of the other geothermal features is the reason that the road between West Yellowstone and Old Faithful has the highest level of congestion in the park. It is also one of the areas of greatest concern, given the sensitive nature and good accessibility of these features. Over the decades, the NPS has introduced new facilities and interpretive information intended to educate visitors and promote conservation of these resources. Yet overcrowding creates conflicts that give rise to undesirable visitor behavior. A study of summer visitor use patterns at major attractions in Yellowstone identified several hot spots of undesirable visitor behavior (Mills and Bramblett, 2017). Behaviors observed by Mills and Bramblett included parking outside of designated areas, creation of social trails, trash in geothermal pools and terraces, people stepping off boardwalks, and destruction of fragile geologic resources. There were high concentrations of unwanted behavior around parking areas, trails and boardwalks at Old Faithful and Midway Geyser Basin, including the Grand Prismatic Spring and Fairy Falls. Figure 3 shows visitors at the Old Faithful area during the peak summer season. It is clear that the high concentration of visitors creates an environment that can easily give rise to these unwanted behaviors.

Active visitor use management in this corridor is essential for visitor safety and to maintain a high-quality experience. Existing data provided by the NPS and others suggests that careful consideration of the level of visitation combined with design interventions at specific locations could go a long way to reduce the negative impacts of the high levels of congestion experienced in summer months. As the Zion shuttle systems has demonstrated, careful planning and design of ATS in the parks can help manage visitor use, visitation levels, and effects of congestion on the park’s resources.
SUSTAINABLE ACCESS SOLUTIONS — PROPOSED SHUTTLE SYSTEM

6.1 Assessing Shuttle System Viability

Understanding visitor use patterns is a critical aspect in developing a plan for implementing a shuttle system. However, it is also necessary to consider the quality of the visitor experience that a shuttle system could provide, particularly as compared to the diminished experience that is common during the summer months when overcrowding can lead to long wait times, extreme traffic conditions, and inability to park and/or access popular features. Therefore, a key question for the system is: How many visitors should be delivered by a shuttle system? To answer this, a range of scenarios was developed, predicated on desired visitor experiences; routing options; stops, access to trailheads and other features; timetables; vehicle types; capacity analysis; trip itineraries; and operating hours and distance. These scenarios embraced the best practices highlighted in Table 1 to ensure that transit efficiency took into account the overall visitor experience. The results are presented in Section 6.2 below, with more detailed description of travel time, capacity, and other assumptions.

Information from the case studies was used to understand operational considerations, such as vehicle types and capacity, typical route times including stops and layovers at destinations, facilities and amenities needed at stops, location options for personal vehicle parking prior to boarding the shuttle, and communication of timetables and route options. One of the principal lessons from Zion NP’s shuttle system is that the system must operate on a frequent enough timetable that visitors can catch the shuttle with minimal wait times. Additional facilities such as comfortable stops, wayfinding information at stops, and interpretive information provided both along the route and at stops heighten the overall experience. Based on these and other lessons from the case studies, a range of scenarios was developed to evaluate potential to provide convenient access to destinations throughout the Geyser Basin, as well as an improved visitor experience.

6.2 Shuttle Routing Options, Stops, and Related Visitor Experiences

An overall system design based on evaluation of these scenarios focuses on three route options between West Yellowstone and Old Faithful. These route options would operate on a synchronized timetable, traveling the same route, but providing a variety of options for stops and length of stay. These options are the Old Faithful Express, the Geyser Basin Explorer, and the Westside Trekker. Figure 4 is a map showing the routes and stops for each route option. A summary of key features of each route option is provided in Table 3.

The proposed system offers three options for visiting features in the Geyser Basin. The fastest and most direct option, the Old Faithful Express, would provide non-stop service from the west entrance at West Yellowstone to the Old Faithful Education Center. The second option, the Geyser Basin Explorer, provides opportunities to stop at many of the most frequently visited Geyser Basin destinations. This route option is intended for visitors that want to spend some time at the features, perhaps take short hikes, or picnic and relax for a few hours, but spend about a half a day overall. The third option, the Westside Trekker, is intended for visitors who want to spend a longer time in the Geyser Basin. This option accommodates cyclists and...
backpackers who can access trails and other roads, and who may be staying for multiple days. It also accommodates visitors who will spend a long day visiting the Geyser Basin features.

Figure 4 Route options for proposed shuttle system (2018). Figure by authors.

An operational evaluation of the three shuttle service scenarios was completed to gain better understanding of the service requirements, number of visitors that could be served, and the potential benefits, such as the number of private vehicles that could be replaced by shuttle service capacity, thereby reducing demand on parking spaces. Table 4 summarizes the results of this analysis, assuming a 12-hour period of service each day from 7:00 am to 7:00 pm. It utilizes estimated driving times at the posted speed limits.

Table 3 Shuttle Service Scenarios for the Geyser Basin Corridor.

<table>
<thead>
<tr>
<th>Shuttle Service Scenarios</th>
<th>Old Faithful Express</th>
<th>Geyser Basin Explorer</th>
<th>Westside Trekker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor Experience:</td>
<td>Round-trip from West Yellowstone to Old Faithful in the quickest possible time</td>
<td>Sight-seeing and photography in the Geyser Basin</td>
<td>Visitor Experience: Sight-seeing and photography in the Geyser Basin</td>
</tr>
<tr>
<td>Walking trail loops</td>
<td></td>
<td></td>
<td>Walking trail loops/hiking</td>
</tr>
<tr>
<td>Picnicking / Day use</td>
<td></td>
<td></td>
<td>Bike loops on low-speed roads</td>
</tr>
<tr>
<td>3 – 4 hours / Half day</td>
<td>Stops: West Yellowstone, Old Faithful</td>
<td>4 – 6 hours / Short day</td>
<td>Picnicking / Day use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stops: West Yellowstone, Madison River Wayside, Madison Junction, Fountain Paint Pot, Midway Basin / Fairy Falls, and Old Faithful</td>
<td>8 – 10 hours / Long day</td>
</tr>
</tbody>
</table>

The analysis estimates that the Express service, which has no intermediate stops, would arrive at Old Faithful in one hour; Geyser Basin Explorer with four intermediate stops/six stops total would arrive at Old Faithful in 90 minutes; and Westside Trekker with eight intermediate stops/ten stops total would arrive at Old Faithful in two hours. The model assumes 30-minute layovers at Old Faithful and upon return to West Yellowstone to provide adequate breaks for drivers. This means that there would be two to three shuttles present at the destinations at any given time requiring layover space at the termini. Each service would require
a different number of buses given the changes in travel times. Both 10-minute and 20-minute headways were analyzed (with shuttles leaving West Yellowstone every 10 minutes/10-minute frequency of service at all stops or every 20 minutes/20-minute frequency of service at all stops). Express requires an estimated fleet size of 22 for 10-minute service and 11 for 20-minute service. Explorer requires an estimated fleet size of 30 for 10-minute service and 15 for 20-minute service. Trekker, with the most stops requires an estimated fleet size of 36 for 10 minute-service and 18 for 20-minute service.

The model also estimates a shuttle capacity of 30 per vehicle and assumes annual service days of 153 from mid-May through mid-October. Running at full capacity (100 percent), the 10-minute frequency model for all services could carry 2,190 round-trip passengers per day or 335,070 visitors per year maximum. Assuming 80 percent capacity (a more realistic average of ridership based on case studies and interviews), 1,752 round-trip passengers/visitors could be carried in shuttles at 10-minute headways and 888 round-trip passengers/visitors at 20-minute headways. All three shuttle scenarios would have the same carrying capacity given the same service durations for each. Implementation of the shuttle system would reduce demand for parking. The analysis found that the 10-minute service could reduce the number of private vehicles by 38 to 45 percent during the peak summer months, removing 674 vehicles from the corridor, and the 20-minute service could reduce private vehicle use by 19 to 23 percent, removing 342 vehicles from the corridor (assuming the park’s average persons per vehicle ratio of 2.6).

Table 4 Shuttle Service Operational Analysis.

<table>
<thead>
<tr>
<th>Shuttle Service Operational Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Old Faithful Express</strong></td>
</tr>
<tr>
<td>Number of Shuttle Stops</td>
</tr>
<tr>
<td>Trip Duration</td>
</tr>
<tr>
<td>Number of Shuttle Vehicles in Operation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Estimated Full Fleet Size Needed</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total Passengers Carried per Day at 80 Percent Capacity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Estimated Number of Private Vehicles that Could be Replaced with Shuttle Use at 80 Percent Capacity in Peak Visitation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Estimated Number of Private Vehicles that Could be Replaced with Shuttle Use at 80 Percent Capacity in Peak Visitation</td>
</tr>
</tbody>
</table>

7 CONCLUSIONS

Analysis completed for the Sustainable Solutions for Visitor Access project indicates that the shuttle system would provide a variety of beneficial outcomes. The three types of services—Express, Explorer, and Trekker—could operate synchronously, providing visitors with a variety of choices to access Geyser Basin sites. The shuttle system would reduce the number of private vehicles in the congested corridor by up to 45 percent on peak summer days assuming a 10-minute frequency of service. The shuttles could provide onboard visitor interpretation and deliver visitors to a variety of recreational experiences and attractions, including some areas that may not be accessible to private vehicles. Additionally, parking areas would be able to operate at the capacities they were originally designed to accommodate. Implementation could help manage visitation levels at popular attractions, reducing crowding on boardwalks and trails, as well as undesirable off trail foot-traffic. Shuttle operations could significantly reduce the number of vehicles and traffic congestion on roads and in
parking areas, thereby reducing pollution and greenhouse gas emissions. The shuttle system would need to be designed with adequate facilities such as staging and layover areas at the West Yellowstone and Old Faithful route termini, and with a maintenance and storage headquarters area in West Yellowstone. Attractive and convenient stops and facilities would need to be carefully designed to fit the context of the park setting. There is a difference between the number of visitors a shuttle system could accommodate and the amount of visitors the system should accommodate given limitations on park resources, space, operations capacity, and other factors. To achieve the outcomes summarized in Section 6.2, visitor use management in the Geyser Basin corridor would need to monitor, meter and manage to the ideal capacity that parking lots can accommodate while simultaneously offering shuttle service as an alternative vehicle access option. This study does not address the visitor capacity of specific sites in the corridor. Analysis of the maximum number of people at one time that each site can accommodate is needed to determine how many visitors the shuttle system should deliver on an ongoing basis. The study also does not fully address financial and operational feasibility. While the study outlines potential options based on other national park models, additional analysis is needed to determine the best approach for Yellowstone and to identify potential partners who could support implementation.

Ongoing work on the project will examine various visitor itineraries and potential adjustments to the timetable to optimize service efficiencies. Concepts for enhancing visitor experience and integrating improvements and amenities as part of implementing the shuttle system are also being explored. After completion of this study, the NPS will need to proceed with a more detailed alternative transportation feasibility analysis, and this may include implementing and testing a shuttle pilot program in the corridor. In summary, this project shows that implementing a shuttle program in the West Yellowstone to Old Faithful corridor could result in a variety of positive outcomes. However, more detailed analysis is needed to determine specific operational and financial models that might be feasible and how these would be implemented.

8 REFERENCES


REDEFINING INDIGENOUS LANDSCAPES FOR AUTHENTIC REPRESENTATION

Shotyk, Olivia
Pennsylvania State University, ocs6@psu.edu

Aeschbacher, Peter
Pennsylvania State University, pja12@psu.edu

1 ABSTRACT
There are few examples of contemporary Indigenous landscape architecture in North America, despite the great number of rich cultures and their strong relationships with the land. A possible reason for this gap in representation includes the impact of colonization on Indigenous design principles and precedent examples, with many communities deprived of opportunities to evolve culturally. However, cultural landscapes pre-dating colonization could be used as precedents of possible Indigenous design. Unfortunately, classification of these types of sites is not currently consistent across North American institutions. Despite the UNESCO World Heritage Committee adopting the term ‘cultural landscape’ in 1992, little progress has been made to broaden the range of heritage sites to include those that hold both cultural significance and natural value. Many sites with World Heritage “natural site” designation are ancestral homes to Indigenous groups and by neglecting to recognize them as culturally significant, UNESCO is misrepresenting the cultural history of Indigenous communities, as well as leaving engagement with Indigenous communities up to the relevant federal body. This research examines a number of pre-colonial sites of significance to Canadian Indigenous communities that should be re-evaluated for their cultural value: examples such as these could stimulate contemporary Indigenous landscape design and provide recognition of the role Indigenous communities have had in North American culture and history. Most importantly, by recognizing the cultural narrative tied to these landscapes, UNESCO and other institutions would be identifying the ongoing relationship Indigenous communities continue to have with landscapes considered culturally significant.

1.1 Keywords
Indigenous peoples, cultural landscapes, UNESCO designation, natural heritage, Aboriginal societies

The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the Council of Educators in Landscape Architecture (CELA), and its printing and distribution does not constitute an endorsement of views which may be expressed. Citation of this work should state that it is from a CELA conference paper. EXAMPLE: Author's Last Name, Initials. 2019. Title of Paper. Sacramento, California: CELA. For information about securing permission to reprint or reproduce this paper, please contact CELA at staff@thecela.org
REDEFINING INDIGENOUS LANDSCAPES FOR AUTHENTIC REPRESENTATION

1 ABSTRACT (Section title: Arial 11 CAP bold)
There are few examples of contemporary Indigenous landscape architecture in North America, despite the great number of rich cultures and their strong relationships with the land. A possible reason for this gap in representation includes the impact of colonization on Indigenous design principles and precedent examples, with many communities deprived of opportunities to evolve culturally. However, cultural landscapes pre-dating colonization could be used as precedents of possible Indigenous design. Unfortunately, classification of these types of sites is not currently consistent across North American institutions. Despite the UNESCO World Heritage Committee adopting the term ‘cultural landscape’ in 1992, little progress has been made to broaden the range of heritage sites to include those that hold both cultural significance and natural value. Many sites with World Heritage “natural site” designation are ancestral homes to Indigenous groups and by neglecting to recognize them as culturally significant, UNESCO is misrepresenting the cultural history of Indigenous communities, as well as leaving engagement with Indigenous communities up to the relevant federal body. This research examines a number of pre-colonial sites of significance to Canadian Indigenous communities that should be re-evaluated for their cultural value: examples such as these could stimulate contemporary Indigenous landscape design and provide recognition of the role Indigenous communities have had in North American culture and history. Most importantly, by recognizing the cultural narrative tied to these landscapes, UNESCO and other institutions would be identifying the ongoing relationship Indigenous communities continue to have with landscapes considered culturally significant.

1.1 Keywords
Indigenous peoples, cultural landscapes, UNESCO designation, natural heritage, Aboriginal societies
2 INTRODUCTION

The release of the Canadian Truth and Reconciliation Commission report in 2015 brought with it a list of calls to action directed at the Canadian government. These were intended to help move forward reconciling the concerns of First Nations, Métis and Inuit inhabitants with the non-Indigenous population (Truth and Reconciliation Commission, 2015). While one of these calls to action refers to how Indigenous people are represented in Canadian heritage and commemoration, none of them specifically discuss Indigenous historic sites other than residential school sites (Truth and Reconciliation Commission, 2015).

Since the release of the report, the federal government passed a bill to increase First Nations, Inuit and Métis representation on the Historic Sites and Monuments Board of Canada, as a step toward addressing the need for equality and representation in heritage site designations (House of Commons, 2018). While this represents a positive development, there is still little progress in explicitly protecting Indigenous historic and cultural landscapes.

Indigenous cultural landscapes are common across North America, but often not identified, officially protected, or recognized for their cultural importance. These landscapes could contribute to a greater understanding of the historical and cultural context of the periods before European settlement. Still important and used by Indigenous communities today, they also shed light on cultural differences that could inform contemporary Indigenous landscape architecture. Contemporary Indigenous landscape architecture is growing in Canada as landscape architects also begin to address the calls to action of the Truth and Reconciliation Commission report. Working between Inuit, First Nations and Métis communities and the federal/provincial governments requires an understanding of the unique relationship between these communities and their land and how landscape architects can represent and be sensitive to this relationship in design.

3 UNESCO WORLD HERITAGE DESIGNATIONS

Using the UNESCO World Heritage designations as the vehicle of study, a story of forgotten and neglected Indigenous communities is revealed. By studying World Heritage sites, it becomes apparent that a number of sites conserved for their natural heritage value in Canada and the United States are also home to a long history of Indigenous occupation. Currently, of Canada’s 22 World Heritage sites, eleven of them are important to Indigenous communities (World Heritage List, n.d.). While some of them have been recognized as such, Canada has six “natural site” designations that hold varying degrees of significance to the local Indigenous communities that are not addressed.

Nahanni National Park in the Northwest Territories was inscribed in 1978 for its scenic river, waterfalls, cave system, and wildlife (Nahanni National Park, n.d.). The site is also the home of the Dene, with evidence of human occupation dating back 9,000-10,000 years. The park shows evidence of the changing lifestyle of the Dene, from a nomadic lifestyle pre-dating European contact to more permanent settlements near trading posts and trails along trapping routes (Parks Canada, 2019a).

The Canadian Rocky Mountain Parks were inscribed in 1984 for their geological and ecological value (Canadian Rocky Mountain Parks, n.d.). The valleys of the mountains are also the ancestral home of the Stoney Nakoda who were forced out of the mountains when Banff National Park was established in 1887. They were allowed back into the park during “Banff Indian Days” to entertain tourists with traditional regalia and celebrations (Hamilton, 2017).

Dinosaur Provincial Park was inscribed in 1979 for its outstanding preservation of fossils of over 35 species of dinosaur (Dinosaur Provincial Park, n.d.). Located in Alberta’s Badlands, the area has long been considered a spiritual place to the Blackfoot or Niitsitapi who consider the fossils to be the bones of the “Grandfather of the Buffalo,” (Russell, 2005).

The Waterton Glacier International Peace Park, stretches from Alberta to Montana and was inscribed in 1995. The area is also the traditional territory of the Blackfoot or Niitsitapi people who have struggled to maintain their rights to the land (Parks Canada, 2019b; Sholar, 2004).

Gros Morne National Park in Newfoundland has been home to a number of Indigenous groups for over 4,500 years. The first occupants have been referred to as the Maritime Archaic, named for their settlements along the seashore (Burzynski, 1999). Later the Dorset people came to live in this area, followed by the ancestors of the Beothuk people. A thousand years after that, the first Europeans arrived: the Norse. The Mi’kmaq arrived to this area around the same time as the Spanish and French. Mi’kmaq still live in the park today (Parks Canada, 2019c).
Wood Buffalo National Park was inscribed in 1983 for its wildlife: the largest population of wild bison and the nesting site of the whooping crane. It is also home to the world’s largest freshwater delta, at the mouths of the Athabasca and Peace rivers (Wood Buffalo National Park, n.d.). The local Indigenous population is made up of Cree, Chipewyan and Metis people, with Indigenous presence in the park dating back 8,000 years. Indigenous access to the park for subsistence hunting and asserting a traditional way of life has been complicated, however. Until 2003, hunting rights were not based on Treaties but rather were hereditary and only considered those who lived on the land at the time it became a park: those who had cultural ties to the land were not included (Parks Canada, 2018). Today, hunting rights are more equal but Indigenous concerns in respect to the park and its management still often fall on deaf ears (Lavoie, 2018).

The United States has even more natural sites that hold cultural significance to local Indigenous communities. Currently, the following UNESCO sites should be re-evaluated in their designation for Indigenous cultural importance: Yellowstone National Park, Everglades National Park, Grand Canyon National Park, Redwood National and State Parks, Mammoth Cave National Park, Olympic National Park, Great Smoky Mountains National Park, Yosemite National Park, Hawaii Volcanoes National Park, Carlsbad Caverns National Park, and the aforementioned Canadian-American Waterton Glacier International Peace Park. While focusing specifically on World Heritage sites in Canada, and by extension the United States, according to a recent study, over one third of “natural” designated sites are home to Indigenous people (International Indigenous Peoples’ Forum on World Heritage, n.d.).

The World Heritage Committee amended their Operational Guidelines for the Implementation of the World Heritage Convention in December 1992 to include cultural landscapes. At that time, they also determined a subset of cultural landscape categories: associative landscapes, clearly defined landscapes, and organically evolved landscapes (Australia ICOMOS, 1995). At the 1995 Asia-Pacific Regional Workshop on Associative Cultural Landscapes, held by the Australian division of ICOMOS (International Council on Monuments and Sites), they began to take advantage of these categories by nominating sites that hold cultural and spiritual significance to Aboriginal communities to the associative cultural landscape category. Associative cultural landscapes refer to sites that do not necessarily hold tangible evidence of a culture, but rather have intangible attributes including acoustics, olfactory and kinetic elements. These are landscapes that are, “embedded in a people’s spirituality, cultural tradition and practice,” (Australia ICOMOS, 1995). This category would be a clear choice for nomination of most of the previously mentioned World Heritage sites.

However, the North American sectors of UNESCO and ICOMOS have not applied these sub-cATEGORIES. This demonstrates that UNESCO already identified, over 20 years ago, that there was a gap in the World Heritage Site classifications which, although they were amended, they were not implemented worldwide. Australia’s Uluru-Kata Tjuta National Park was inscribed in 1987 as a natural heritage site but after the 1992 World Heritage Convention, they re-nominated the park as a cultural site with the support of the traditional Aboriginal stewards, earning a mixed cultural/natural site designation (UNESCO World Heritage, n.d.). Despite the rich history of Indigenous cultures associated with many of North America’s UNESCO World Heritage sites, there does not seem to be any movement toward recognizing these communities through the UNESCO platform, denying these communities greater visibility.

4 INDIGENOUS PEOPLE AND CULTURAL LANDSCAPE MANAGEMENT

In 1992, the same year that cultural landscapes were adopted by the World Heritage Committee, traditional management (referring to traditional techniques and respecting traditional knowledge of Indigenous communities) was accepted by the Committee as acceptable management of World Heritage sites (UNESCO World Heritage, n.d.). While in some cases, such as Nahanni National Park, strong connections have been forged with the local Indigenous community to create a management plan for the heritage site, in other cases, this type of collaboration is nonexistent (Parks Canada, 2019a).

Wood Buffalo National Park, for example, has been a site of contention between the local Indigenous communities and the federal and provincial governments. The UNESCO World Heritage Committee threatened to add Wood Buffalo National Park to the list of sites in danger this summer, after a petition from Mikisew Cree First Nation was heard in 2014 (Lavoie, 2019). The petition spurred the World Heritage Committee to monitor the park and organize a report detailing their concerns. They include the existing and planned hydroelectric dams which are reducing the water flow into the Peace-Athabasca delta, the largest inland delta in the world. Another concern outlined was the lack of engagement with First Nations communities both in monitoring the site and impact, as well as in respecting Traditional Ecological
Knowledge (World Heritage Committee, 2019). Canada has until 2020 to turn around the negative impact on Wood Buffalo National Park but First Nations groups have been concerned over the environmental impacts of the WAC Bennet dam for decades. The dam was built in 1968 before regulated federal environmental assessments, followed by the Peace dam in 1980 (Lavoie, 2016). The concern from First Nations groups stems from the impact which the decreased and unpredictable water level has on their traditional way of living. Dried out areas in the delta prevent access to traditional hunting grounds and have changed the ecological composition of the area. When the hydro company releases water from the dam, flooding occurs, washing away traps and drowning wildlife. A third dam is on its way, causing much concern over further deterioration of habitat in the delta (Lavoie, 2016).

This is just one of many examples of the disconnection between federal bodies working in national or economic interest and Indigenous communities who have acted as custodians of these sites for hundreds, often thousands of years. In other “natural site” examples, Indigenous communities are deprived of their traditional way of life, often through hunting and fishing restrictions. If these sites were recognized as cultural sites, federal and provincial institutions would be forced to recognize the heritage and impact Indigenous communities have had on these sites, and hopefully amend management plans to actively include Indigenous people.

5 UNITED NATIONS DECLARATION ON THE RIGHTS OF INDIGENOUS PEOPLES

The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) was passed in 2007, with four votes against its adoption: from Canada, the United States, Australia and New Zealand (Barrera, 2019). Although Canada dropped its opposition in 2016 and has since supported the declaration, implementing it will still take considerable time (Fontaine, 2016). Relevant to this paper are the following UNDRIP articles that have the opportunity of addressing the inequality of current North American UNESCO World Heritage designations as well as other institutional conservation projects that exclude Indigenous communities from the process:

Article 8.2: “States shall provide effective mechanisms for prevention of, and redress for: any action which has the aim or effect of dispossession of them of their lands, territories or resources…” (United Nations, 2007, p.10)

Article 11.1: “Indigenous peoples have the right to practice and revitalize their cultural traditions and customs. This includes the right to maintain, protect and develop the past, present and future manifestations of their cultures, such as archaeological and historical sites, artefacts, designs, ceremonies…” (United Nations, 2007, p. 11)

Article 12.1: “Indigenous peoples have the right to… maintain, protect, and have access in privacy to their religious and cultural sites…” (United Nations, 2007, p. 12)

Article 26.1: “Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired.” (United Nations, 2007, p. 19)

Article 26.2: “Indigenous peoples have the right to own, use, develop and control the lands, territories and resources that they possess by reason of traditional ownership or other traditional occupation or use, as well as those which they have otherwise acquired.” (United Nations, 2007, p. 19)

Article 26.3: “States shall give legal recognition and protection to these lands, territories and resources. Such recognition shall be conducted with due respect to the customs, traditions and land tenure systems of the indigenous peoples concerned.” (United Nations, 2007, p. 19)

According to the Declaration, these are the minimum standards to ensure well-being and dignity of Indigenous peoples (United Nations, 2007). Currently, the Canadian government has not passed any laws that would write UNDRIP into the constitution, nor has any other country (Barrera, 2019). After the creation of UNDRIP, the UNESCO World Heritage Committee created a policy on engaging with Indigenous communities in order to support their declaration on Indigenous rights. While the World Heritage Committee encourages active engagement, it is at the discretion of each federal body whether or not to engage. Active opposition from the Indigenous community, such as in the Wood Buffalo case, compels engagement.

6 CONNECTING CULTURAL LANDSCAPES TO LANDSCAPE ARCHITECTURE

Protecting cultural landscapes is critical because of the role they hold in society. Indigenous cultural landscapes are, “living landscape[s] that an Aboriginal group values because of their enduring relationship with that place and its continuing importance to their cultural identity,” (Buggey, 2008). All of the “natural”
designated World Heritage sites that have been discussed as supporting cultural heritage can be considered cultural landscapes due to the lengthy history of Indigenous presence and ongoing significance to Indigenous communities. The significance of a cultural landscape designation is that it paints a picture of an Indigenous group’s relationship to the land, a significant component of Indigenous culture, survival, and religious beliefs. Indigenous culture and spirituality are profoundly connected to the land. At the mercy of weather, migrating food sources, and hostile environments, their lives have always revolved around their physical environment and how to endure and survive it (Buggey, 1999). While their relationship has changed due to land treaties and their segregation from traditional ways of using the land, the importance of land is not forgotten. A chief of a Mi'kmaq community in New Brunswick spoke of it’s significance in one recent land claim battle, “This land means everything to me. This land means everything to my community. This land means everything to the surrounding areas. It’s everything. Plain and simple,” (Fahmy, 2017).

Cultural landscapes can be used as cues to inform a contemporary practice of Indigenous landscape architecture. Just as Western relationships with land and nature inform Western landscape architecture, so too is there the opportunity to inform Indigenous landscape architecture by learning from Indigenous cultural landscapes. The need to recognize the cultural contribution that Indigenous communities have had on World Heritage sites then goes to inform the practice of landscape architecture in the 21st century as it relates to Indigenous communities, both in urban and reserve/reservation settings. Landscape architecture firms across Canada are working with Indigenous communities on projects from land claim agreements, to masterplanning of territorial parks, as well as public parks and reflection spaces (NVision Insight Group, n.d.; Brook McIlroy, n.d.; HTFC Planning and Design, n.d.). All of these projects reflect an understanding of Indigenous land management, Traditional Ecological Knowledge, and localized geography. These are all lessons that can be learned from Indigenous cultural landscapes.

Protecting and valuing Indigenous cultural landscapes is imperative as it provides visibility to a minority population, recognizes the value of their cultural beliefs and stewardship of these landscapes, and shapes the notion of what a national park is: a beautiful place that has been managed for thousands of years and continues to be thoughtfully managed by people indigenous to this land. Landscape architects should understand this better than anyone, as they too insert culture and value into the spaces they manage. In a post-colonial world, it is everyone’s job to recognize and celebrate Indigenous cultures and learn from these sites about traditional ways of living. To do this, however, requires that these spaces are first acknowledged for what they are, namely Indigenous cultural landscapes.

7 REFERENCES


http://trc.ca/assets/pdf/Calls_to_Action_English.pdf


THE ROLE OF SALIENT CANAL STRUCTURES IN ENVIRONMENTAL ADAPTATION

Rising, Hope Hui
Texas A&M University, hope.rising@tamu.edu

1 ABSTRACT

This study used mediation analysis to investigate the potential of water elements in mediating wayfinding differences due to gender and familiarity. In an unfamiliar environment, women and newcomers, on average, do not navigate as effectively as men and residents because of their tendency to use an eye-level instead of top-down map-like perspective for wayfinding (Devlin and Bernstein 1995, Malinowski and Gillespie 2001). Salient features, such as waterscapes (Yabiku, Casagrande et al. 2008, Faggi, Breuste et al. 2013), can potentially help women and newcomers navigate more effectively (Vinson 1999, Chen, Syvitski et al. 2012). Waterscapes were classified using Lynch’s elements of imageability, landmarks, nodes, paths, edges, and districts (Lynch 1960). Participants (21 females and 39 males) from eight Dutch, German, and Belgian water towns completed cognitive mapping, photovoice, and emotional recall protocols, which measured their mental image coherence, waterscape mappability and identifiability, and their attachment towards waterscapes. The findings suggest that mappable canals with salient structures enabled women and newcomers to better use the top-down map-like perspective and to more effectively sequence eye-level views. Identifiable eye-level canal scenes helped evoke attachment towards mappable canals to contribute to their environmental adaptation in an unfamiliar setting. Frequent flooding has brought more flood refugees and water retention projects to safer higher grounds (Andoh and Declerck 1997, Najarian, Goenjian et al. 2001, Hartmann and Driessen 2017). Integrating water elements into the public realm can potentially make relocation destinations more adaptable to flood refugees, who tend to be disproportionately female (Few 2003, Fothergill and Peek 2004).

1.1 Keywords
Place attachment, water features, spatial cognition, flood refugees, relocation, wayfinding
2 INTRODUCTION

Relocation can be stressful and traumatic (Najarian, Goenjian et al. 2001). Yet it has been considered an effective adaptation measure for circumventing the impacts of natural disasters (King, Bird et al. 2014). Few researchers have studied how environmental design helps facilitate a more positive relocation experience. Migrants tend to choose relocation destinations that resemble where they are from (Scannell and Gifford 2010). Flood refugees, who are often from low-lying areas imbued with water, are thus more inclined to seek proximity to water bodies as they migrate to safer higher grounds. The increasing storm intensity has led to a need to implement more water retention projects in upstream locations, which tend to be relocation destinations. By investigating how to systematically integrate waterscapes into the public realm of relocation destinations, researchers can help planners, designers, and other environmental decision makers make involuntary migration less stressful and motivate proactive relocation from flood-prone areas.

Korpela (1989) noted that newcomers often sought out water bodies for environmental self-regulation so as to reduce stress associated with being in an unfamiliar environment; this process of environmental adaptation leads to place identity when components of the physical environment, such as waterscapes, are used to maintain psychological balance and coherence of one’s self. This may be a similar type of environmentally derived place attachment that often forms among newcomers before they develop place identity, or identification with a place as an extension of the self (Hernández, Hidalgo et al. 2007).

The tripartite theory of place attachment suggests place identity and place dependence as contributors to place attachment (Scannell and Gifford 2010). This research used a wayfinding perspective to translate environmentally derived place identity and place dependence into place identifiability and place mappability to investigate the impacts of physical settings on environmentally derived place attachment without the social dimensions of place attachment that require time to develop. This perspective is particular relevant for investigating flood refugee’s environmental adaptation in an unfamiliar environment and their perception of relocation destinations. The focus on wayfinding in the public realm also helps fill a gap in the place attachment literature that has mainly focused on socially derived place concepts.

The environmental image often involves two frames of reference—a top-down map-like and eye-level photograph-like perspective. These two facets of spatial schemas are widely discussed as allocentric and egocentric frames of references by neuroscientists (Mou, McNamara, Valiquette, & Rump, 2004). These perceptions seem to correspond to two components of imageability proposed by Lynch (1960): structure and identity. Structure is similar to the mappability-based legibility, and identity is akin to the identifiability of environmental features, as described in Kaplan’s (1984) functional view of aesthetics. This study postulates that these two perspectives of water-based imageability can be conceptualized, in the context of wayfinding, as water-based mappability and water-based identifiability, or environmentally derived waterscape dependence and waterscape identity.

Women are disproportionally affected by flooding (Few 2003, Fothergill and Peek 2004). However, compared to men and residents, women and newcomers do not navigate as effectively in an unfamiliar environment; women and newcomers tend to rely on an eye-level instead of map-like perspective and do not use environmental cues as often to aid wayfinding (Devlin and Bernstein 1995, Malinowski and Gillespie 2001). Salient environmental features can potentially mediate wayfinding differences due to gender and familiarity (Vinson 1999, Chen, Chang et al. 2009). This study hypothesizes that salient features, such as water elements (Yabiku, Casagrande et al. 2008, Faggi, Breuste et al. 2013), can potentially help women and newcomers navigate an unfamiliar setting more effectively (Vinson 1999, Chen, Syvitski et al. 2012).

This study investigates how various waterscapes, as water-based elements of imageability, help mediate wayfinding differences due to gender or familiarity. Specifically, it tests whether the mappability or identifiability of a waterscape type mediates the significant influence of gender and familiarity on the coherence of mental image. To qualify waterscape mappability and waterscape identifiability as environmentally derived waterscape dependence and waterscape identity, the study also strives to test whether they form a tripartite with waterscape attachment.

3 METHODS
Golledge (1992) stated that spatial anchors contribute to spatial familiarity, which he defines as an ability to identify and locate features in addition to relating them to other features in spatial memory. Cognitive mapping was employed as a participatory method for studying water-based mappability because it has been used to investigate the extent to which water spatially anchors people’s mental maps (Southworth, Cranz, Lindsay, & Morhayim, 2012). Certain socioeconomic and age groups are likely to have difficulty drawing accurate sketch maps of a large-scale environment, although they are capable of navigating the environment (Downs & Siegel, 1981). Instead of acquiring sketch maps, a survey-administered cognitive mapping protocol was used as a prompt to obtain the recall sequence of water-based features. These recall sequences served to determine the extent to which these waterscapes were spatial anchors that contributed to water-based mappability. The recall sequence matters in this research because spatial anchors are predisposed to be among the first features recalled from participants’ mental maps (Osmond, 1963).

Lynch (1960) used photograph recognition to supplement sketch maps and verbal interviews with an egocentric perspective of spatial memory. However, the photographs were preselected by investigators and may not have been as ecologically or cognitively valid as those obtained from photovoice. Photovoice enables participants to take photographic images to express their impressions of an environment. (Ruggeri, 2014). This research thus employed photovoice to investigate water-based identifiability because the most preferred scenes in unfamiliar urban places have been found to be the most identifiable (Herzog, Kaplan, & Kaplan, 1982). However, photovoice has been largely used for studies investigating smaller-scale environments than cities. In the absence of the investigator, participants may be inclined to take photographs of salient features to which they have easy access as opposed to making efforts to travel to specific locations to capture the most memorable pictures of an entire city. Because it was not possible for the investigator to travel with each participant around the city to take five pictures, a photovoice recall protocol was used instead of the actual photovoice protocol during each interview. Participants were guided to recall five pictures, articulate the content of each recalled photograph, and locate the observer’s position and viewing angle on a city map.

Visual access to plants has been found to reduce stress because of biophilia, or human innate affinity with nature (Grinde, Patil et al. 2009). Gardening can also help the displaced cope with the emotional distress of being away from home by inducing biophilia-based place attachment (Brook 2003). Aquaphilia, or human instinctual attachment to water, similar to biophilia, has an ostensibly universal nature due to its partial genetic influence (Coss, 1990). However, aquaphobia could potentially be induced by past traumatic events related to drowning or flood-induced property damage. This study used aquaphilia sensitivity baseline as a control variable measured by people’s preference to approach or avoid a water-based environment both visually and physically.

Waterscapes were differentiated into water landmarks, which are salient features along or across water, canals, lakes, rivers, and harbors, because they roughly correspond to Lynch’s (1960) five elements of imageability, which are landmarks, paths, nodes, edges, and districts. For each of the five waterscape types, mappability, identifiability, and attachment were proposed as indicators for Lynch’s (1960) cognitive components of imageability, namely, structure, identity, and meaning.

Venice has been considered the epitome of charming water cities while many other cities are also known to be water-dominated settings. Among the alluring water cities that have been considered comparable to Venice, the following six were chosen as study sites based on precipitation pattern similarity and geographical proximity for minimizing sampling cost: Amsterdam and Giethoorn in the Netherlands, Ghent and Bruges in Belgium, and Berlin and Hamburg in Germany. Only Amsterdam and Hamburg are coastal cities with easily accessible harbors, while the other four are inland water cities. Rotterdam, the second largest Dutch city, and Almere, the fastest growing city in Europe, were added to the selection of study sites. This is because, similar to Amsterdam and Hamburg, these two coastal polder cities are also appealing water cities with easily accessible harbors. The final list of study sites comprised four coastal water cities and four inland water cities. This selection of water cities allowed for some level of variability in the amounts and types of water features. All eight water cities have canals, and all four coastal water cities have a water density greater than 10% due to the presence of larger water bodies, such as harbors and lakes. The water density for the inland cities is less than 10%. The water density was calculated by dividing the total surface of water in each city by its total area of land.

A simple and obvious field-interview sampling strategy for residents and visitors in these eight cities does not exist. Each city’s nine sampling sites included major entry points, such as airports, inter-city train...
stations, and bus stations, city halls, tourist bureaus, and various randomly selected hotels, cafes, ethnic stores, and universities. These sites were chosen to conveniently sample a sufficient mix of residents and visitors, high- and low-income populations, experts of environmental design, non-experts, and immigrants and visitors from varying countries of origin. A randomized order was first used to sequence the eight water cities. A random sequencing of sampling sites was then performed to create an approximation of a random sample that could be as representative of a theoretical sampling frame as possible. This theoretical sampling frame assumed that it is possible to capture all residents and visitors in each water city. Each sampling site was assigned 5 hours of sampling time, which was a total of 45 hours for each water city. To generate measures for waterscape attributes, individual factors, and coherence indicators, 60 semi-structure interview participants were recruited across all eight water cities’ sampling sites to answer questions using a paper survey instrument.

As shown in Table 1, to produce the measures of mappability, identifiability, attachment for each waterscape type, the investigator recoded results of interview items 1, 2, 3 as 1 or 0, depending on whether their answer involved one of the targeted waterscapes, which are canal, harbor, lake, river, and water landmark, as opposed to water in general. The classifications of these waterscapes were based on the literal use of these five waterscape terms or the names of actual water bodies in participants’ responses. When a response’s waterscape type was unclear, the participant was asked to provide clarification before ending the interview. Mappability and identifiability accounted for the extent to which each of these waterscape types was salient in each participant’s (top-down) cognitive map and (eye-level) cognitive image. The investigator generated a weighted average by multiplying each base score with a weight from 5 to 1. This weighting accounted for the sequence of recall to reflect the level of salience of each waterscape in spatial memory as a spatial anchor.

### Table 1. Waterscape variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Interview items for field participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterscape mappabilitya</td>
<td>1. Cognitive mapping protocol: imagine you are drawing a map of the city. Please name or describe the five features or locations that come to mind first. Please do not consult a city map.</td>
</tr>
<tr>
<td>Waterscape identifiabilitya</td>
<td>2. Photovoice protocol: if you were to take five pictures of the city to describe it to someone who has never been there, what would you take pictures of?</td>
</tr>
<tr>
<td>Waterscape attachmenta</td>
<td>3. Non-visual protocol: what are the five things you would miss about the physical environment if you had to leave the city tomorrow?</td>
</tr>
</tbody>
</table>

a. Code each answer 1 or 0 based on whether or not it contains a targeted waterscapeb; assign a weight from 5 to 1 to account for the sequence of recall; use weighted averages for measures.
b. A targeted waterscape can be a canal, river, lake, harbor, or a water landmark; a water landmark refers to a landmark along and across water bodies.

As shown in the following formula, an average was taken from the sum of all five weighted base scores to derive measures for waterscape mappability, identity, and attachment:

$$\text{Weighted average} = \frac{(5 \times \text{first answer base score} + 4 \times \text{second answer base score} + 3 \times \text{third answer base score} + 2 \times \text{fourth answer base score} + 1 \times \text{fifth answer base score})}{5}$$

A similar coding scheme was applied for interview items 1, 2, and 3 in Table 1 to assess the degree to which each participant would likely seek proximity to each waterscape type as a spatial anchor for navigating unknown territories. This arguably generated the measures of canal attachment, harbor attachment, lake attachment, river attachment, and water landmark attachment.

### 3.1 Measures for individual factors

Table 2 exhibits three interview items for indicating the participants’ level of environmental familiarity through their status as visitors or residents, gender, and aquaphilia baseline. The response to interview item 1 in Table 2 was coded as 1 or 2 for visitors or residents based a length of stay less than or at least 90
days, the duration for a Schengen visitor visa required for entering the European Union from non-visa-exempt countries. A male or female participant was given a score of 1 or 2, respectively, for gender as a categorical variable (item 2 in Table 2). A five-point Likert scale was used to ordinate the score for aquaphilia sensitivity baseline (item 4 in Table 2) based on the assumption of equal spacing between response categories.

**Table 2. Measures for individual factors**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Interview items for field participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor/Resident a</td>
<td>1. How many years/days have you been in this city (altogether)</td>
</tr>
<tr>
<td>Gender b</td>
<td>2. Which sex or gender do you identify with?</td>
</tr>
<tr>
<td></td>
<td>□ Female (2) □ Male (1) □ Other (0)</td>
</tr>
<tr>
<td>Aquaphilia sensitivity baseline c</td>
<td>3. If you could live anywhere, would you choose to live □ right on the water (5) □ with easy access to water (4) □ with visual access to water only (3) □ far away from water (2) □ as far away from water as possible (1)?</td>
</tr>
</tbody>
</table>

a. Code the response with 2 and 1 for residents and visitors using 90 days as a cutoff.
b. Code female and male participants with 2 and 1 to generate a categorical variable.
c. Assume response categories as equally spaced points along a Likert scale to generate scores as shown above in parentheses.

In between the cognitive mapping and photovoice protocol, participants were guided to sketch their mental maps by the following instructions: “Please draw a map of your city on the next page. Include as many features as you can recall. Number the features directly on the map to indicate the sequence in which they emerge in your memory.” Fifty-five sketch maps were collected from 60 field participants because five participants could not draw their cognitive maps from recall. The sketch maps were presented in a randomized sequence in Qualtrics for evaluation by four independent raters without previous exposure to the study or the eight cities.

**Table 3. City image coherence measures**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Interview items for field participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual-perspective coherence a</td>
<td>1. Ratings by raters 1 and 2 using uncolored sketch maps and the evaluation rubric and coding scheme (Author, 2016)</td>
</tr>
<tr>
<td>Colored allocentric coherence a</td>
<td>2. Which city is this map about? □ Almere □ Amsterdam □ Berlin □ Bruges □ Ghent □ Giethoorn □ Hamburg □ Rotterdam □ Not Sure</td>
</tr>
<tr>
<td>Contribution of water b</td>
<td>3. To what extent do the map’s blue features help you identify the city? □ Very much (3) □ Somewhat (2) □ Not (1)</td>
</tr>
<tr>
<td>Water-based egocentric coherence b</td>
<td>4. To what extent do non-blue features cluster along blue features? □ Very much (3) □ Somewhat (2) □ Not (1)</td>
</tr>
</tbody>
</table>

a. Code 1 or 0 for indicating correct or incorrect city identification.
b. Assume response categories as equally spaced points along a Likert scale to generate scores as shown above in parentheses.

d. Raters 1 and 2 evaluated the original sketch maps using a rubric distilled from the literature on the developmental stages of spatial knowledge and the theory of imageability. The average scores from raters 1 and 2 for the original uncolored sketch maps were used to measure dual-perspective coherence (item 1 in Table 3). Raters 3 and 4 evaluated sketch maps with water features colored in blue by the investigator. They compared the colored sketch maps with the colored cartographic maps of the eight cities for 10 seconds each. The investigator assigned a score of 1 or 0 when a colored sketch map was correctly or incorrectly identified by the raters. The average scores from raters 3 and 4 were used to measure colored allocentric coherence (item 2 in Table 3).

The measures for items 3-5 in Table 3 were also derived from the average ratings between raters 3 and 4. The raters had 10 seconds to answer each of the evaluation questions for items 3-5 in Table 3. Contribution of water (item 3 in Table 3) was based on the degree to which water helped the raters identify the city associated with each sketch map. Lastly, the raters were asked to assess the extent to which non-
blue features clustered along the blue features on each sketch map to produce the indicator of water-based egocentric coherence (item 5 in Table 3). This interview question measured the degree to which water helps the sequencing of identifiable eye-level scenes into procedural knowledge. A three-point Likert scale was used to ordinate the responses for contribution of water and water-based egocentric coherence. The investigator then multiply the average score for allocentric coherence by the average score for the contribution of water as a weight to generate the measure of water-based allocentric coherence (item 4 in Table 3). The aforementioned sketch map evaluation procedures and scoring rubrics were calibrated and tested to have sufficient interrater reliability in a previous study (Rising 2016).

A macro by Preacher and Hayes (2008) was used to conduct mediation analyses in SPSS Statistics 22 to understand how waterscape attributes mediated the effects of gender and familiarity on individually perceived water-based imageability. Aquaphilia sensitivity baseline was controlled as a covariate. Gender and the group variable of visitors or residents rotated as the independent variable. Dual-perspective coherence, water-based allocentric coherence, water-based egocentric coherence, as the dependent variable. A mediation analysis was conducted for each combination of independent and dependent variable with each waterscape attribute indicator as a mediator. Multiple mediation analyses were also performed when more than one waterscape attribute indicator significantly mediated the relationship between the same independent and dependent variables. The subsequent section reports only those analyses with significant outcomes.

4 RESULTS

Figure 1 shows the results of three significant mediation analysis models. Canal mappability, canal identifiability, or both variables were included as intervening variables for these three mediation analysis models using aquaphilia sensitivity baseline as a covariate, gender as the independent variable, and each coherence measure as the dependent variable. Aquaphilia sensitivity baseline was a significant control variable in all models.

The best-fitting model (Model B) indicates that a significant gender effect on water-based allocentric coherence was fully mediated by canal mappability. In addition to water-based allocentric coherence, canal mappability also significantly influenced the other two coherence measures (dual-perspective coherence and water-based egocentric coherence). Gender had a significant effect and a marginally significant effect on canal mappability with either one of the two water-based coherence measures (water-based allocentric coherence or water-based egocentric coherence) as the dependent variable in Model B and Model C. No
significant gender effect was observed when canal identifiability was introduced as a second mediator and the non-water coherence measure, dual-perspective coherence, was the dependent variable. Canal identifiability did not significantly influence dual-perspective coherence in the presence of canal mappability as the other mediator. While gender had a significant effect on canal identifiability, it did not significantly influence dual-perspective coherence.

Similarly, using canal mappability, canal identifiability, or both as intervening variables, three models were tested with the group variable of visitors or residents as the independent variable, aquaphilia sensitivity baseline as a covariate, and each coherence measure as the dependent variable. Figure 2 shows the results of the significant models. Aquaphilia sensitivity baseline was a significant control variable for all three models. While the insignificant direct path of Model A indicated no gender effects on dual-perspective coherence, the direct path of Model D indicated that dual-perspective coherence significantly differed between visitors and residents. While canal identifiability had no significant mediating effect, canal mappability fully mediated the significant group effect of visitor or resident on dual-perspective coherence with a marginal significance.

Note. ***p < .001; **p < .01; *p < .05; p < .10; independent variable: visitors or residents (1: visitor; 2: resident); control variable (d): aquaphilia sensitivity baseline; dependent variable: coherence measure.

**Figure 2. Intervening Influences for group effect on coherence measures.**

Consistent with Models A, B, and C, canal mappability had a significant effect on all three coherence measures. While model B shows significant gender effects on water-based allocentric coherence and canal mappability, no group effect of visitors or residents was found for canal mappability or water-based allocentric coherence in Model E. With water-based egocentric coherence as the dependent variable, Model F shows no significant group effect of visitors or residents on canal mappability while canal mappability had a significant positive relationship with water-based egocentric coherence. Model F indicates that the intervening effect of canal mappability made the group effect of visitors or residents on water-based egocentric coherence significant.

To better understand the mediation analysis models using gender or the group variable of visitors or residents as independent variable, additional mediation analyses were conducted using gender or the group variable and aquaphilia sensitivity baseline as control variables. Canal identifiability was included as the independent variable with canal mappability as the mediator and coherence measures as dependent variables. Results from the models using gender or the group variable as a control variable were differentiated by subscripts 1 or 2 in Figure 3. Model G1 in Figure 3 shows that canal mappability fully mediated the effect of canal identifiability on dual-perspective coherence with aquaphilia sensitivity baseline and gender as covariates. In contrast, Model G2 had no mediation effect when the group variable and aquaphilia sensitivity baseline were included as covariates; however, the positive correlations between canal identifiability and canal mappability and between canal mappability and dual-perspective coherence remained significant. Canal mappability fully mediated the effect of canal identifiability on water-based
allocentric coherence for both Models H1. Neither gender nor the group variable was a significant covariate in model H1 or H2 while aquaphilia sensitivity baseline was a significant covariate in both models. In model I1 (Figure 3), canal mappability fully mediated the marginally significant effect of canal identifiability on water-based egocentric coherence when aquaphilia sensitivity baseline and gender were included as covariates. Model I2 (Figure 3) shows a full mediation of the canal identifiability’s effect on water-based egocentric coherence by canal mappability when aquaphilia sensitivity baseline and the group variable of visitors or residents were included as covariates. Aquaphilia sensitivity baseline was a significant control variable in both Models I1 and I2. While gender was not a significant control variable in Model I1, the group variable was significant in Model I2. Using canal mappability, canal identifiability, or both variables as mediators, mediation analyses were conducted to explore the relationship between water-based allocentric coherence or canal mappability as the independent variable and canal attachment as the dependent variable. Gender, the group variable of visitors or residents, and aquaphilia sensitivity baseline were included as covariates.

Model I1 (Figure 3) shows a full mediation of the canal identifiability’s effect on water-based egocentric coherence by canal mappability when aquaphilia sensitivity baseline and gender were included as covariates. Model I2 (Figure 3) shows a full mediation of the canal identifiability’s effect on water-based egocentric coherence by canal mappability when aquaphilia sensitivity baseline and the group variable of visitors or residents were included as covariates. Aquaphilia sensitivity baseline was a significant control variable in both Models I1 and I2. While gender was not a significant control variable in Model I1, the group variable was significant in Model I2. Using canal mappability, canal identifiability, or both variables as mediators, mediation analyses were conducted to explore the relationship between water-based allocentric coherence or canal mappability as the independent variable and canal attachment as the dependent variable. Gender, the group variable of visitors or residents, and aquaphilia sensitivity baseline were included as covariates.

Figure 3. Mediation of canal identifiability’s influence on coherence measures by canal mappability.

Figure 4 shows the results of three significant models with full mediation. Model J included both canal mappability and canal identifiability as mediators and water-based allocentric coherence as the independent variable. Model K used canal identifiability as the mediator and water-based allocentric coherence as the independent variable. Model L confirmed that canal identifiability fully mediated the significant path between canal mappability and canal attachment.

Figure 5 provides the outcomes from the three mediation analyses conducted for the effect of water-based egocentric coherence on canal attachment using canal mappability, canal identifiability, and both canal mappability and identifiability as mediators. Model M indicates that canal mappability fully mediated 21% of the relationship between water-based egocentric coherence and canal attachment. In contrast, canal identifiability did not fully mediate the relationship between water-based egocentric coherence and canal attachment, although model N had the highest adjusted R square. Model O shows that an additional 14% of the influence of water-based egocentric coherence on canal attachment could be explained by canal identifiability on top of the 21% by canal mappability in Model M.
Figure 4. Mediating influence of canal identifiability over effects of water-based allocentric coherence or canal mappability on canal attachment.

Note: ***p < .001; ** p < .01; * p < .05; dependent variable: canal attachment; control variable 1 (d): aquaphilia sensitivity baseline; control variable 2 (e): gender; control variable 3 (f): visitors or residents.

Figure 5. Mediating influences for effects of water-based egocentric coherence on canal attachment.

Note: ***p < .001; ** p < .01; * p < .05; - p < .10; IV: water-based egocentric coherence; DV: canal attachment; control variable 1 (d): aquaphilia sensitivity baseline; control variable 2 (e): gender; control variable 3 (f): visitors or residents.

However, the relationships between water-based egocentric coherence and canal identifiability and between canal mappability and canal attachment became insignificant due to a full mediation of the relationship between canal mappability and canal attachment by canal identifiability, as previously illustrated by model M.
5 DISCUSSIONS

Women may have fewer identifiable scenes along canals to contribute to their dual-perspective coherence (Model A from Figure 1). However, this probable cause can be mediated by the introduction of more salient canal configurations to help make an environment more adaptable to women and to facilitate the formation of their dual-perspective spatial memory (Model G1 from Figure 2). It is also possible that the gender-sensitive effect of water cannot be properly accounted for by dual-perspective coherence because the measure does not differentiate water from non-water elements on sketch maps. Future research should examine the gender effect on both water-based and non-water-based measures of dual-perspective coherence. Albeit gender-invariant, dual-perspective coherence is significantly higher among residents with a greater level of environmental familiarity than visitors (Model D from Figure 2). This result provides content validity for dual-perspective coherence as a strong measure of survey knowledge. Compared to visitors, residents’ higher survey knowledge may be explained by more salient canal configurations in their two-dimensional cognitive maps (Model D from Figure 2). Making canal configurations more memorable in areas with attractions for visitors can potentially make it easier for newcomers to become familiar with unknown territories. Canals with mappable structures help transform recognizable canal scenes into coherent canal edges, both of which are more frequently used by newcomers than residents (Model F from Figure 2).

Unlike dual-perspective coherence, water-based allocentric coherence, which measures water-based survey knowledge or the salience of waterscapes in cognitive maps, does not significantly differ between residents and newcomers with less environmental familiarity (Model E from Figure 2). This result suggests that visitors and residents have a relatively similar level of command of water-based survey knowledge and that cities with more waterscapes are more adaptable to less knowledgeable newcomers. Recognizable canal scenes, such as waterfront landmarks and identifiable bridges, help encourage proximity-seeking behaviors toward canals with a coherent two-dimensional structure (Model L from Figure 4). In the absence of mappable canal configurations, distinguishable canal sights are not sufficient for evoking aquaphilic behaviors (Models M, N, and O from Figure 5). Most cities have coherent waterfront edges formed by the clustering of waterfront features and developments; however, if these coherent waterfront edges do not form a noticeable regional configuration as a unified whole, prominent canal scenes in cognitive images alone do not necessarily contribute to the use of canals as water-based spatial anchors. Instead, people’s attachment to canals necessitates a memorable canal arrangement in their mental maps for making spatial sense of coherent waterfront edges and identifiable canal scenes. Once mappable canal configurations are in place, canals with more distinguishable scenes are more likely to serve as loci of attachment. These findings suggest that in addition to introducing more salient regional structures for canals, water cities can be made more socially coherent by adding more pedestrian bridges across canals or making canals more visible from the most frequently traversed rights-of-way.

One possible future direction is to use virtual cities with identical layouts with or without water features to better pinpoint the role of water as a spatial anchor for men and women. This approach will also enable researchers to better parse out the effect of environmental familiarity from that of gender to observe how different developmental stages of spatial knowledge unfold as participants make subsequent visits to the assigned virtual cities. Future studies may also focus on particular refugee groups in the context of diaspora to further examine their specific needs for more adaptable relocation destinations and the effects of previous flood exposure on their responses to water elements in the public realm.

6 REFERENCES


Herzog, Kaplan, & Kaplan, 1982


Southworth, M., Cranz, G., Lindsay, G., & Morhayim, L. (2012). *People in the design of urban places.*


Quantitative Study on the Vegetation Landscape Characters of Chinese Buddhist Mountain Environments Based on eCognition Image Interpretation Technology: A Case Study of Jizu Mountain, Yunnan Province

Xueling Zhang
E-mail: zhangxueling@mail.tsinghua.edu.cn
Alternate Contact: (+86)18310808533

Shuhua Li
Corresponding author
E-mail:406625699@qq.com

1 ABSTRACT
China's Buddhist mountains have become symbols of large-scale Chinese traditional scenic spots and taken on striking diversiform landscape characters, with natural vegetation coexisting with artificial vegetation. As a newly-emerging smart image analysis technique, eCognition can help us conduct research and analysis of the vegetation landscape characters and realize the instant output of the drawings and the corresponding vector data. This paper is about the quantitative analysis of and experiment conducted on the images of the vegetation landscape of the scenic area of Jizu Mountain on the basis of the multi-spectral remote-sensing satellite image data of China Resources (ZY-3). In the analysis and experiment, the eCognition object-oriented classification method is employed. With the spectral heterogeneity, multi-scale segmentation function and normalized vegetation index as the standards for image analysis, the mathematical algorithm suitable for the research on landscape is obtained by the membership function, with the characters of six kinds of vegetation landscapes extracted, such as the coniferous forest, broad-leaved forest, bamboo forest, sparse forest land, gardens, and orchards. The distribution of the vegetation landscape in Jizu Mountain is scientifically presented, with the algorithm description and drawing generation of vegetation landscape characteristics realized. Evaluated with the error matrix, the classification accuracy is great. The study provides a quantitative survey and analysis method for a highly spatial analysis of contemporary landscapes and analysis and design of urban green space; it also provides valuable and promising remote sensing interpretation platforms and special technologies for scientific research on human settlements such as urban and rural planning and architecture.

1.1 Keywords
Chinese Buddhist mountain landscape; vegetation landscape character; eCognition; image interpretation technology; Jizu Mountain.
INTRODUCTION

As the coordination of rational thinking, the analytic logic and advanced technology is increasingly valued in landscape architecture, the quantitative analysis has become a critical basis for description of landscape science (Khwanruthai, et al. 2011) (Zhe Li, et al. 2018), and the digital technology has played a key role in landscape character investigation, analysis and performance (Carrera, et al. 2017). Recently, Remote Sensing (RS), Geography Information Systems (GIS) and Global Positioning Systems (GPS) have been further applied in landscape architecture research (Zhang Xueling. 2018). As a result, the digital analysis of traditional landscape environment has high level, large spatial scope, strong comprehensiveness and scientific significance (Liu, et al. 2017).

Chinese Buddhist mountains represent an important part of China’s traditional landscape, a masterpiece by nature and human. Since ancient times, natural landscape and Buddhist mountain have interdepended for development. Affected by nature, history, religion, aesthetics, spatial understanding and planing and building techniques, they have formed landscape compounds with typical vegetation as the main body, and “continuous perceptual groups” (Susanne K.Langer, 1953) of landscape as spatial organization mechanism. Such landscape compounds, a combination of natural and cultural landscape (Li, et al. 2018), is featured by specific vegetation and spatial patterns. It not only presents multiple geology and platform, profound humanistic connotation and rich religious characteristics, but also highlights the beauty of vegetation (Yao, et al. 2014). For example, Chinese Buddhist mountain landscape of the West Mountain, Fragrant Hills, Wengshan Hill in Beijing developed since the Ming Dynasty keeps abundant vegetation types. It has distinctive forest forms and aspection, with natural landscape being of its iconic feature. The eight outlying temples of Chengde, Tiantai Mountain in Zhejiang Province and Jizu Mountain are also home to Chinese Buddhist mountain landscape. Based on religious landscape, numerous plants have been grown and maintained there, so zonal vegetation landscapes are distinctive.

Landscape character is one of the important propositions of modern landscape architecture research. As it can be sensed by people, landscape is characterized by natural factors, human factors, or both (Martin Belen, et al. 2018). Landscape character is a unique, identifiable and continuous landscape “texture” formed by the landscape elements under the influence of the natural environment, historical development and regional culture. It is an organic representation of a scientific model, with uniqueness, complexity, multiple scale and continuity (Morrison, et al. 2018). The study of vegetation landscape character emphasizes the use of rational and logical thinking in analyzing its natural landscape components and its process of generation and development scientifically. It presents the full composition model, deep decoding and seedling evolution mechanism of landscape space with the corresponding relations confirmed between changes in the landscape system and the development of landscape environment (Cetin, et al. 2018). It provides a scientific and effective research approach for modern landscape construction, and promotes scientific research on and sustainable development of scenic spots including Chinese Buddhist mountain.

Can vegetation landscape characters be quantified? Can the landscape environment, as an integration, be decomposed into more accurate and measurable character elements for digital analysis? Faced with such problems, eCognition based on contemporary digital landscape theory and remote sensing technology has given a relatively systematic and clear solution (Nagabhatla, et al. 2016). As an emerging intelligent image analysis software, eCognition adopts the fuzzy classification algorithm supported by the decision expert system; it breaks through the limitations of traditional commercial remote sensing software such as GIS based on spectral information, and proposes a revolutionary classification technology, the object-oriented classification method. The method greatly improves the automatic recognition accuracy of spatial resolution data, satisfies the needs of scientific research and engineering applications, and provides a new quantitative analysis technology for the study of vegetation landscape character of Chinese Buddhist mountains (Chmielewski, et al. 2014). Through the eCognition's remote sensing image analysis, we can carry out information collection and character analysis of vegetation landscape based on satellite remote sensing map (Frauenfelder, et al. 2015). Taking spectral heterogeneity and NDVI as vegetation image classification characters, by the membership function algorithm, we can effectively extract the information on typical vegetation landscape character elements, scientifically improve the classification accuracy of landscape character, and present the distribution of vegetation landscape character by vectors. While promoting the research on the traditional Chinese Buddhist mountain landscape characters, it is of significance in improving landscape survey and analysis technology.
3 STUDY AREA

Jizu Mountain is located in the Erhai Lake area of Dali Bai Autonomous Prefecture, east of Cangshan Mountain and Erhai Lake, and south of Jinsha River. It is part of Dali national scenic area. The main parts of the mountain range are from Jiegou Village in Tapan Hill in the east to Tianzhu Mountain in the west, and from the Shazhijie River to the south to the northern slope of Jiuchong Cliff in the north. It covers a total area of 2,822 hectares (see Figure 1). Jizu Mountain is located in the transitional part between subtropical and temperate zones, and it has an obvious three-dimensional climate, complex topography and landforms, abundant animal and plant resources, and excellent ecological environment. Rich terrain changes and vegetation resources have shaped vivid and diverse surface landscape environment.

The Jizu Mountain scenic area currently has a large number of temple landscapes, which is highly integrated with surrounding vegetation. Vegetation, such as coniferous forest, broad-leaved forest, bamboo forest, sparse forest, tea gardens and orchards, presents regular distribution, with plant landscape being an integral part in landscape environment. The spatial relationship between sequence and contrast, inwardness and outwardness, penetration and hierarchy, and guidance and suggestion needs to be further explored and analyzed.

Figure 1. Remote sensing image of the core landscape area of Jizu Mountain(2018). Photo by the author.

4 DATA ACQUISITION AND PREPROCESSING

The ZY-3 satellite is China’s first independent civilian high-resolution stereo mapping satellite. Through stereoscopic observation, which can make 1:50,000 scale topographic maps, thus serving land resources, agriculture, and forestry fields. The satellite can seamlessly cover the areas within 84 degrees of the north and south latitudes of the earth, with a regression period of 59 days and a revisit period of 5 days.

The ZY-3 high spatial resolution remote sensing image of Jizu Mountain scenic area was acquired on January 23, 2018. The spectral bands include blue band (450~520nm), green band (520~600nm), red band (630~690nm) and near-infrared band (760~890nm). The spatial resolution was 5.8m, with no cloud in image field, in good atmospheric environment and 11° tilt angle. The processing steps for the remote sensing image were:

1. Perform FLAASH atmospheric correction on the original image data. It is to eliminate the influence of refraction and scattering on ground objects, and to improve the accuracy of the ground object extraction.

2. Perform orthorectification with the 1:10,000 map of Jizu Mountain area as a reference. The quadratic polynomial correction method, the characteristics of the ZY-3 satellite and the WGS84 coordinate system were employed.

3. According to the research, an appropriate image range was intercepted for the subsequent secondary image correction and eCognition analysis.
5 TECHNOLOGY ROADMAP

(1) Multi-scale hierarchical segmentation of eCognition images of Jizu Mountain was to obtain basic analysis images and corresponding data at different levels. The difficulty lies in setting the segmentation conditions of each level according to spectral characters, geometric shapes and topological characters of the plant landscape elements, so as to accurately segment the spatial and shape characters of the Jizu Mountain vegetation.

(2) The segmented basic images were to select training sample plots (hereinafter referred to as sample plots) for statistical analysis, with the classification characters determined according to the differences of various plant landscape characters in Jizu Mountain, in preparation for classification and analysis of plant landscape characters.

(3) The vegetation landscape character description based on the Normalized Difference Vegetation Index (NDVI) was to analyze the images in depth by the membership fuzzy classification method. The membership function was applied to inter-class classification through landscape character setting. Object characters and inter-class characters were to accurately define the classification criteria of objects.

(4) Based on the steps above, the remote sensing images of Jizu Mountain core landscape area and its radiation area were analyzed, the vegetation landscape characters were classified and analyzed, and technical drawings and related vector data were obtained.

(5) The sample plots were sampled again for accuracy analysis, with the classification accuracy of the study obtained through field investigation. A technical summary was conducted with the following research options explored.

The technology roadmap is shown in Figure 2.

![Figure 2. Technology roadmap of Jizu Mountain remote sensing image analysis(2018). Photo by the author.](image)

6 METHODS AND RESULTS

6.1 Image segmentation

According to field research samples of Jizu Mountain, the fractal net evolution algorithm was to segment the eCognition platform. Within the segmentation scale of different surface vegetation landscape
characters, large-scale and small-scale image objects exist simultaneously after segmentation, forming a four-level network of multi-scale remote sensing image objects. It is necessary to consider the difference and identity of the spectral, shape and spatial characters of vegetation communities under the different surface conditions in remote sensing images, and to follow the principle of minimum heterogeneity to optimize the algorithm formula (Vaz, et al. 2015). After repeated comparisons and debugging, the formulas for the heterogeneity metric criterion in this study are:

\[ F = w_1 \times c_1 + (1 - w_1) \times c_2 \]  \hspace{1cm} (1)

\[ c_2 = w_2 \times c_3 + (1 - w_2) \times c_4 \]  \hspace{1cm} (2)

where \( F \) represents the heterogeneity criterion, \( w_1 \) the weight of the shape, and \( c_1 \) and \( c_2 \) the color difference metric and the shape difference metric. \( c_2 \) includes smoothness \( c_3 \) and compactness \( c_4 \), and \( w_2 \) indicates the weight of smoothness and compactness. Smoothness refers to the smoothness level of the boundary of the merged region, and compactness is to ensure that the merged region is more compact. Both the smoothness and compactness have a weight, which form shape difference metrics. It can be seen that the multi-scale hierarchical segmentation can divide not only the different objects for different scales, but also more accurately segment objects based on their spatial and shape characters. Besides, it can optimize the segmentation accuracy according to the logical topological relations of the upper and lower levels in the classification.

6.2 Segmentation parameter setting

According to the typical landform of the Jizu Mountain area, the segmentation scale function was tested and selected. The segmentation function generally includes the scale, the number of levels, the color factor, the shape factor, the smoothness and the compactness (Arsanjani, et al. 2013). In this study, the images were segmented based on landscape vegetation spectral characters, geometric shape and topological characters. Through the eCognition multi-resolution segmentation function, a object level network of multi-scale remote sensing image with a, b, c and d levels is developed.

Among them, Level a was to segment forest land and non-forest land. The segmentation scale should not be too large, for fear that the ground objects are fragmented. Considering the fact that the high degree of interlaces between forest land and non-forest land in Jizu Mountain, it is advisable to divide the forest land from the non-forest land with a large scale and explore the classification of the interlaced zone at the bottom level. The segmentation scale was determined to be 100 by commissioning. Level b was to distinguish coniferous forest, broad-leaved forest, sparse forest land and construction land. On the basis of segmentation of Level a and the shape characters of natural elements of tea garden, orchards and sparse forest under manual intervention, the natural elements can be separated by setting the scale to 50. Level c was to distinguish sparse forest, bamboo forest, tea gardens, and orchards. By comparing samples, the spectrum, shape, compactness and smoothness characters of various vegetation were analyzed, with vegetation landscape information elements effectively extracted. Level d was to further improve extraction accuracy of vegetation landscape characters, and to improve the indexing of structure, gap, shadow and naked area. Figure 3 and Table 1 show the scale parameters and drawings for each level of segmentation.

**Table 1. Hierarchical segmentation scale and discrimination parameters.**

<table>
<thead>
<tr>
<th>Object hierarchy</th>
<th>Segmentation scale</th>
<th>Color weight</th>
<th>Shape weight</th>
<th>Smoothness</th>
<th>Compactness</th>
<th>Classification level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level a</td>
<td>100</td>
<td>0.9</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
<td>Forest land, non-forest land</td>
</tr>
<tr>
<td>Level b</td>
<td>50</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.3</td>
<td>Coniferous forest, broad-leaved forest, sparse forest land, construction land</td>
</tr>
<tr>
<td>Level c</td>
<td>30</td>
<td>0.9</td>
<td>0.1</td>
<td>0.5</td>
<td>0.2</td>
<td>Bamboo forest, tea gardens and orchards</td>
</tr>
<tr>
<td>Level d</td>
<td>10</td>
<td>0.8</td>
<td>0.3</td>
<td>0.5</td>
<td>0.1</td>
<td>Structure</td>
</tr>
</tbody>
</table>

March 6-9, 2019
6.3 Object character extraction

Based on the segmentation images and sample survey data, a statistical analysis was made, with the classification characters determined according to the character differences of various images (Tang, et al. 2007). According to visual analysis processing of the four spectral bands of multi-spectral remote sensing images of the Jizu Mountain core landscape area, the eCognition nearest neighbor classifier was to select sample plots for classification test. Practice shows that a few sample characters for each type of vegetation landscape was selected at first, that the classification results can be optimized and that the classification accuracy can be improved by continuously setting the undivided and misclassified objects as samples. The separability between various types of sample plots was observed by the distribution maps of the vegetation landscape character spectra.

6.3.1 Vegetation character indexes

The vegetation character index is a concise and rational metric of surface vegetation. More than 40 vegetation character indexes have been defined and widely used in remote sensing analysis of global and regional land coverage, vegetation classification and environmental change (Durieux, et al. 2008). The Normalized Difference Vegetation Index (NDVI) is to determine the integration of vegetation community types, growth status, and vegetation coverage. It has been verified by the expert group of the Institute of Geographical Sciences and Natural Resources Research of the Chinese Academy of Sciences and field data (2012); its spatial consistency is good. In the analysis of vegetation landscape characters, NDVI enhanced the difference between the scattering of green leaves in the near-infrared range and the absorption of chlorophyll in the red-band range, which is the best indicator for the species and growth status of the vegetation community. Figure 15 shows an analytical map of NDVI of the Jizu Mountain core landscape area.

The vegetation character indexes are calculated as follows:

$$I_{NDVI} = (p_{\text{nir}} - p_{\text{red}})/(p_{\text{nir}} + p_{\text{red}})$$

where $p_{\text{nir}}$ indicates the reflectance in the near-infrared band, and $p_{\text{red}}$ indicates the reflectance in the red band.

6.3.2 Spectral heterogeneity indexes
In the classification, due to the similarity of the spectral information of coniferous forest, broad-leaved forest and bamboo forest, there is a certain degree of misclassification, so the texture information was added into spectral information (Cleve, et al. 2008). The grey level co-occurrence matrix (GLCM) reflects the comprehensive information on the gray level change of the images, as well as the arrangement law and partial patterns of the analyzed images. Homogeneity is one of the main characters of GLCM, indicating the homogeneity of a region. The higher the homogeneity, the greater the value. According to the above statistical analysis method, the classification indexes are shown in Table 2, with the analytical map shown in Figure 4.

### Table 2. Hierarchical classification indexes.

<table>
<thead>
<tr>
<th>Level</th>
<th>Category</th>
<th>Classification characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level a</td>
<td>Vegetation, non-vegetation</td>
<td>NDVI</td>
</tr>
<tr>
<td>Level b</td>
<td>Construction land, tea garden, orchards, sparse forest land</td>
<td>NDVI, compactness, mean</td>
</tr>
<tr>
<td>Level c</td>
<td>Coniferous forest, broad-leaved forest, bamboo forest</td>
<td>NDVI, compactness, smoothness</td>
</tr>
<tr>
<td>Level d</td>
<td>Building, shadow, gap</td>
<td>Normalized Difference Built-Up Index, compactness, brightness</td>
</tr>
</tbody>
</table>

![Figure 4. Analytical map of gray level co-occurrence matrix (GLCM) in the Jizu Mountain core scenic area(2018). Photo by the author.](image)

**6.4 Analysis of vegetation landscape characters**

The classification of vegetation landscape object characters is a fuzzy logic function classification based on class hierarchy. eCognition offers two common classification methods: Nearest Neighbor and Membership Functions. The membership function is a simple method for expressing any character range with the same range (0-1), available to edit and adjust each character; it provides a transparent membership function for relations between the character value and the class membership, precisely defining the criteria of a class for an object using object characters and related inter-class characters (Lopez, et al. 2001). According to different conditions in the extraction of vegetation information of Jizu Mountain, the spectral heterogeneity and NDVI were as image classification characters to analyze the membership of vegetation landscape characters. The analytical results are shown in Figure 5.
6.5 Accuracy evaluation

The accuracy evaluation is of importance for the extraction of vegetation landscape characters because the accuracy of a extraction classification image of vegetation landscape characters directly affects the accuracy of data analysis and the rationality of scientific evaluation (Ahadnejad, et al. 2009). It is advisable to compare the consistency between each pixel of the two images in accuracy evaluation. In this study, field artificial survey data were taken for reference. Together with remote sensing analysis results, using the reference data to establish an error matrix in units of pixels for the calculation of accuracy evaluation.

In most cases, it is difficult to obtain the complete reference data, so the whole image was replaced with partial pixels or categories to evaluate the accuracy of the image. The error matrix, also known as the confusion matrix, is a standard format representing accuracy evaluation. In this study, four accuracy evaluation indexes of producer accuracy (PA), user accuracy (UA), overall accuracy (OA) and Kappa coefficient were to quantitatively evaluate the influence of the segmentation scale on the classification accuracy, which acted as the accuracy verification standard. Its formula is as follows:

\[
K = \frac{N \sum_{i} x_{ii} - \sum_{i} (x_{ii} y_{ii})}{N^2 - \sum_{i} (x_{ii} y_{ii})}
\]

The sample plot data mainly includes 332 samples of surveyed vegetation landscape character formation, vegetation landscape character distribution, landscape character structure and morphological structure. Through artificial interpretation, the objects are as statistical objects, and the error matrix and overall accuracy were to express the accuracy evaluation results. The classification accuracy and error matrix of the Jizu Mountain core landscape area are shown in Table 3. The overall accuracy is 78.92%.

<p>| Table 3. Classification accuracy and confusion matrix of the Jizu Mountain core landscape area. |
|---------------------------------|-----------------|-----------------|----------------|-----------------|-----------------|----------------|
| category                        | Structure       | Tea gardens, orchards | Sparse forest land | Coniferous forest | Broad-leaved forest | bamboo forest  | Total samples | User accuracy |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|
| Structure                       | 45              | 2               | 3               | 2               | 1               | 6              | 59            | 76.272        |</p>
<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tea gardens, orchards</td>
<td>1</td>
<td>38</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>Sparse forest land</td>
<td>0</td>
<td>1</td>
<td>50</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>57</td>
</tr>
<tr>
<td>Coniferous forest</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>43</td>
<td>2</td>
<td>3</td>
<td>58</td>
</tr>
<tr>
<td>Broad-leaved forest</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>44</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>Bamboo forest</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>42</td>
<td>52</td>
</tr>
<tr>
<td>Total samples</td>
<td>49</td>
<td>52</td>
<td>66</td>
<td>58</td>
<td>52</td>
<td>55</td>
<td>332</td>
</tr>
<tr>
<td>User accuracy</td>
<td>91.84</td>
<td>73.08</td>
<td>75.76</td>
<td>74.14</td>
<td>84.62</td>
<td>76.36</td>
<td></td>
</tr>
</tbody>
</table>

Overall accuracy: 78.92% (KAPPA=0.7469)

7 DISCUSSIONS

In this paper, the optimal segmentation scale is obtained by multi-segmentation and classification analysis of remote sensing images of the Jizu Mountain scenic area. Based on the extracted spectral information on the vegetation objects in the sample plots, the texture information and geometric information, the object-oriented classification method is to interpret the images. Spectral heterogeneity and NDVI are as image classification features. By the membership function algorithm, six types of vegetation landscape character information such as coniferous forest, broad-leaved forest, bamboo forest, sparse forest land, tea gardens and orchards are extracted effectively. The classification accuracy reaches 78.92%, scientifically presenting the distribution of vegetation landscape characters in Jizu Mountain.

The analysis results show that the object-oriented hierarchic segmentation membership function classification method has a high accuracy, which can effectively distinguish the overall landscape characters of vegetation communities around Chinese Buddhist mountains, and is suitable for the quantitative analysis of the vegetation elements of Chinese Buddhist mountains. Based on the eCognition remote sensing image analysis of the vegetation landscape elements in Jizu Mountain, this study analyzes and validates a complete set of remote sensing analysis technologies suitable for scenic spots. With the support of higher accuracy remote sensing images, the set of technologies can accurately identify typical surface landscapes such as mountains, rivers, springs and ancient trees, providing more scientific and reliable digital technologies for the analysis of vegetation landscape in the Jizu Mountain scenic area.

A comparison of similar remote sensing image analysis technologies, the eCognition remote sensing image analysis technology features diverse segmentation scales, advanced classification methods and rich image characters and algorithms can meet the needs of landscape architecture and urban and rural planning resources surveys. The acquired classification accuracy can conduct the characteristic data collection and graphical expression of the vegetation landscape in the landscape environment, providing reliable basic data and accurate basic drawings for subsequent large-scale analysis, judgment, transformation and new construction. What is worthy of attention in the follow-up study is that, because of the great similarity between broad-leaved forest, tea gardens and bamboo forest, there are still some misclassifications in the results; if the ZY-3 remote sensing stereo information and full color spectrum fusion remote sensing images are combined, and the digital elevation model (DEM) is developed, the classification accuracy will be further improved.

The quantitative analysis of landscape characters based on the eCognition remote sensing image interpretation technology is a new method and technology for landscape character and resource survey, and it occurs with the development of contemporary landscape architecture science, computer and related remote sensing technology. The related research provides a quantitative research method characterized by objective quantitative analysis and multi-dimensional visual presentation for the study of large-scale landscape environment characters, and also provides the advanced remote sensing analysis basis and approach for spatial analysis, auxiliary analysis and planning design of scenic spots. On the basis, human vision is being rapidly replaced by the satellite vision, which is of significance in technological progress. Besides, it provides a valuable and promising remote sensing interpretation platform and special technology for scientific research on human settlements such as urban and rural planning and architecture.
8 ACKNOWLEDGMENTS

Many thanks go to Yanfeng Li, Yukun He, Hao Wen, Ming Zhao, Chongxian Chen and my parents for their indispensable help in this research, and thanks also to the RS data support from Beijing Satlimage Information Technology Co., Ltd. The author is grateful to the reviewers and the editors for their detailed comments on this paper.

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. This research is supported by the Post-doctoral Science Foundation Project of China (No. 2018M641363).

9 REFERENCES


CEL A MEDIA STATEMENT

Title of Paper or Research: Quantitative Study on the Vegetation Landscape Characters of Chinese Buddhist Mountain Environments Based on eCognition Image Interpretation Technology: A Case Study of Jizu Mountain, Yunnan Province.

Author: Xueling Zhang; Shuhua Li*.

Institution or Professional Affiliation: Tsinghua University

Authors please select one of the following: I DO want to prepare a media statement for general release from the 2019 CELA Conference.

Media Statement: Chinese Buddhist mountains have become the symbols of large-scale Chinese traditional scenic spots and taken on striking diversiform landscape characters, and natural vegetation coexisting with artificial vegetation. The paper uses a newly-emerging smart image analysis technique, that eCognition, which can help us to conduct research on and analysis of the vegetation landscape characters and realize the instant output of the drawings and the corresponding vector data. On the basis of the multi-spectral remote-sensing image data of China Resources (ZY-3) satellite of Jizu Mountain, through analysis and experiment, extracts the characters of six kinds of vegetation landscapes, such as the coniferous forest, broad-leaved forest, bamboo forest, sparse forest land, gardens, and orchards.
RESEARCH METHODS

Edited by Bin Jiang & Chuo Li
1 ABSTRACT
The current extended lifespan of people makes healthcare a fertile topic in the field of the built environment (Glanz, 2015). Most previous studies regarding the healthcare environment has been conducted using traditional methods such as interviews, focus groups, and on-site observations. However, those traditional methods rarely integrated with network connectivity measures which has been widely used in transportation planning, urban design and indoor circulation simulation. This research aims to develop a new method for interpreting the importance of various spaces in healthcare environment using behavior mapping and network connectivity calculation.
A senior center designed for Chinese immigrants in the United States was selected for this study. Using 42 points selected in this center as observation points, two well-trained observers conducted behavior mapping hourly from 9 am to 1 pm following the same route but starting from different directions. Based on these maps, a value was assigned to each point indicating its importance of the users' daily activities. The connectivity significance of each point weighted with its corresponding value was then calculated based on the Graph theory using customized parametric tools. The results inform the relationships between differently spaces and usage; future research can use these relationships to develop appropriate design principles. The resulting method can potentially inform the future research and design regarding healthcare environments, for example, for retirement communities, hospitals and children daycares.

1.1 Keywords
Behavior Mapping, Connectivity Measure, Healthcare
2 INTRODUCTION
Healthcare is a fertile topic in the field of built environment. Considering the increasing aging population worldwide, eldercare is an urgent area requiring researchers’ attention (Rowe, Fulmer, & Fried, 2016). However, healthcare research faces multiple challenges due to the special health conditions of the population. For example, seniors with cognitive issues cannot give clear responses to verbal communication, meaning interviews and focus groups may not be the appropriate methods for aging studies. To address this issue, behavior mapping has been proposed as a method for interpreting the significance for outdoor spaces in healthcare environments. But there is still a lack of data analysis for this method. This paper extends a new method by combining behavior mapping and connectivity measures to analyze the observation data.

2.1 Behavior Mapping
Behavior mapping, an observational method that has been widely used in child studies, is an unobtrusive, direct method for analyzing the participants’ activities in the observed locations (Cosco, Moore & Islam, 2010). Two concepts sculptured this approach, behavior settings and affordance. Behavior settings include not only the physical settings but also the people and their behaviors, i.e., how people behave in a functional space. Affordance is how the physical environment supports people’s activities in a specific setting. As a well-developed method, behavior mapping includes observation systems such as System for Observing Play and Leisure Activity in Youth (SOPLAY) (McKenzie, Marshall, & Sallis, 2000), Observational System for Recording Physical Activity in Children – Preschool Version (OSRAC-P) (Brown, Pfeiffer, & McIver, 2006), and Environment and Policy Assessment Observation (EPAO) (Bower, Hales, & Tate, 2008). These three systems code children’s locations during the observation process using a base map. Although all the systems were developed for child studies, they represent the potential to be adopted to aging studies. Compared to interviews and focus groups, which require direct communication with the target population, behavior mapping, is a more effective method in collecting data from aging groups, especially those with cognitive issues.

2.2 Connectivity Measures
Connectivity measures is based on Space Syntax Theory introduced by Bill Hillier and Julienne Hanson (1989). The primary concept is to graph a space consisting of edges and nodes. The edges represent all the possible routes in the study area connecting the nodes, which are locations of the start and end points of each edges. By integrating the distances of each edge, the least cost route can be identified for a given pair of nodes (origin node and destination node). For each node in the study area, its betweeness, meaning how often a node is traversed when traveling between other origin and destination nodes, can also be calculated (Varoudis, Law, & Karimi, 2013). This concept has been implemented in lots of practices such as bicycle facility allocations, pedestrian network use and user behavior prediction, etc. (Dursun, 2007).

3 METHODS
A senior center designed for Asian immigrants in Atlanta, GA was selected as the case for this study, using behavior mapping as the primary method of data collection. Since the population for this study is elders 65 and older, not children, a new behavior mapping protocol was proposed for this population. The process is based on the following the five steps:
(1) Develop a base map for behavior mapping. The base map requested from the senior center was grouped into five functional zones including sitting spaces, service spaces, indoor activity spaces, outdoor activity spaces, and relaxing spaces. Under each functional zone, multiple points, representing the physical features of interests, were placed on the map to illustrate detailed functions, in total 42 points were assigned on the map (Figure 1). For example, under indoor activity spaces, there were 9 points representing different activities such as billiard, ping-pong, Mahjong, CaraOK, and dancing stage.
(2) Clarify behaviors to be recorded. Considering the purpose this study, exploring the importance of different spaces in the senior center, people’s behaviors are classified by the function of the
space. For example, if they were stayed at the billiard area, either playing or watching, their behaviors were defined as billiard related. Detailed behaviors, such as chatting, were not listed as an observed behavior. The buffer zone was 6 feet around the observational points, meaning people who were 6 feet away from the observational points will not be counted.

(3) Design a behavior mapping path. A path was designed going through both indoor and outdoor spaces of the senior center to record the people’s behaviors at the 42 observational points during the observational periods.

(4) Schedule behavior mapping periods. The behavior mapping is scheduled hourly from 9 am to 1 pm due to the operation time of the senior center. Each period lasted about 25-30 minutes.

(5) Record behaviors. Two observers walked along the designed path to record the users’ behaviors. As the researcher walking along the designed path, the number of people at each observational point was counted and recorded on the base map. The reason of two researchers doing observation at the same time along the same path is to address the reliability issue (Gifford, 2016; Yin, 2014).

During the five-hour observation, 10 maps were collected, five from each observer. The maps were overlaid to calculate the value of each points based on a 1-5 value scale, with 1 representing the least important and 5 the most. Based on the value of each point, we developed a method similar to the Space Syntax theory. Each point is defined as a node, while a route connecting two points is defined as a path. The possible routes connecting each point were calculated when the routes repeated, the more routes overlaid, the more important the path spaces.

The data were analyzed in two phases. The first phase, behavior mapping, statistically analyzed the value of functional spaces and functional points to obtain some basic understanding of the space usage in the senior center. The second phase combined behavior mapping and connectivity map to assess the significance of different functional spaces and circulation in the center.

Figure 1. Functional Spaces and Functional Points. Produced by the author.

March 6-9, 2019
4 RESULTS

4.1 Significance of Different Functional Zones

The average value of each functional zone was calculated using the value of each point as seen in Table 1. Relaxation space and Indoor activity space received higher average values than other spaces. Sitting spaces and service spaces had the same value 3. These two spaces were the supportive spaces for elders, indicating their general roles in the functional zones. Outdoor activity space had the lowest value. One reason was because the senior center limited the elders' access to the outdoor space that elders cannot go out by themselves. They can only go out with care staff. The other reason was because the outdoor environment was poorly designed for activities.

Table 1. Average Value of Functional Zones

<table>
<thead>
<tr>
<th></th>
<th>Outdoor Activity Space</th>
<th>Sitting Space</th>
<th>Service Space</th>
<th>Indoor Activity Space</th>
<th>Relaxing Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Value</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3.29</td>
<td>3.5</td>
</tr>
<tr>
<td>Points (In each functional zone)</td>
<td>7</td>
<td>21</td>
<td>5</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

The map below demonstrates the significance of the points under each zone (Figure 2). For indoor activity spaces, billiard area, dancing stage, and mahjong room received the highest value of 5, meaning these indoor activities are mostly preferred by the elders. For outdoor activity spaces, entrance point received the highest value of 5. The center has two entrances, but one is blocked by the terrace. Thus, the main entrance is the only one the people enter and exit the senior center. Although the senior center has a small vegetable garden and a terrace for walking, few elders came outside and use them.

Figure 2. Value of Functional Points. Produced by the author
4.2 Circulation Between Functional Zones

The circulation map seen in Figure 3 was calculated using connectivity measures. By connecting the 42 points, 861 routes were generated. The color illustrates the possible routes between these points, with blue representing fewer routes and red representing more routes. The routes were then used to represent the significance of the paths between different functional zones as illustrated in Figure 3. Entrance is the most important path on the map with highest flow of people since this is the point connecting the indoor and outdoor spaces. The path between the front desk and the reading tables to connect sitting spaces was found to be important. The circulation between tables represented by yellow, indicates that those paths are the most efficient routes connecting tables and other functional points such as billiard area and entrance. At the edge of the building, the color in dark blue, suggests a low connectivity between these spaces. Although TV corner was in high usage (value of 4), people came here only to sit, this lack of movements meaning the calculation results matched the observation results.

Approximately 90% of the significance of the paths are same with the observation results with only the flow around the raised planters, the mahjong room, and the billiard area being different from the observation. Mahjong room and Billiard area represent in highest usage of the indoor activity spaces, but the connectivity to these points is not as convenient as was expected. The map indicates high connectivity between the raised planters; however, they received the lowest value of 1, meaning few elders enjoying them. The results of the behavior mapping and connectivity measures were combined to develop the findings.

![Figure 3. Heat Map of Circulation Significance. Produced by the author.](image-url)
5 DISCUSSION OF FINDINGS

5.1 Design Suggestions for Circulation

_Sitting Spaces and Arrangement_

Different from retirement communities, senior centers do not provide accommodations as elders come there for day activities. Instead of a bedroom, they have an assigned seat in one of the sitting spaces (Miner, Logan, & Spitze, 1993). Thus, ensuring that every elder sits on the seat they prefer is a challenge for care givers. The connectivity measures provide a possible solution. For elders who are willing to participate in social activities, their seats can be assigned along the high flow routes (yellow in the map above). Elders who prefer quite spaces can sit along the low flow routes (blue in the map above). In addition, from a design perspective, the designers can add barriers in or between the sitting spaces and the activity spaces to rearrange the routes connecting these two. For example, several planters can stop elders going from their sitting to the billiard area, changing the former from a high flow social space to a low flow quiet space.

_Entrance_

The Entrance is one of the most important points in a healthcare facility since it sees the highest flow of people. All the possible routes connecting the entrance point to other functional spaces should be designed carefully due to the high flow of people. Different from some spaces for general groups, the entrance and front desk spaces at healthcare facilities should have easy access to elevators, stairs to divide the flow of people.

_Outdoor Activity Space_

How to encourage users of healthcare facilities enjoy the outdoor environments is a typical issue for designers. Elderly users prefer moderate level activities, such as billiards and dancing in the indoor space since outdoor activities are difficulty for them (Lennartsson, & Silverstein, 2001). Their primary need for outdoor spaces is a long-covered terrace for walking, meaning a space with indirect sunshine. In addition, the space should be easily accessible from their sitting spaces.

5.2 New Method to Interpret Space and Circulation

The purpose of this study was to propose a new method for interpreting the significance of various spaces and circulation. Behavior mapping formed the base of this study for collecting the values of different functional zones in healthcare facilities, which is a senior center in this case. Connectivity measures are the advanced step for optimizing the observation results as a measurable model. For example, in this study, the connectivity map illustrated a high flow between the service spaces and the indoor activity spaces. If future studies demonstrate the same flow, then the routes connecting these two require more design and auxiliary features. This research is only the initial step using this combination method. In the future, when more cases are added to the database, a framework can be developed to guide the future design of spaces and circulations in healthcare environments, especially in elder care facilities. By using this framework, designers can easily obtain a map of the significance of the spaces and circulation for a proposed site, thus effectively enhancing the design process.

6 CONCLUSION

In the near future, healthcare will become an even more important field for designers and researchers in the built environment. There is no doubt that research methods such as interviews and focus groups, which directly communicate with users, are effective for obtaining people’s perception of the built environment. However, as the healthcare environment becomes more dependent on Artificial intelligence, new methods and technologies need to be involved in this interpreting process. A framework providing a standard of spaces and circulation significance can guide future design and research in the healthcare environment, both indoor and outdoor spaces. This study represents the beginning of the framework development, introducing the primary methodology that can enrich the database for developing the standard.

7 REFERENCES


ADVANCING DESIGN RESEARCH: CREATING A NEW FRAMEWORK FROM THREE APPROACHES TO CASE STUDY RESEARCH

Little, Sarah  
University of Oklahoma  
sarah.little@ou.edu

Cox, Adina  
University of Kentucky  
Adina.cox@uky.edu

1 ABSTRACT  
Design researchers need to adopt language that reflects a more traditional view of research. Case study is a good example. ‘Case study’ encompasses a variety of activities from novice endeavors to rigorous research inquires. As the foundation of the LAF:CSI grant opportunity, Francis (2001) represents the standard for landscape architecture case study. The authors contend that Francis (2001) is actually a post occupancy evaluation (POE) and not a case study. Adjacent disciplines have similar naming issues with case study investigations. Therefore, the authors advocate for the profession to adopt Yin (2018) as the standard. After comparing Yin (2018) with three case study writings in design research: Francis (2001), Groat (2002), and Swaffield (2017), all three are influenced by Yin and Francis (2001) is clearly a POE. The main issue with Francis (2001) is the lack of a research question on which the case study process hinges. In application, work conducted within the LAF:CSI reports no research questions. Inquires are designed around project details only. While Francis (2001) has value as a POE model, landscape architecture researchers need to quit referring to the article as a case study and adopt Yin (2018) as the model for case study research.

1.1 Keywords  
Case study, research methods, design research, landscape architecture
INTRODUCTION

While the predominate focus has been on landscape history and theory/criticism (Gobster, Nassauer, & Nadeneck, 2010), design research is evolving to include disciplines within the social and natural sciences. A possible catalyst is the rise of PhD programs with a design focus over the last 20 years. Milburn and Brown (2016) administered a survey to landscape architecture assistant, associate, and full professors in 2014 and compared the results with an identical survey administrated in 1998. In the 16-year span between the surveys, the percentage of respondents with a PhD grew from 15% to 42%. As more landscape architecture professors with PhDs enter Academia, one could expect that landscape architecture research will continue to evolve.

One necessary step within the evolution of landscape architecture research is to adopt language that reflects a more traditional view of research. Case study is a good example. The term ‘case study’ can encompass a variety of activities within the design profession from novice investigations, such as precedent searches and post occupancy evaluations (POE), to rigorous research endeavors. For clarity, the authors are utilizing the term ‘case study’ to refer to the latter.

Francis’ (2001) article “A Case Study Method for Landscape Architecture” is the accepted standard for case study research in landscape architecture. The Landscape Architecture Foundation, who commissioned the study, adopted the methodology in their grant funded effort, CSI: Case Study Investigation (LAF:CSI), which funds research on an annual basis. According to Google Scholar, the article has been cited only about 291 times. While the citations may be low, the impact of the article is the influence on the LAF:CSI initiative. While the article greatly advanced landscape architecture research, it exacerbates the problem of non-conformity to traditional research terminology in that the method as defined by Francis (2001) is largely descriptive of design and construction processes (Swaffield, 2017) with little attention given to the relationship between place and socio-physical factors.

Other sources of case study methodology for designers include Groat (2002) in Architectural Research Methods and Swaffield (2017) in Research in Landscape Architecture Methods and Methodology. In this paper, the authors will compare, contrast, and analyze case study research methodologies by these authors incorporating information from the leading authority on case study research from the social sciences: Yin’s (2018) Case Study Research and Applications: Design and Methods. Comparative dimensions include the primary reference source, definitions of case study, value to the profession, possible research questions, designing case study, gathering data, analyzing data, and findings. The authors examine how case study research can be tailored to the needs of designers and design researchers, while enhancing rigorous methodological processes by applying knowledge from the social sciences. The authors assert that Francis (2001) is actually a model for POE and advocate that Yin (2018) should be considered the standard for case study research in landscape architecture as no adjacent disciplines have rigorous traditions.

2 LANDSCAPE ARCHITECTURE RESEARCH

The terms landscape architecture research and design research are used interchangeably in the paper. While the focus of inquiry is dependent on discipline, e.g., landscape architecture, architecture, etc., at the heart of the endeavor is research. Regardless of discipline, research must be systematic and repeatable. Research is systematic when data is collected and analyzed systematically, i.e., conforms to a methodical and rigorous process. Research is repeatable when another researcher duplicates the systematic processes and arrives at similar findings. Quality standards, such as validity and reliability in quantitative research and trustworthiness and credibility in qualitative research, address sample selection, data collection and analysis, and identification of findings to ensure that research is systematic and repeatable. The goal of research is to contribute to a knowledge base, either by generalizing to a larger population through a quantitative approach or by building theory through a qualitative approach.

More and more emphasis is placed on conducting research within design disciplines. With University budgets continuing to shrink, University administration continues to issue directives to conduct peer-reviewed and/or externally-funded research. One problem is that design disciplines may not be invited to participate in such research endeavors given a lack of knowledge by others in adjacent disciplines as to what design research has to offer. One way to overcome this reality may be to adopt language which reflects a more accepted and traditional view of research. From anecdotal experiences in Academia, the authors have heard research terms misused often within the context of design research. A simple browsing of research articles is a literature review. Quantitative quality standards such as reliability
and validity are used for qualitative research; instead of dependability and trustworthiness. During countless presentations, students refer to precedent searches they conducted in search of design inspiration as case studies. If the goal is that landscape architecture professors participate in more peer-reviewed and/or externally-funded multi-disciplinary research projects, then more rigor is needed within design research. A good place to begin is a brief exploration of examples of case study research within adjacent disciplines. Other design disciplines, such as interior design and architecture, are easy to identify as potential research collaborators. When thinking of a range of other potential research collaborators, the range of landscape architecture research must be considered. On one end of the spectrum is research surrounding environmental performance, e.g., green roofs and rain gardens, and the adjacent discipline would be engineering. On the other end is research focusing on human health and well-being, e.g., stress reduction, place attachment, and cognitive functioning, and adjacent disciplines include planning and public health. A quick search on Google Scholar utilized a Boolean search of the "adjacent discipline" AND "case study", citations and patents were omitted from the search, and only the first 10 results were considered (see Table 1). In the adjacent disciplines explored, none of the articles that related to the discipline utilized a reference source to guide a case study investigation. In other words, all the articles that were related to each discipline did not depict a case study. Often, the term 'case study' was used when the research involved a place; however, the research was not a case study investigation as defined by Yin (2018). Place was the case, but a case study investigation was not conducted. What became clear in this brief literature search is that other adjacent disciplines struggle with case study research.

Table 1: Results of a brief literature search of case studies within landscape architecture adjacent disciplines.

<table>
<thead>
<tr>
<th>Search terms</th>
<th>Google Scholar results</th>
<th>Related to discipline (out of 10)</th>
<th>Actual case study</th>
<th>Primary source cited for case study</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;interior design&quot; AND &quot;case study&quot;</td>
<td>~ 23,000</td>
<td>5</td>
<td>1 out of 5</td>
<td>none</td>
<td>(2) non-related articles cited Yin as a primary source.</td>
</tr>
<tr>
<td>&quot;architecture&quot; AND &quot;case study&quot; -computer - software -circuits - network -mind - geology</td>
<td>~ 92,100</td>
<td>6</td>
<td>0 out of 6</td>
<td>none</td>
<td>Since the term 'architecture' has been adopted by many professions, several terms were identified for exclusion.</td>
</tr>
<tr>
<td>&quot;urban planning&quot; AND &quot;case study&quot;</td>
<td>~ 302,000</td>
<td>10</td>
<td>0 out of 10</td>
<td>none</td>
<td>Research mislabeled as case study--simulations, PAR, participatory games, etc.</td>
</tr>
<tr>
<td>&quot;public health&quot; AND &quot;built environment&quot; AND &quot;case study&quot;</td>
<td>~ 38,400</td>
<td>7</td>
<td>0 out of 7</td>
<td>none</td>
<td>(1) non-related article cited Yin as a primary source.</td>
</tr>
<tr>
<td>&quot;stormwater&quot; AND &quot;case study&quot;</td>
<td>~ 34,600</td>
<td>10</td>
<td>0 out of 10</td>
<td>none</td>
<td>Too many engineering disciplines therefore, 'stormwater' was used. Most of the studies involved a place; therefore, the use of the term 'case study'.</td>
</tr>
<tr>
<td>&quot;Low impact development&quot; AND &quot;case study&quot;</td>
<td>~ 6,200</td>
<td>10</td>
<td>0 out of 10</td>
<td>none</td>
<td>Too many engineering disciplines therefore, 'LID' was used. Most of the studies involved a place; therefore, the use of the term 'case study'.</td>
</tr>
</tbody>
</table>

Interestingly in the 60 articles reviewed (10 for the 6 adjacent disciplines), 3 cited various editions of Yin’s *Case Study Research: Design and Methods*. Two appeared in the "interior design" search; Breslin and Buchanan (2008) was not directly related to interior design but advocated for the use of case study in design, and Khan, Christopher, and Burnes (2008) was related to product design not interior design and
documented an actual case study. Gangeness and Yurkovich (2006) was the third article which appeared in the “public health” search and advocated for the use of case study research in nursing.

3 CASE STUDY COMPARISONS

Since no standard of case study research was found in adjacent disciplines, the authors decided to adopt (Yin, 2018), the standard in social sciences, as the standard to compare other case study approaches in design research. Three examples of design research case study were selected to compare with Yin (2009): Francis (2001), Groat (2002) in *Architectural Research Methods*, and Swaffield (2017) in *Research in Landscape Architecture Methods and Methodology*. The authors had intended on using Deming and Swaffield (2011), *Landscape Architecture Research: Inquiry, Strategy, Design*, instead of Groat (2002) so that all design related case studies were from landscape architecture; however, the organization of Deming and Swaffield (2011) made comparisons difficult since the book did not contain a chapter devoted to case study research, instead references to case study were peppered throughout the book. References were compared on the following criteria: primary source and defining case study, value to the profession, research questions, designing the case study research, gathering data, analyzing data, and findings from a case study.

3.1 Defining Case Study

“A case study is an empirical method that: investigates a contemporary phenomenon (the “case”) in depth and within its real-world context, especially when, the boundaries between phenomenon and context may not be clearly evident.” (Yin, 2018, p. 15).

Table 2: Comparing the selected writings based on primary source cited and definition.

|----------------|------------|----------------|--------------|------------------|

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“…an empirical method that: investigates a contemporary phenomenon (the “case”) in depth and within its real-world context, especially when, the boundaries between phenomenon and context may not be clearly evident.” (p. 15).</td>
<td>“…a well-documented and systematic examination of the process, decision-making, and outcomes of a project, which is undertaken for the purpose of informing future practice, policy, theory, and/or education” (p. 16).</td>
<td>Modified (Yin, 1994) in order to account for historic phenomenon “an empirical inquiry that investigates a phenomenon or setting” (p. 346).</td>
<td>“…a general approach to research, and not a set of specific methods” (p. 107).</td>
</tr>
</tbody>
</table>

How each source defines case study is illuminating when compared to Yin (2018). Groat (2002) and Swaffield (2017) reference versions of Yin to define case study. Groat (2002) modifies the definition slightly to account for the historical aspect of architectural research by eliminating the word ‘contemporary’ and adding ‘setting’ to accompany ‘phenomenon’. Swaffield (2017) utilizes Yin (2014) to define case study but refines the definition with contributions from Gerring (2004) in that case studies are not a way to analyze cases, but to define cases. Francis (2001) offers a definition with no provenance, although in the footnotes he directs the reader to Yin (1993) and Yin (1994) for a more in-depth exploration of case study.
The most striking difference between the definitions beyond the provenance is that Francis (2001) is defining a POE given the exclusive focus on ‘project’ as the case. While the others employ a broader definition of case, e.g., contemporary phenomenon, setting, Francis (2001) greatly limits the scope of the inquiry by solely focusing on the project as the case.

3.2 Value to the Profession

Table 3: Comparing the selected writings based on value to the profession.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Value to the profession</td>
<td>A way “to understand complex social phenomena” (p. 5).</td>
<td>Teaching, research, practice, theory building, criticism, and communication and outreach</td>
<td>Explain “causal links among an array of socio-physical factors and events” (p. 349).</td>
<td>“...suited to the investigation of complex phenomena such as designed landscapes” (p. 105).</td>
</tr>
</tbody>
</table>

Each source identifies the value of case study to their respective disciplines. Yin (2018), Groat (2002), and Swaffield (2017) acknowledge the complex nature of the object of study. For Yin (2018), the object of study is social phenomena; Groat (2002) and Swaffield (2017) also recognize social dimensions but further refine the object of study to acknowledge the built environment in that Groat (2002) references “socio-physical factors and event” (p. 349), and Swaffield (2017) references “complex phenomena such as designed landscapes” (p. 105). However, Groat (2002) may be too ambitious in the assessment of the possibility of identifying “causal links” (p. 349). While landscape environmental performance research, e.g., stormwater quality in rain gardens or cooling effects of trees, may be able to accomplish this task, behavioral and social research rarely identifies causality. “In the eyes of many, the emphasis [on causal relationships] has led to a downgrading of case study research because case studies (and other types of nonexperimental methods) cannot directly address this issue” (Yin, 2009, p. 16). Regardless of causality or correlation, case study adds value to the profession by offering a way to manage the complexities of the socio-physical environment.

Francis (2001) is a stark deviation from the other sources is that there is no acknowledgement of the complexity of the social and physical variables within the built environment and the ability of the case study method to manage the complexities. Instead, Francis (2001) identifies areas of the profession that case study adds value.

3.3 Research Questions

Table 4: Comparing the selected writings based on types of research questions.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Research questions</td>
<td>Mainly how and why questions regarding a &quot;contemporary set of events, over which the investigator has little or no control” (p. 13).</td>
<td>“…big questions at the intersection of policy and design” (p. 17).</td>
<td>Cites (Yin, 1994) explanatory, descriptive, exploratory, or some combination</td>
<td>Identify a knowledge gap that can be tested through “either a set of research questions or a set of testable hypotheses” (p. 27).</td>
</tr>
</tbody>
</table>
The types of research questions explored within the case study traditions compared may be the most illuminating. Yin (2018) gives considerable attention to type of research question that is appropriate within case study inquiry. Two conditions must be meet. First, the researcher has little or no control over the phenomena being studied, i.e., the research is conducted outside the confines of a controlled environment, such as a laboratory. Second, the events must be current; historical inquires are excluded. While Groat (2002) expands the definition of case study to include historical investigations as stated in section 4.1, no mention of historic events is included in the types of research questions permittable within case study.

Yin (2018) goes on to illustrate that ‘how’ and ‘why’ questions can be explored through explanatory case studies and sometimes ‘what’ and ‘who’ questions through exploratory case studies. Groat (2002) defers to Yin (1994) as to the types of research questions and the resulting case study typology, i.e., explanatory, exploratory, and description. Swaffield (2017) takes a more pragmatic approach by linking gaps in the knowledge base to developing research questions in order to fill these gaps.

Francis (2001) does not adopt the ‘who, what, where, how’ convention when identifying appropriate questions for case study research. Francis (2001) posits that appropriate questions occur “at the intersection of policy and design” (p. 17). ‘Policy and design’ give no acknowledgement to the social and physical complexities inherent in the built environment and may miss the mark in research question generation. A quick review of the LAF:CSI website reveals this issue surrounding formation of research question. LAF:CSI investigations are not centered around a research question. In project briefs and the downloadable data from all LAF:CSI investigations, no research questions are reported. Only project details are given. The lack of research question to guide the inquiry better lends Francis (2001) to a POE than a case study.

### 3.4 Designing Case Study Research

“Note that a research design is much more than a work plan. The design’s main purpose is to avoid the situation in which the evidence does not address the initial research questions” (Yin, 2018, p. 26).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A case study design</td>
<td>&quot;…can be organized around the type of project, the problem, the geographical region, or the designer” (p. 20).</td>
<td>guided by developing theory; not a grand theory but a sufficient blueprint for your study, a hypothesis</td>
<td>&quot;...the best case study design is that which provides the most powerful understanding of variation—why one situation differs from or is similar to another” (p. 110).</td>
<td></td>
</tr>
<tr>
<td>must consider the following: research question, propositions, the case, the logic linking the data to the propositions, and criteria for interpreting findings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Designing a case study must be purposeful in the goal of answering the research question(s). Yin (2018) suggests that each case study contain five main components: research question, propositions (if any), its case(s), the logic linking the data to the propositions, and criteria for interpreting findings. As discussed in the previous section, the necessity to design a case study around the research question is problematic for Francis (2001).

Typically, the research questions answered by case study tend to begin with ‘how’ or ‘why’. In answering the questions, propositions formed in the beginning may help to identify areas of study within the case study; however, the use of propositions may not be required. Also, rival propositions are useful to identify as well. The ‘case’ may be a place, a neighborhood, an individual, or an event. The case or unit of analysis should be a real-life, contemporary phenomenon in which the researcher has no control over behavioral events. All data collected should be analyzed in a way consistent with the type of data.
collected, i.e., qualitative, quantitative or mixed, and most appropriate to answer the initial question. Ultimately, findings from case studies are used to build theory.

Groat (2002) and Swaffield (2017) follow a similar format in that designing the inquiry is focused on providing a clear means to generate findings. Groat (2002) suggests that the research design should be guided by developing theory and looking to any propositions in order to develop theory. Swaffield (2017) focuses on crafting a research design that focuses on explaining the variation of the case, i.e., what made the case worthy of selection. Francis (2001) organizes the inquiry around design/ construction factors surrounding projects which focuses more on documenting the process as in a POE than on documenting a phenomenon.

### 3.5 Gathering Data

Table 6: Comparing the selected writings based on methods for gathering data.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Pre) Hone skills, train, develop protocol, gain human subjects approval, screen and select final cases, conduct pilot study.</td>
<td>Person(s) free of bias, skilled in asking questions, listening, comprehending the issues.</td>
<td>Systematic and consistent: site visits, site analysis, historical analysis, design process analysis, behavioral analysis, interviews with designers, developers, managers, and public officials, interviews with users and non-users, archival materials, bibliographic searches, internet searches.</td>
<td>(Not specified)</td>
</tr>
<tr>
<td></td>
<td>Evidence types: Documentation, archival records, interviews, direct observations, participant observation, physical artifacts.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Triangulate evidence, assemble data, maintain chain of evidence, exercise care with digital information.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

While case studies explore complex phenomena, the methods of data collection distinguish case study from other approaches, such as ethnography which require years of data collection. All sources accept multiple methods for data gathering. Swaffield (2017) avoids discussing details of data gathering. The terminology used across the other sources vary, but the methods include a broad range of traditional research data gathering methods, such as interviews, documentation, observation, physical artifacts, and archival research. Groat (2002) includes “spatial analyses” and Francis (2001) includes “site analysis” and “design process analysis” which are examples of data gathering more specific to the design practice. Yin (2018) and Francis (2001) describe the importance of training or knowledge for the person conducting the research. Francis (2001) also discusses the importance of avoiding bias by the researcher. This can be a significant issue in the design profession, especially in the case of POE, where design firms seek to evaluate their own projects and may not be aware of bias or know how to address bias. Yin (2018) goes...
further to describe pre-data-gathering steps which include honing research skills, training data collectors, developing consistent and systematic data gathering protocol, gaining human subjects’ approval, screening and selecting final cases, and conducting a pilot study.

3.6 Analyzing Data

Table 7: Comparing the selected writings based on methods for analyzing data.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Create a general strategy for analyzing data based on theoretical propositions, working your data from the “ground up,” descriptive frameworks, or rival explanations.</td>
<td>In the Bryant Park example, analysis is simply reporting the details of the project. No specific methods of analysis are discussed. Mention of “behavioral analysis” (p. 26) but no details are given.</td>
<td>Data analysis should follow the research design. “...applying multiple analyses to a complex case, by adopting multiple theoretical perspectives across the case, or by undertaking several smaller case studies embedded within a larger complex case” (p. 110).</td>
<td>...apply multiple analyses to a complex case, by adopting multiple theoretical perspectives across the case, or by undertaking several smaller case studies embedded within a larger complex case</td>
<td></td>
</tr>
</tbody>
</table>

Yin (2018) outlines general strategies for analyzing data based on theoretical propositions, descriptive frameworks, use of qualitative and quantitative data, or rival explanations. Using theoretical propositions is the most preferred approach for data analysis. Propositions that guided the development of the research questions and data collection will help to identify data analysis strategies. Creating a descriptive framework can help in analyzing data. Descriptive frameworks, the second strategy, help to organize data in situations where propositions may not be clear. The framework should be aligned with the research questions and data collection methods just as in theoretical propositions. With more rigorous research questions and data collection methods, Francis (2001) could potentially conform to a descriptive framework that would allow for design and construction details; however quality standards, such as credibility, trustworthiness, etc., would need to be considered. The third strategy of utilizing both qualitative and quantitative data strengthens the overall analytic design. Finally, testing a rival explanation strengthens your overall findings.

Whichever strategies employed for data analysis should be considered at the very beginning of the research project in the formation of the research questions. The whole case study design should factor the types of questions, the necessary data to answer these questions and how the data will be analyzed. Groat (2002) and Swaffield (2017) advocate a similar holistic approach to data analysis. The non-conforming approach is Francis (2001) which depicts data analysis as simply reporting the details regarding the design and construction of projects. While mention to potentially more rigorous behavioral research exists in the Bryant Park example, no details of the methods and data collection or analysis are given. For Francis (2001) to achieve the level of case study research described by Yin (2018) more rigorous data collection and analysis is needed.

3.7 Findings

Yin (2018) uses the term ‘analytical generalization’ to refer to the use of the findings at the end of a case study inquiry. Analytical generalization is not to be confused with statistical generalization. In quantitative research, findings from a smaller sample are generalized through statistical analysis to a larger population provided that the sample is representative of the population. Findings from case studies are meant to be compared with existing theory in an effort to refine theory. Findings from case studies work to build theory or generalize “to theoretical propositions and not to populations or universes” (Yin, 2009, p. 15), which
essentially constitutes theory building, the goal of qualitative research. Since the case study method typically represents mixed-method research, the qualitative use of findings is appropriate.

Table 8: Comparing the selected writings based on how apply findings.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Findings</td>
<td>Analytical generalization</td>
<td>Findings are presented as lessons for future projects with no directions on how the findings were generated.</td>
<td>Findings should develop theory (Yin, 1994).</td>
<td>Analytical generalization (Yin 2014). “This uses existing theory as a template against which to compare the results of a new study. Hence theory develops inductively, as evidence accumulates” (p. 108).</td>
</tr>
</tbody>
</table>

Groat (2002) and Swaffield (2017) defer to editions of Yin’s *Case Study Research: Design and Methods* when reporting on the use of findings in case study research. While not citing Yin directly, an argument could be made that Francis’ assertion that findings are presented as lessons for future projects could qualify as analytical generalization. While Yin (2009) defines analytical generalization as utilizing existing theory to evaluate a case study, Francis (2001) is utilizing findings from case study to build theory to inform future projects.

4 Conclusion

Ultimately, research is a rigorous, systematic, and repeatable endeavor which generates knowledge that is used to build theory at the end of a qualitative inquiry or generalize to a larger population in a quantitative inquiry. When comparing three case study traditions within design research, the influence of Yin’s *Case Study Research: Design and Methods* becomes clear. Groat (2002) and Swaffield (2017) utilize Yin as the standard in conveying many details about defining case study research, formulating research questions, and applying findings. While both researchers slightly tweak Yin’s version of case study to more closely address the needs of their respective professions, Yin is definitely the starting point, i.e., the standard of case study research.

When considering case study as a research method, Francis (2001) fails to align with Yin (2018) in many facets of case study investigation explored. The most pronounced is the creation of a research question. While Yin (2018), Groat (2002), and Swaffield (2017) clearly articulate ways to craft a research question, Francis (2001) gives no acknowledgment to the complexities of the social and physical dimensions inherent in landscape architecture. The research question almost feels de-emphasized. When exploring the application of Francis (2001) in the LAF:CSI program, project briefs contain no information regarding the research question which guided the inquiry. Unfortunately, the research question is key to case study research. The research question guides the design of the case study investigation, methods utilized, and data gathering and analysis techniques. Case studies as defined by Francis (2001) are not guided by research questions beyond finding out specific project details.

Beyond the concerns surrounding the research question, Francis (2001) fails to detail a research method in that his findings may not be repeatable, i.e., a different researcher may not arrive at the same findings. In his definition of case study, Francis (2001) describes his method as a “well-documented and systematic examination” (p. 16) which is consistent with most definitions of research in general. One key piece is missing: repeatability. No quality standards exist in Francis (2001) that would address
repeatability. For example, practitioners, such as project managers and design professionals, are often interviewed within the Francis case study model. This sample represents a small and finite pool of interviewees. Some quality standards that may be applicable to this example are data saturation and member checking. Data saturation refers to the point where the data contributes no new information to the understanding of the activity (Creswell, 2007). With a finite sample, data saturation may be impossible to achieve. Member checking is a way to confirm with research participants that the researcher documented their input accurately and findings represent their experience (Lincoln & Guba, 1985). Francis (2001) mentions nothing about data saturation or member checking or any quality standard which would address issues with repeatability.

Francis (2001) at the current iteration represents a POE and not a case study method. While POE would not qualify as research, knowledge generated from POE studies could contribute to the practice knowledge base and benefit the profession. The position of the authors is that Francis (2001) has value, but the profession needs to stop calling it a case study method. In order for design research to evolve to a point where landscape architecture professors are solicited to engage in multi-disciplinary, peer-reviewed, externally-funded research project, we need to adopt language that reflects a more traditional view of research. Case study is a good place to start.

5 References
ENGAGED SCHOLARSHIP

Edited by Malika Bose, Benjamin Spencer, and David La Pena
TEACHING LANDSCAPE ‘TRIAGE’ THROUGH FIELDWORK: SITE ANALYSIS AT WHITE PARK, MORGANTOWN, WEST VIRGINIA

HAAS, VAIKE
West Virginia University, vaike.haas@mail.wvu.edu

1. ABSTRACT

West Virginia University students contributed to site analysis through fieldwork at White Park, a brownfield and urban forest with pockets of old growth, layered cultural history and a convoluted network of trails. An irregular grid of circular berms covers White Park: these served as firebreaks for spills from oil tanks during the 1890s-1950s, when oil tanks periodically caught fire from lightning strikes. Superfund monitors White Park’s levels of soil contamination from metals and volatile organic compounds, but only a few of the 46 tank wells on site are known to be mitigated.

White Park’s oil tank well berms vary in diameter and include some concentric outer rings and straight segments – features similar to prehistoric Native American mounds in the region. Some trees at White Park, predating the US Civil War, show bark scars echoing ‘tomahawk rights’ blazes that settlers used to claim territory. White Park’s historically and ecologically significant terrain is also used for recreation: the park’s 170 acres are covered with an incredibly tangled web of trails, favored for mountain biking and ROTC military training.

Students’ incremental analysis (2014-2018) of this complicated site was supported by faculty’s research of the park’s cultural history as the site of Native American and early pioneer settlements and oil industry. White Park’s complexities challenged students to design for multiple objectives: remediate oil contamination, interpret cultural history, and minimize trail user conflicts. This project has applicability for educators as a case study of a complex cultural landscape site analysis project requiring incremental collection of field data from a public site. This service-learning effort encouraged thoughtful problem-solving which benefited both students and the community. In 2019, students’ landscape triage design approach informed professional analysis and planning work, and will continue to inform master planning, trail work, and public interpretation at White Park.

1.1 Keywords

Site inventory, brownfield, witness trees, trail design, urban forest, cultural landscape, service-learning

The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the Council of Educators in Landscape Architecture (CELA), and its printing and distribution does not constitute an endorsement of views which may be expressed. Citation of this work should state that it is from a CELA conference paper. EXAMPLE: Author’s Last Name, Initials. 2018. Title of Paper. Blacksburg, Virginia: CELA. For information about securing permission to reprint or reproduce this paper, please contact CELA at staff@thecela.org
INTRODUCTION
This case study involves the site analysis of a mostly woodland urban park, in which student fieldwork over several years helped decipher site elements into design priorities that informed public decision making at a pivotal moment. This paper documents opportunities inherent in service-learning through fieldwork, particularly for landscape architecture students 'unpacking' a public site with complex existing conditions and layers of cultural history.

Deciding which landscapes warrant long-term protection can require what Melnick (2016: 292) terms "cultural landscape triage, choosing to save certain places while letting other ones remain only in the historical record". While interpreting cultural landscapes often characterizes landscape architects' work (Goetcheus, Karson & Carr, 2016: xii), meaningfully connecting a site's history with its redesign and "revealing forgotten stories and restoring damaged ecologies" requires a "rigorous and flexible research-driven design process" (Wolz 2016: 252). West Virginia University students investigated White Park through another form of landscape triage: rather than choose which of several cultural landscapes to preserve, students analyzed characteristics of one cultural landscape to puzzle out three main priorities for the park's future: streamlining the convoluted network of trails, identifying areas possibly in need of brownfield remediation, and preserving the park's oldest trees.

To assess the site's existing conditions, landscape architecture students interpreted topographic maps in the field, used compasses to read bearings and navigate the convoluted trail network, and practiced estimating the ages of trees -- all while incrementally documenting the locations of (previously unmapped) secondary trails, relics of 19th-century industrial use as an oil tank field, and trees predating the oil tank field. During the course of this extended effort, the abrupt removal of the park's interpretive signs brought out another future master plan priority, investigated by the author: topics for public interpretation, especially of the site's cultural history. This multi-year, collaborative effort began in the effort to answer the initial research question, Could White Park's grid of circular berms predate the site's use as an oil tank field? During the course of site analysis, the project's focus shifted to a broader landscape triage question, Which physical features of White Park are priorities for remediation, preservation, master planning, and/or public interpretation?

METHODS
Through visits to White Park doubling as plant identification field trips, landscape architecture students contributed to an incremental site analysis of the park's 170 acres through multiple iterations during 2014-2018. Student teams documented existing site conditions within assigned, roughly 5-acre areas (each encompassing two or three former oil tank wells) within White Park. Most areas were explored and mapped in detail by multiple teams of students (in groups of 2-4) over sequential years. Once students were familiar with the entire park, they divided into teams to analyze their assigned sites.

Trails. Students mapped White Park's secondary (single track) trails, a convoluted network used for hiking and mountain biking. When we began this work, no comprehensive trail map for White Park was available; maps showed only the park's primary, multi-user trails (gravel paved around 1998). Using a detailed, 2-foot contour topographic map, and reading contour signatures and bearings, we gradually mapped the extensive secondary trail network during class trips. Each year, I refined the overall draft trail map as the whole class group navigated between oil tank wells to become acquainted with the park as a whole. During this step, students took individual turns to lead the class through the secondary trail network, navigating with a compass and the draft trails and topography map under my guidance. This was the first experience of orienteering for about one quarter of the students. Most students had minimal prior orienteering experience, but about a quarter of each class was already proficient; these students I designated as team leaders. Wrong turns became opportunities to document additional secondary trails. Once the class was ready to divide into teams, they navigated independently, confirming the draft trails map accurately described secondary trails leading to and through their assigned areas. I compiled this information, revising the draft trail map each year, with aerial photos, Global Positioning System (GPS) tracks generated during class, and field notes. One particularly enthusiastic undergraduate teaching assistant facilitated this by volunteering to GPS track extensive portions of the trail network.

Brownfield contamination. In lecture, we discussed the historic use of White Park as an oil tank field and interpreted historic site and aerial photos to determine the extent of industrial use and oil tank locations. In the field, students located visible relics of oil industry (oily sheen, pipeline remnants), looked for evidence of underground elements retaining surface water and obstructing deep roots, and highlighted
areas with visible evidence of brownfield contamination. Because of the site’s historic nature and uncertain mitigation status, students did not disturb soils or attempt to survey transects with equipment. Instead, relying on the topographic map for detailed general information, students drafted cross-sections of each assigned oil tank well berm enclosure, using field measurements to identify the lowest outlet point of each tank well and to determine maximum water depth. They also diagrammed surface water flow movement, combining field observation with interpreting topographic contours. In design charrettes (fast-paced design exercises), teams explored possible brownfield remediation strategies based on site conditions for each oil tank well.

**Historically significant trees.** Within their assigned areas, student teams identified and listed native and invasive plant species present. They located trees of sufficient trunk diameter to have an estimated age over 100 years: this diameter varied by the growth rate for each species, ranging from 18” to 33” (as discussed under Findings). We calculated trunk diameters at breast height, 4.5 feet above the ground, by measuring trunk circumference whenever possible. Some trees were located in such steep terrain that this was not feasible, in which case we estimated diameter. The dimensions of White Park’s largest tree, a white oak students found, were confirmed by state foresters after I nominated it for the Big Tree Inspection Program.

**Cultural history.** I reviewed property records, historical accounts, archival photos and news articles to ‘unpack’ more information about White Park’s history and Morgantown’s early settlement. A graduate research student helped gather this information from city archives. I compiled a list of archaeological surveys of the area and found records of several regional sites with similar circular berms originating in pre-historic, rather than early industrial, earthwork. This research informed my teaching and students’ understanding of the site.

**Public interpretation.** Each year, I compiled students’ data until fieldwork documented minimal updates to maps of trails, significant trees, and visible relics of industry. In January 2019, I comprehensively confirmed student trails and trees data. I made minor adjustments to the trail map to incorporate a high-resolution aerial image which became available in 2018, and I confirmed in the field students’ tree mapping and identifications. In doing so, I noticed physical evidence of the trees’ history of marking property boundaries (discussed under Findings). I summarized key aspects of White Park’s history as a basis for future interpretive signage. Student teams contributed to this effort by exploring priorities for public interpretation as part of design charrettes. I made student-data driven maps available to the land manager, land owner and key stakeholders to inform decision making processes affecting White Park’s future.

## 4 FINDINGS

Field-based exercises within a complex cultural landscape helped students build practical, analytic skills towards a “combined understanding of the human activities, the physiographic and biologic processes, and the cultural associations that have shaped terrain, ecosystems, and perceptions over time” (Goetcheus, Karson & Carr, 2016: xii). The fieldwork and analysis process shaped priorities for design initially in student charrettes, and later during public meetings with stakeholders and city officials.

### 4.1 Trails

When we began this work, trail maps and the Floyd Brown Group (2008) master plan for White Park documented only the primary network of gravel multi-user trails, which total 3.26-miles. According to one long-term Morgantown resident, who remembers biking there in 1987, White Park’s secondary trail network dates to “almost the beginning of mountain-biking” -- trails proliferated through both sanctioned and unsanctioned efforts until they became “what might very well be the densest network of trails in the state… and that’s not a good thing” (personal communication, July 2019). In recent years, volunteers closed off some mountain biking trails and improved others with ramps and banked turns, linking trail segments into one continuous Blue Loop of around 3.4 miles; however, this route intersects with the primary gravel trails 17 times, often with short sight distances or through steep descents (‘gravity drops’) along gaps in the oil tank berms.

Producing an accurate trail map helped students learn orienteering and topographic map reading – skills better to learn through fieldwork, rather than in front of a client on a site visit. The trail map will be an important resource for future master planning, guiding future trail volunteers to target specific problem
areas. In mapping trails, we found the capability of a handheld GPS unit (Oregon 600) of limited use under tree canopy cover, especially where slopes were steep. One undergraduate teaching assistant volunteered to map trails using the handheld GPS unit in the winter months, which was more successful. However, after half a dozen field days exploring the trails (and once walking around the same circular berm three times at dusk), he concluded, “Nothing about White Park makes sense” (January 2019).

The disorienting nature of the trail network explains why the Reserve Officers’ Training Corps (ROTC) uses White Park for military training: the unique topography provides orienteering challenges, and when ROTC students navigate the site they are expected to read contours on the move, rather than rely on the trail network (personal communication, ROTC student also majoring in landscape architecture). Given the site’s tree canopy cover, we found mobile phone activity tracking apps (especially ‘All Trails’) more effective than GPS for trail mapping, particularly when used in conjunction with a paper map to mark trail locations on topographic contours. The mobile phone app and compasses helped students keep track of their bearings -- not an easy feat, in an existing trail network that on paper looks like someone threw a fishing net at a park (Figure 1). Two students, in filling out project evaluation forms, lamented the “confusing” state of the trails; a third student noted more positively, “we also learned how to trail map.”

In mapping the trail network, we found that park descriptions of over five miles of trails at White Park wildly underestimated the existing network; in fact, within White Park, we mapped 15.5 miles of trail, 286 trail intersections, and 31 intersections of trails and roads. We also found a portion of one oil tank berm cut away to use as fill for a ramp, which raised additional concerns about protecting the general form of the berms as part of the cultural history of the site.

Figure 1. Trails and forest age at White Park. Red dots pinpoint oldest trees; shading shows forest age. Photo and graphic by author, using: students’ trail/tree mapping, undergraduate teaching assistant L. Wenger’s GPS data (2018), aerial photo from Monongalia County Land Records (2018).

4.2 Brownfield Contamination

From 1906 to 1924, West Virginia was the top oil-producing state (Allen & Matchen, 2017). Eureka Pipeline Company moved oil from West Virginia to “Philadelphia and the Atlantic Seaboard” (Callahan,1926: 250), operating in Morgantown from 1890 to around 1940 as a subsidiary of Standard Oil Company (Dominion Post, 2012; Core 1983: 143). In 1889, Eureka drilled near the confluence of Cobun Creek and Monongahela River next to White Park (now a car dealership on US-119). By 1890, Eureka
Beginning in the 1890s, Eureka built Morgantown’s oil tank field, which totaled 700 acres including White Park (Triad, 2009: 4). At peak capacity in 1926, the tank field could hold more than a million barrels of oil (Carvell, 2013; Morgantown History Museum, 2012). In 1890, there were eight oil storage tanks near White Park; in 1900, there were 31; by 1926, there were 55 (Callahan, 1926: 250). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.

A United States Geological Survey (USGS) aerial photograph shows that all but four of the Eureka Oil Pipeline Company’s “24 wells produced 1,800 barrels of crude oil a day” (Dominion Post, 2012). Volatile odors were noted during the 2009 DEP reinspection, which lists many more organic compounds detected below action levels (Triad, 2009: 30-31). A brownfield is a post-industrial landscape that is contaminated or perceived to be so. It remains unclear to what extent White Park requires remediation. In 1898, after a resident reported “tar-like deposits” near the middle school next to the park, White Park was enrolled in the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) as WVD98766168, but not included on Superfund’s National Priorities List (Triad, 2009: 1). Around 1988, Eureka Oil Pipeline Company and Pennzoil Products “remediated several ‘tar pit’ areas at White Park” (Triad, 2009: 13). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.

The list of known soil contaminants at White Park is extensive. Volatile odors were noted during Superfund’s National Priorities List (Triad, 2009: 1). Around 1988, Eureka Oil Pipeline Company and Pennzoil Products “remediated several ‘tar pit’ areas at White Park” (Triad, 2009: 13). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.

The list of known soil contaminants at White Park is extensive. Volatile odors were noted during Superfund’s National Priorities List (Triad, 2009: 1). Around 1988, Eureka Oil Pipeline Company and Pennzoil Products “remediated several ‘tar pit’ areas at White Park” (Triad, 2009: 13). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.

The list of known soil contaminants at White Park is extensive. Volatile odors were noted during Superfund’s National Priorities List (Triad, 2009: 1). Around 1988, Eureka Oil Pipeline Company and Pennzoil Products “remediated several ‘tar pit’ areas at White Park” (Triad, 2009: 13). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.

The list of known soil contaminants at White Park is extensive. Volatile odors were noted during Superfund’s National Priorities List (Triad, 2009: 1). Around 1988, Eureka Oil Pipeline Company and Pennzoil Products “remediated several ‘tar pit’ areas at White Park” (Triad, 2009: 13). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.

The list of known soil contaminants at White Park is extensive. Volatile odors were noted during Superfund’s National Priorities List (Triad, 2009: 1). Around 1988, Eureka Oil Pipeline Company and Pennzoil Products “remediated several ‘tar pit’ areas at White Park” (Triad, 2009: 13). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.

The list of known soil contaminants at White Park is extensive. Volatile odors were noted during Superfund’s National Priorities List (Triad, 2009: 1). Around 1988, Eureka Oil Pipeline Company and Pennzoil Products “remediated several ‘tar pit’ areas at White Park” (Triad, 2009: 13). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.

The list of known soil contaminants at White Park is extensive. Volatile odors were noted during Superfund’s National Priorities List (Triad, 2009: 1). Around 1988, Eureka Oil Pipeline Company and Pennzoil Products “remediated several ‘tar pit’ areas at White Park” (Triad, 2009: 13). Around 2010, two additional tank wells were remediated. Four out of 46 tank wells located within White Park are documented as remediated; 19 have likely not been, and the status of 23 remains unknown (Triad, 2009: 4). In recent stakeholder discussions, two long-term neighborhood residents shared experiences (around the 1980s) of children falling into tar pits but clambering out. One long term resident recalled her son once “came home covered in oil. He said he fell in a hole of oil and couldn’t get out. He was hysterical. He thought he was going to die right there.” The whereabouts of these ‘tar pits’ remains unknown, but a 2010 aerial shows distinct dark circles in some tank wells (Figure 2), perhaps the ‘tar pits’.
earthen dam (with rock fill) created the 12-acre Cobun Reservoir, holding a 3-day supply of drinking water for Morgantown (Beard, 2018; Core, 1984: 317; MUB, 2017). Fracking (hydraulic fracturing) is underway just 1500 feet upstream of the city’s drinking supply water intake on the Monongahela River (Board, 2014), across the river from White Park at the former Morgantown Ordnance Works. Concerned about the integrity of the water supply after the 2014 Elk River leak affected Charleston’s water supply, Morgantown Utility Board (MUB) initiated construction of the around $48-million George B. Flegal Dam and Reservoir project as a back-up water supply for Morgantown, if Monongahela River “becomes contaminated for any reason,” according to MUB General Manager Tim Ball (interviewed by Beard, 2018). MUB originally planned to build, beginning in July 2019, a 30”-diameter raw water pipeline connecting the new reservoir to the utility facility at Monongahela River through White Park, buried about 10 feet deep, crossing four unmitigated oil tank well locations, and within as little as 30 feet of open water of the reservoir (Figure 2, dashed black line).

Figure 2. Students found 8 oil tank sites (orange) not previously located by Triad (2009). We agreed some tank sites appeared mitigated (green), unmitigated (red), or not evident (yellow). Students found oily sheen in many low-lying areas (purple, inset). Photo and graphic by author.

Students found oily sheens and other traces of oil industry throughout the park and industrial remnants in the less used southern portion, including walls, rusted pipes and a storage barrel. I found additional rusted pipes along Cobun Creek below the dam; others likely remain throughout the site, as topographic contours hint at buried infrastructure as well as documenting the tank well berm locations. As part of their site analysis where standing water and/or organic muck soils were evident, students probed (from the tank well edges) to determine the approximate depth of hydric soils, which often seemed to constrain vegetation growth (Figure 2, purple areas). In 2017, one group of students discovered what they described as a “hardpan layer” submerged just below the hydric soil layer in one oil tank well. In 2018, knowing to look for it, we found this hardened soil layer common to many tank wells, which might help isolate surface water from groundwater and slow the movement of contaminants from the soil surface into groundwater (and the reservoir). Commonly, brownfields are capped with clay for the same purpose.

In 2019, working on a 10-year rotation independent of MUB’s pipeline plans (or my students’ work), the DEP initiated follow-up soil testing at White Park and created a 1’ contour map and digital elevation model to assess surface water movement. After I attended a preliminary stakeholder meeting with MUB in April 2019, the DEP invited me to join their site visit with the City Engineer, US Environmental
Protection Agency (EPA), and Triad Engineering in May 2019; until then, all had been unaware of the “hardpan” subsurface layer located by students. The EPA representative speculated that it could be evidence of past remediation, poured concrete, or simply bedrock, as the massive above-ground storage tanks would have required some foundation; further investigation by Triad is underway. The student-driven trail map also helped the non-local agency representatives navigate White Park to devise their 2019 soil sampling program. Navigation evidently was a problem during previous inspections; in 2009, Triad found 21 out of 76 estimated tank wells but marked 8 as having “no evidence remaining” (2009: 18) that my students, on the other hand, found conspicuous.

4.3 Historically Significant ‘Witness’ Trees

The draft trail map was crucial to locating White Park’s witness trees as well. ‘Witness tree’ has two meanings: trees old enough to have witnessed the Civil War, or trees used as survey markers to witness property lines. The oldest trees students found at White Park could have witnessed not only to the Civil War but also the Revolutionary War and Morgantown’s early settlement. In West Virginia, old growth trees tend to be located along property lines because it is customary to leave trees unlogged near boundaries, to avoid enmity with neighbors and mark property lines in remote locations (personal communications with two West Virginian students, 2015-2016).

Witness trees offer insights into the local ecology at the time of settlement. Settlers arrived en masse in Monongalia County only after the 1770s; before then, Native Americans in the region applied fire to hunting grounds to maintain open landscapes and attract game with rich new plant growth (Cronon & Demos, 2003). The generally open-grown form of the witness trees at White Park (Figure 5, at right) suggests they developed their branches in an environment more like an oak savannah than a closed canopy forest, where competition for light requires young trees to grow straight trunks with minimal lateral branching. Archival photographs (1895-1920s) confirm that much of White Park was used as pasture before the oil tank field’s development, preserving an open oak savannah similar to what would have been promoted by regular burning. In fact, three of the witness trees students found were photographed as well-established in 1895-1926. Today, White Park’s older trees are conspicuous, surrounded mostly by young pioneer species (maple, black cherry, tulip tree) that thrive under conditions of disturbance.

Of 61 witness trees we located in the field, 29.5% were white oaks (Table 1), consistent with historic survey records, which indicate that white oaks comprised 32.7% of the pre-settlement canopy in Ridge & Valley ecosystems in West Virginia (Abrams & McCay, 1995: 222). I validated the method we used for approximating tree age by counting tree rings for two recently fallen trees on site (one white oak, one black oak); the growth factor multiplied by diameter in inches did reasonably estimate the tree’s age.

<table>
<thead>
<tr>
<th>Count</th>
<th>%</th>
<th>Species and common name</th>
<th>trees date to:</th>
<th>growth factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4.9%</td>
<td>Acer rubrum, red maple</td>
<td>1884-1898</td>
<td>x 4.5</td>
</tr>
<tr>
<td>7</td>
<td>11.5%</td>
<td>Acer saccharum, sugar maple</td>
<td>1788-1876</td>
<td>x 5.5</td>
</tr>
<tr>
<td>1</td>
<td>1.6%</td>
<td>Fagus grandifolia, American beech</td>
<td>1878</td>
<td>x 6.0</td>
</tr>
<tr>
<td>3</td>
<td>4.9%</td>
<td>Liriodendron tulipifera, tulip tree</td>
<td>1883-1917</td>
<td>x 3.0</td>
</tr>
<tr>
<td>3</td>
<td>4.9%</td>
<td>Platanus occidentalis, sycamore</td>
<td>1811-1887</td>
<td>x 4.0</td>
</tr>
<tr>
<td>2</td>
<td>3.3%</td>
<td>Prunus serotina, black cherry</td>
<td>1853-1894</td>
<td>x 5.0</td>
</tr>
<tr>
<td>18</td>
<td>29.5%</td>
<td>Quercus alba, white oak</td>
<td>1740-1876</td>
<td>x 5.0</td>
</tr>
<tr>
<td>3</td>
<td>4.9%</td>
<td>Quercus coccinea, scarlet oak</td>
<td>1863-1887</td>
<td>x 4.0</td>
</tr>
<tr>
<td>7</td>
<td>11.5%</td>
<td>Quercus rubra, red oak</td>
<td>1857-1893</td>
<td>x 4.5</td>
</tr>
<tr>
<td>14</td>
<td>23.0%</td>
<td>Quercus velutina, black oak</td>
<td>1827-1899</td>
<td>x 4.0</td>
</tr>
</tbody>
</table>

While confirming students’ tree identifications in January 2019, I found distinctive scars in the bark of witness trees at White Park echoing ‘tomahawk rights’, a regional tradition dating to early settlement. In 1777, West Virginia was still part of Virginia. The General Assembly of the Commonwealth of Virginia
allocated 400 acres to each homesteader settling on “western waters” (including streams and rivers of Morgantown’s Monongalia County) by June 24, 1778 (Core 1974: 156). Settlers established their right to land by living there for a year or raising a crop (‘corn rights’), often claiming property by blazing trees (‘tomahawk rights’) to remove patches of bark (Core 1974: 156). According to Monongalia County deed record descriptions, “Tomahawk rights grew from four in 1768 to over 1,200 in 1776” (Rice, 1970: 66).

Most of the blazed trees at White Park date from the 1850s-1860s. Five blazed trees at White Park show bark scars in two patterns: an “L” shape on four trees northwest of Woodland Trail along the reservoir; and a “U” or “O” shape on one white oak across the trail nearby. These trees make up part of an allée of old oaks flanking the main trail. Their trunks lean slightly and branches stretch widely over the trail, suggesting there was a canopy gap over the trail when the trees were developing their basic structure: thus, Woodland Trail may be as old as the 1850s.

In July 2019, I found two more blazed trees in a pocket of old growth forest along Big Tree Trail, near Mississippi Street. This trail is near the property line of White Park’s first settler, Jonathan Cobun (or Coburn), one of the region’s earliest traders, who was active in the upper Monongahela River valley as early as the late 1730s (Lough, 1969: 91). By 1770, Jonathan Cobun settled 400 acres including part of White Park; he owned 1,028 acres, including Dorsey’s Knob Park, by 1790 (Monongalia County Commissioners, 1790), and founded Fort Cobun, near Dorsey cemetery (Figure 3, star). One black oak on Cobun’s former property line shows 4 blazes making up half an “O” or a backwards “C”; another has four blazes forming “T”. These trees only date to 1875 or 1904. However, one white oak along Cobun’s line measures 49” in diameter, and likely dates to around 1774 – a contemporary of Cobun and possible witness of his property line. This tree is marked with a single large blaze (and modern graffiti: “J” and “N”).

Figure 3. Relationship of trees and berms to Cobuns’ 1770-1790 property lines. I shifted boundaries 30 ft northwest from McBride et. al (2003: 13); they suggested lines could shift slightly NW or SW. Based on: 1976 USGS map; Lathrop, Penny & Proctor, 1886. Diagram, photo by author.

The blazed trees at White Park are culturally significant and warrant further comparison with deed records and historic property boundary descriptions. To gain a better understanding of survey bearings
and site dimensioning in the author’s site engineering course, students drafted property boundaries from deed descriptions at White Park in a class exercise. Eureka purchased the area in 1897; it seems unlikely that Eureka or subsequent owners (i.e., the City of Morgantown, Morgantown Utility) would blaze trees with tomahawks to mark internal parcel boundaries within a larger city property (purchased in 1947-1979).

One witness tree growing at White Park (Figure 5, far left) is so large that its open-grown form is clearly visible in winter months from the overlook across the Cobun Creek Reservoir, about 400 feet away. It is the 22nd largest white oak in the state (per B. Hannah, state forester, Big Tree Inspection Program, personal communication), and dates to around 1740. Among the witness trees we located, this tree and another white oak (#18) are of particular interest (Figure 5) because they grow directly on tank well berms; their large trunks imply they predate the Eureka Pipeline Company by at least 90 years. This raised the question, Could White Park’s grid of circular berms predate the site’s use as an oil tank field? Archival photographs (WV Regional History Center) show considerable vegetation (including trees and shrubs) established on the tank well berms in 1897, even though the tank field was newly built at the time.

While exploring the park south of the reservoir, where there are few witness trees, students noticed that partridgeberry (Mitchella repens) was growing on some of the berms. This groundcover we otherwise observed growing only in undisturbed forests on plant identification walks during 2014-2018. Partridgeberry seems unlikely to grow in an area disturbed by extensive oil company earthwork a hundred or so years ago. This area warrants further investigation, especially as Jonathan Cobun’s 1770 property line appears to angle to a point equidistant from three tank well berms at the center of the small peninsula south of the reservoir, and these berms are less circular than the others (Figure 3).

4.4 Cultural History

An interpretive sign (removed for unknown reasons between 2017-2018) informed visitors to White Park of the presence of Hopewell and Adena cultures in the area, of nearby archaeological sites (Grave Creek Mound and Picture Rock petroglyphs), of early settlers of the property, and of Eureka Pipeline Company’s use of the site as an oil tank field – while omitting to mention the circular berms throughout White Park (or their origin). The sign concluded, “The land has stories to tell; we just have to ask.” Along with gravel for primary trails, this sign was funded by a Recreational Trails Grant around 1998 (personal communication, Mon Valley Green Space Coalition members). After reading this sign, students said they were confused about the berm’s origins and cultural significance; it seemed to imply some of the berms could be Native American mounds predating the oil tanks. If so, did the pipeline company repurpose important relics of Adena, Hopewell, Fort Ancient, or Monongahela cultures?

Native American cultures present in West Virginia along the Ohio River and its tributaries included the Adena (Early Woodland Period, first millennium BC), the Hopewell (Late Woodland period, early first millennium AD), and the Fort Ancient (Late Woodland Period, second millennium AD), according to Milner (2004: 9, 54-55). The Monongahela settled the Monongahela River valley contemporaneously with the Fort Ancient, living in “circular houses” within “small, circular stockade villages” until 1690 (Maslowski, 2017). Regional historians recorded the 1700s presence of Delaware, Mingo, Shawnee and Iroquois (Wiley 1883: 24; Withers, 1831; Lewis,1889), with permanent settlements near Pittsburgh and seasonal settlements “at the mouth of nearly every creek along the Monongahela River” (Wiley 1883: 21, 24).

One such settlement was located near present-day White Park “at the mouth of Cobun’s Creek” and “judging from its ruins as described by early settlers…. must have been of considerable size” (Wiley 1883: 24, 648). Wiley mentions piles of mussel shells at this settlement. The first investigators of the Fort Ancient Buffalo Site (46 Pu 31) in Putnam County, West Virginia similarly noted, “The field is covered with fragments of mussel shells” (Martin, 1936); 1,031 burials were excavated from the Buffalo Site by 1965 (Department of the Interior, 2018). Mussels were a mainstay of the local Native American diet. They are now rare because of ecological change in freshwater rivers; some mussel species are endangered or extinct. Given the evidence of mussel shells which elsewhere accompanied major settlements and Wiley’s 1883 description of an extensive settlement, the floodplain bench near Cobun Creek bridge could house considerable cultural artifacts. This floodplain bench today houses MUB’s treatment facility and is the terminus of the new raw water pipeline originally planned through White Park along Woodland Trail’s cluster of witness trees, next to the reservoir. The Morgantown Utility Board’s website lists a frequently asked question (2019) that appears to highlight these potential concerns:

“Was MUB aware of… the fact that White Park may contain Native American artifacts?

…MUB applied for and received permits for its originally planned work from the State Historic
Preservation Office (SHPO) of the West Virginia Division of Culture and History. This permit requires that MUB cease work if any historic artifact is found during the construction process.”

Figure 4. Circular berms a) at Kanawha River in Dunbar, West Virginia (Powell 1894: 414, 424), public domain; b) at Holston River, Sullivan County, Tennessee (Thomas, 1887: 76), public domain; c) at White Park’s, by students I. Molgaard, A. McKenzie, Z. Grossl and L. Chacalos.

Several similarities between earthworks identified in other archaeological surveys of Native American sites and White Park’s berms are worth noting. In Monongalia County, prehistoric cultures left hill-shaped mounds as well as enclosures consisting of “embankments, circumvallations, or walls, and all symmetrical in form. The defensive enclosures were always situated on well-chosen hills... the sacred enclosures are always found on level river bottoms; seldom upon table lands” (Wiley 1883: 18-19). White Park’s circular berms vary in diameter (130-315 ft, as measured on topographic map, and are usually about 4 feet tall) and are sometimes bound by concentric outer rings or include straight sections or isolated small dome-shaped mounds (Figure 3). Concentric circular enclosure mounds (Figure 4) similar to those at White Park were excavated in Kanawha County, West Virginia (Powell 1894: 414, 424). The excavations revealed a “hard central core of brick-red clay” (Powell 1894: 424). Trail erosion and downcutting at White Park along the Blue Loop revealed red clay in one of the larger berms (Figure 2, *).

People of the Hopewell culture built grids of circular mounds along Ohio’s Scioto River (Squier & Davis, 1848), and “widely spaced circular structures” often characterized the even earlier Adena settlements (Clay 2009: 49). In Ohio, concentric ring mounds 1140-ft in diameter and 4-ft tall were demolished from 1837-1856 to form a rectangular street grid in “the squaring of Circleville” (Reps 1965: 485). In Columbus, Ohio, a 1953 housing development demolished two circular mounds and their 400-ft diameter enclosure (Baby & Goslin, 1953; Cramer, 2008). Underappreciation of the cultural significance of mounds was similarly reported among Monongalia County’s early settlers, who “were not interested much in antiquities, and would not stop long to examine any trace of camp, grave or fort” (Wiley 1883: 21). Involving students in the fieldwork for White Park presented opportunities for them to discuss shifting attitudes towards preserving and interpreting cultural heritage.

Another clue that White Park may be a culturally significant Native American site was uncovered by our discovery of a stone wall within one berm and piles of loose stones nearby. Near the dam in White Park, students found a stone wall exposed within a distinctive corner of one berm (also taller than the others, at about 9 feet, Figure 3). At White Park, I found two low piles of loose stones: one just outside the stone wall berm and another at a property corner of the park, behind Greenbag Road. If Eureka Pipeline Company constructed this berm, neither its location – perched at the very edge of a steep slope - - nor its interior stone wall -- make sense. As the student who found this area said, “Why build a retaining wall at all?”
Well into the late 18th century, “stone-pile graves” were common, especially along Cheat River in Preston County, at the headwaters of Dunkard Creek, and near Point Marion, Pennsylvania. These barrows became scarce as their stones were “hauled away” for re-use in the 19th century (Wiley 1883: 27). Near White Park, a 1931 West Virginia and Regional History Center archives photo (#016874) of jumbled stones just east of Dorsey’s Knob is captioned: “The Indian graves were opened by the late [local historian] Hu Maxwell, in which were found a few bows.” Stone pile graves can still be found in Morgantown today: when we found a stone pile on another site, a contractor told me they are locally known as “Ezekiel stones,” and should not be disturbed, as they are places where people have “laid their burdens down” (personal communication, R. Lyttle, fall 2018).

Excavation along the Holston River in Sullivan County, Tennessee (Figure 4) of a 5-ft tall circular mound revealed that it contained 12 stone-pile Native American burials encircled by a stone wall (Thomas, 1887: 76). In an early regional account, Thomas Jefferson (1787: 103) noted numerous “barrows…of different sizes, some of them constructed of earth, and some of loose stones. That they were repositories of the dead, has been obvious to all: but on what particular occasion constructed, was matter of doubt.”

Early archaeologists attempted to determine the age of mounds from trees growing on them, measuring trunk diameters or counting tree rings (Thomas 1887: 108). Measuring the circumference of the oldest trees at White Park brings that tradition full circle. Confirming students’ tree identifications in January 2019, my son and I made a discovery. The two oaks growing directly on berms are missing their trunk base flare, compared to other comparably sized oaks on site. Furthermore, we found two oaks with partially buried trunk flares (Figure 5), suggesting the Eureka Pipeline Company buried the bases of existing trees during construction of the berms at the oil tank field. How far the trunk flares are buried, is sometimes difficult to tell. The buried trunk flares suggest the trees were growing before the berms were constructed and survived being partly buried, even though white oaks generally do not tolerate cut and fill.

Table 2. Selection of archaeological surveys conducted near Morgantown, compiled by the author from Big Blue Archaeological Research Inc., 2003: 19-20; Green County, 2011; Preservation Alliance of West Virginia, 2005.

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Dates to</th>
</tr>
</thead>
<tbody>
<tr>
<td>46 Mg 2</td>
<td>Floodplain camp (?), near Dorsey’s Knob, mouth of creek</td>
<td>unknown prehistoric</td>
</tr>
<tr>
<td>46 Mg 3</td>
<td>Picture Rocks petroglyphs, Hamilton Farm</td>
<td>unknown prehistoric</td>
</tr>
<tr>
<td>46 Mg 5</td>
<td>Rock shelter on a hillside, overlooking creek/river confluence</td>
<td>prehistoric</td>
</tr>
<tr>
<td>46 Mg 12</td>
<td>Fort Hill, Monongahela village at Suncrest Towne Center</td>
<td>17th century CE</td>
</tr>
<tr>
<td>46 Mg 15</td>
<td>Village, Pyle Farm (Osage USGS quadrangle)</td>
<td>late prehistoric</td>
</tr>
<tr>
<td>46 Mg 16</td>
<td>Village on hillside terrace, tributary of Mon River</td>
<td>late prehistoric</td>
</tr>
<tr>
<td>46 Mg 17</td>
<td>Village, south of Dorseys’s knob, terrace overlooking Mon River</td>
<td>late prehistoric</td>
</tr>
<tr>
<td>46 Mg 18</td>
<td>Stone burial mound at LaPoe (Osage USGS quadrangle)</td>
<td>pre-historic?</td>
</tr>
<tr>
<td>Survey Number</td>
<td>Site Description</td>
<td>Period</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>46 Mg 20</td>
<td>LaPoe Monongahela village site (Osage USGS quadrangle)</td>
<td>pre-historic</td>
</tr>
<tr>
<td>46 Mg 21</td>
<td>LaPoe, circular village site in Monongalia County</td>
<td>16th-17th century CE</td>
</tr>
<tr>
<td>46 Mg 22</td>
<td>Baker village site, ridge top/hilltop west of Decker’s Creek</td>
<td>late prehistoric</td>
</tr>
<tr>
<td>46 Mg 23</td>
<td>Worley/South Hills camp, hillside bench, Aaron’s Creek</td>
<td>10th century CE</td>
</tr>
<tr>
<td>46 Mg 28</td>
<td>Hillside bench camp (?), between Aaron’s Creek &amp; Cobun Creek</td>
<td>late prehistoric</td>
</tr>
<tr>
<td>46 Mg 29</td>
<td>Myer’s camp, ridge top and hillsides overlooking Cobun’s Creek</td>
<td>unknown prehistoric</td>
</tr>
<tr>
<td>46 Mg 51</td>
<td>Stone mound, on high knoll (ridge top)</td>
<td>unknown prehistoric</td>
</tr>
<tr>
<td>46 Mg 52</td>
<td>Stone mounds, on a hillside bench (or high knoll)</td>
<td>late archaic / late prehistoric</td>
</tr>
<tr>
<td>46 Mg 66</td>
<td>Camp, ridgetop and hillside</td>
<td>late archaic / late prehistoric</td>
</tr>
<tr>
<td>46 Mg 190</td>
<td>Hillside bench</td>
<td>c.1851-1900</td>
</tr>
</tbody>
</table>

The survey located nearest to White Park was 46 Mg 2 (personal communication, curator for Grave Creek, 2019). I speculate that 46 Mg 2 could be located on the floodplain bench at Cobun Creek bridge, bordering White Park. While 46 Mg 2 does not include Cobun’s Creek in its description, no other creek is near Dorsey’s Knob. The identifier (second survey in the county) corresponds with the settlement described by Wiley at the mouth of Cobun Creek (1883: 24); furthermore, an archaeological site described as “m2… Indian hunting camp… close to Cobun Creek Bridge” is mentioned in a summary of key cultural assets of Morgantown (Schmoyer, c. 1970: 66). Cobun Creek Bridge is on White Park’s boundary.

A State Historic Preservation Office archeologist, perhaps misled by the lack of the Cobun name in the description for 46 Mg 2, said that no archaeological surveys were conducted along Cobun Creek, except one preceding recent construction of the new reservoir many miles upstream (personal communication, January 2019). This appears to conflict, however, with the descriptions of 46 Mg 2, Schmoyer’s account of “m2”, Hu Maxwell’s (possibly undocumented) excavation of graves nearby at Dorsey’s Knob, and an account of Reverend Stacy Groscup who, during construction adjacent to White Park along Greenbag Road “observed a Native American occupation at the Kennedy Center site, including fire pits and burials” (McBride, McBride & Rasmussen 2003: 19). Further assessment of the state’s archived archaeological reports is needed, to determine if there have been prior archaeological surveys at White Park, besides McBride, McBride & Rasmussen’s unfruitful search for Fort Cobun in 2003. This calls attention to the need for first-hand archival research, and presents an opportunity for discussion with students, who are often accustomed to retrieving information digitally.

### 4.6 Public Interpretation

Besides the topics outlined above, one of the gaps in public interpretation at White Park is when exactly the park was founded, and for whom it was named. A 1929 archives photo caption of children at a creek describes their setting as “Traction Park at Cobun Creek…. at the end of the trolley line in South Morgantown” (Raese & Raese, 2001). A 1938 map confirmed Traction Park’s location at present-day White Park (Recreation Council of Monongalia County, 1938) implying unofficial recreation on Eureka Pipeline Company property preceded First Ward Park/White Park’s official establishment.

Once West Virginia’s oil boom dwindled, the City of Morgantown acquired portions of White Park property in 1947 and 1973 from Eureka Pipeline Company (Anderson, 1988: 6; deed records). The 1947 purchase of 17 acres (6.9 hectares) for $1,800 created what was then known as First Ward Park (Anderson, 1988: 6), named for the surrounding neighborhood. First Ward Park was established before the adoption of the National Historic Act of 1966; thus, early park improvements would not have been restricted by those guidelines. In 1984, Morgantown’s Board of Park and Recreation (BOPARC) commissioned a $30,000 “comprehensive master plan for future development of White, Marilla, and Krepp’s Parks” (Anderson 1988: 13), indicating First Ward Park was renamed White Park by then. The 1985 bicentennial of Morgantown also coincides with the probable time period when the park was renamed, sometime before 1984-1988.

Research has not yet uncovered a definitive answer on whom White Park is named for. It seems most likely that White Park was named after I. C. White (1848-1927), West Virginia’s first state geologist and WVU professor, who refined applications of anticlinal theory for oil drilling, making the oil and gas industries much more profitable after 1898 (Allen & Matchen, 2017; Armstrong, 2015). Furthermore, I. C. White influenced Eureka Pipeline Company’s profits and made important contributions to Morgantown’s early parks. Morgantown’s first park, Whitemoore Park, was founded by I. C. White in 1823. White
married Mary Moorehead; their company, the Peninsula Company, also sold 45 acres to the City to create Marilla Park. However, White Park might be named instead for either of two other prominent local figures: Frances J. White, the 1930s Director of the Monongalia County Recreation Council (Anderson, 1988: 3) or Captain William White, a prominent and controversial character in Monongalia County's settlement history. BOPARC has not yet been able to locate the 1984 parks plan (personal communication with BOPARC director, January 2019), which might clarify the origin of White Park's name.

The complex nature of White Park's history warrants additional research and interpretation for park visitors. As one student observed: "I played hockey at White Park for more than two years and never knew the history of the site at all… It is an interesting hidden gem in town I feel is underappreciated."

4.5 Learning Outcomes

Asked to reflect on their learning experience working at White Park in fall of 2018, landscape architecture students highlighted developing skills in site analysis and brownfield remediation, an important need in West Virginia. One student commented, White Park is a "a prime example" of the type of "projects we will need to remediate…. it gave us a good idea of what to expect." Another stated: "This project was my first look into working on a 'brownfield' type of site. I learned a lot about site analysis." Building students' analytic skills is important because "The issues confronting practitioners—climate change, global urbanization, economic inequality—are unprecedented. … Landscape architects engaged in the field of cultural landscapes today are building a critical and necessary dimension of continued and innovative success in design practice" (Goetcheus, Karson & Carr, 2016: vi).

Short, team-based design exercises (charrettes) challenged students to address possibly oil-contaminated soils at White Park without excavating the culturally significant site. Many designs relied on shade-tolerant wetland plant species to break down oil over time. Some designs included clay caps to keep surface water from percolating contaminants into the groundwater and Cobun Creek Reservoir. A few designs incorporated boardwalks with proposed interpretive signs. Students will work in future classes to propose a streamlined trail network, highlighting White Park's points of interest, protecting sensitive areas, and minimizing conflicts between walkers and cyclists. As White Park's witness trees approach their second and third centuries of maturity, measures are needed to protect them from soil compaction and disturbance, and secondary trails should avoid low-lying areas within the park as possible areas of soil contamination.

5 CONCLUSION

While local historians are consistent in portraying White Park as a retired oil tank field, landscape architecture students at West Virginia University have learned that the site's history is certainly more complicated than that. "Traces of early settlements, the remains of industrial activities, and geological formations become allusions to the unique history of each landscape" (Wolz 2016: 237).

A line of witness trees along Big Trees Trail marks Jonathan Cobun's property line from 1770. Eureka Pipeline Company built berms in White Park to surround oil tanks and contain oil spills and lightning strike fires. Whether Eureka selected the White Park site because any berms were already present remains uncertain. There were native American graves and settlements nearby. Even if the berms are a relic only of industry rather than of prehistory, they still have cultural significance worthy of interpretation and preservation: they are unique landforms more than a century old. Some of the witness trees show scars from 'tomahawk rights' – possibly warranting historic protection. The BOPARC director is excited about the learning opportunities this research presents for children in summer camps as well as for university students. Students found navigating the White Park site challenging but conducive to building analytic skills. Future park planning should include deciphering the park’s many layers of history.

Site analyses by students and a study of the area's cultural history suggest that it deserves to be reinterpreted in ways that enhance mountain biking trails but preserve centuries-old trees; reduce contamination but promote ecological health through biodiversity of plant species; and introduce visitors to the history of Native Americans and early settlers in the area. In terms of next steps, students will engage with the Morgantown’s Board of Park and Recreation of Morgantown (BOPARC) and White Park’s volunteer trail crews to help plan how to streamline and reconfigure trails to improve navigability and minimize potential conflicts between mountain bikers and hikers.

Morgantown Utility Board’s original planned route for the raw water pipeline through White Park would have removed or impacted 17 of the 100+ year old trees we located. In spring 2019, MUB marked
trees for removal, including trees perched above the steep slope to the reservoir; the utility was within a few weeks of bringing in the contractor for logging along the main trail of the park when concerns were voiced by area residents and stakeholders. The process of community-driven design that ensued is a topic beyond the scope of this paper, but site analysis diagrams summarizing student data and refining their work at White Park empowered stakeholders to advocate successfully for MUB to halt construction, abandon the original pipeline route, and host public meetings for feedback on alternate pipeline routes. DEP initiated boring soil samples in formerly “no evidence remaining” tank wells located by students; MUB contracted additional 10-foot deep soil boring tests along possible pipeline alternative routes; the City Arborist worked to GPS locations of witness trees that students identified. Students’ incremental data collection and charette exercises thus benefited the community by gathering site analysis information that would have been impossible to collect on short notice. Their landscape triage approach to site analysis led to the preservation of irreplaceable public assets (the witness trees) and supported professionals’ site analysis work for a culturally and ecologically sensitive public site.

6 REFERENCES
34. Morgantown History Museum. (2012). Eureka Pipeline Company. Exhibit, archived at the local history facility, the Aull Center, Morgantown, WV.
43. Schmoyer, J. (c. 1970). The historical, cultural, and archaeological resources of Monongalia County. Report funded by the Monongalia County Courts.
ENGAGED LEARNING IN THE LANDSCAPE: CAMPUS AS LIVING LAB

NELSON, HOLLY GRACE
Rutgers University, holly.nelson@rutgers.edu

KAUNZINGER, CHRISTINA
Rutgers University, christina.kaunzinger@rutgers.edu

HARTMAN, JEANMARIE
Rutgers University, jhartman@sebs.rutgers.edu

GANO, EDWIN
MKW Landscape Architects, egano@mkwla.com

STRUWE, LENA
Rutgers University, lena.struwe@rutgers.edu

LAWSON, LAURA
Rutgers University, ljlawson@sebs.rutgers.edu

1 ABSTRACT
This paper is a case study of the Rutgers University’s Living Lab Initiative, which grew out of grassroots student, faculty, and staff effort and is evolving into a vital component of a university-wide endeavor to amplify hands-on research and education through a network of campus resources and experiences in gardens, forests, and biodiversity collections. Our goal is to enhance and innovate college education, promote lifelong learning, and enrich human lives as we improve campus sustainability and promote conservation of global natural resources. Through these experiential learning opportunities, students also develop skills in interdisciplinary teamwork and joint problem solving, integration and synthesis of data across specialties, and build confidence in communication, both verbal and written. To date, our Living Labs include a pollinator meadow and garden complex associated with the newly built New Jersey Institute of Food, Nutrition and Health and restoration of an historic arbor trail. Challenges inhibiting our success include an understaffed grounds crew, conflicting definitions of landscape stewardship, and lack of understanding about natural ecological dynamics. As we move forward, we realize the significance of these student-designed landscapes in activating conversations about engaged learning and sustainability on campus.

1.1 Keywords
Living labs, campus as lab, design build, engaged scholarship, experiential learning, interdisciplinary curriculum
2 INTRODUCTION

“All education is experimental, whether we call it that or not.”

(John Dewey at a conference at Rollins College, 1931, as qtd. by Reynolds, 1997)

Stepping onto a university campus, an individual can often feel the tangible character of the landscape as a place of learning. Within the composition of grounds and buildings, the university fulfills a significant part of its mission by being a place where students, staff and faculty move, interact, think, reflect, and connect ideas to practice. In a very literal sense, land grant universities have historically used the campus landscape as classroom, farm, and laboratory for teaching, research and outreach on agricultural and horticultural topics. More recently, university missions to address pressing environmental and social needs have led to significant examples of energy efficient buildings and green infrastructure on campuses. These efforts have the potential to not only serve as exemplars of new technologies but also to become critical actors in student learning, curricula development, research, and public outreach. We want to use our land, our students, our curricula, our faculty expertise and our Facilities staff – to catalyze transformation of our campus landscape.

This paper provides a case study of one such evolving effort, the Living Lab Initiative within the School of Environmental and Biological Sciences at Rutgers, The State University of New Jersey. This program was initiated by students and faculty in the Department of Landscape Architecture through independent student projects and courses. Students designed and installed discrete ‘experiments’: habitat, food production, composting, and restoration of historical landscapes into the campus open space. As the program and individual projects have grown, new collaborations have developed. In addition to being outdoor classrooms, these new landscapes function as sites for research, or for recreation by the campus population and our neighbors. These places serve as demonstrations of how we could more wisely shape our landscape. While there are sustainable landscapes at other universities, they are typically not designed, installed, maintained, monitored and communicated by students. We hope that this case study can provide a blueprint for others.

3 CONTEXTUALIZING LIVING LABS

Although there are many definitions of engaged scholarship, our use of the term sits at the intersection of traditional outreach scholarship and publically engaged scholarship. As described by Doberneck, Glass and Schwietzer in their 2010 essay, “From Rhetoric to Reality: A Typology of Publically Engaged Scholarship,” engaged scholarship should express the three central missions of land-grant universities (instruction, research, and service) should be informed by and generate scholarship, and should serve a public good to society (Doberneck et. al., 2010).

At the heart of the Living Lab initiative is experiential learning. Supporting experiential learning through campus experience is not a new idea. John Dewey’s 1938 essay, Experience and Education is foundational in discussions of experiential learning, making the case of the school as microcosm for larger society. In his work to transform Oberlin College and town into a sustainable community, David Orr directly cites John Dewey’s influence, stating:

Dewey proposed that we “make each of our schools an embryonic community… with types of occupations that reflect the life of the larger society”(…)The school, its relations with the larger community and all of its internal functions, Dewey proposed to remake into curriculum (Orr, 2013).

Oberlin exemplifies the campus as classroom model, where students become aware of their environmental impact and also discover that their individual impact upon creating environmental change can be powerful (Orr, 2011).

Many campuses have sought to teach sustainability through campus as classroom models. Bardaglio and Putnam’s 2009 book, Boldly Sustainable: Hope and Opportunity for Higher Education in the Age of Climate Change, provides case studies of seven universities, large and small, who have dedicated their campuses broadly to sustainable goals: Northern Arizona University, Emory University, Arizona State University, Berea College, Green Mountain College (now closed), College of the Atlantic, and Ithaca College. Bardaglio’s vision of a sustainable campus runs parallel to Orr’s:
Today’s students “must be able to ask the important questions, grasp the big picture, and commit to an ethos of stewardship (“how to live”) at the same time that they acquire the necessary knowledge, skills, and professional training to make a real difference in the world (“how to make a living”) (Bardaglio and Putnam, 2009).

Our concept of living laboratories builds on experiential learning and comprises various definitions, ranging from a research concept to a place in which to learn and experiment. Of particular interest to Landscape Architecture are notions of using the landscape as the ‘living’ component of living labs (both in terms of being composed of living materials and in terms of the landscape’s mutability) and how these laboratories relate to community in terms of research and innovation (such as participatory design or co-creation—sometimes including user communities as a source of creation).

A living lab is not a test bed as its philosophy is to turn users, from being traditionally considered as observed subjects for testing products/services against requirements, into value creation in contributing to the co-creation and exploration of emerging ideas, breakthrough scenarios, innovative concepts and related artifacts. Hence, a living lab rather constitutes an experiential environment, which could be compared to the concept of experimental learning, where users are immersed in a creative social space for designing and experiencing their own future. (Schumacher, 2014)

We particularly like Schumacher’s comment that living labs could also form creative social spaces on campus for students to design and explore their future.

The Living Lab program evolving at Rutgers builds on the experiences of Living Labs at other institutions. One of the earliest examples of Living Labs developed at MIT as “a research concept defined as an open innovation ecosystem or environment centered on practices and uses in the field of Information and Communication Technology by the users themselves” (MIT Office of Sustainability). Key to the concept is user-centered design—the notion that the user provides feedback for technological innovation. Degrees of user involvement include becoming a co-creator, a tester and a judge. Major product development activities include: Co-creation; Exploration; Experimentation; Evaluation. These Living Lab principles are applied to innovative technological products, but MIT has since applied the notion of a Living Lab to sustainability with the idea of using the campus as a testbed and incubator for sustainability with various scales of impact—campus, city, and globe (Ibid.). Another model is Alexander Felson’s Experimental Landscapes at the Urban Ecology and Design Laboratory (UEDLAB) at Yale, which provide a systematic framework to shape landscape through designed experiments formulated jointly by design practitioners and ecologists, part of a movement to reframe the relationship of science to practice (UEDLAB; Felson, 2015).

The recently-launched and growing Learning by Leading™ program at U.C. Davis, led by Kathleen Socolofsky and Carmia Feldman, provides us with a fascinating contemporaneous example of place-based, experiential learning at a land-grant university (U.C. Davis Arboretum and Public Garden a). This program consolidates three of U.C. Davis’ land-based operational units - the Arboretum, Grounds and Landscape Services, and Putah Creek Riparian Reserve – to form the UC Davis Arboretum and Public Garden which spans the entire university. Stewardship of these resources is woven into the curriculum and the community in these ways: its resources encourage students and community to become environmental leaders, learn about climate change, and explore and embrace regionally appropriate landscapes. Considered both an outdoor museum and a living laboratory, the Learning by Leading™ program combines horticultural knowledge with sustainable maintenance practices. Public engagement is integrated throughout the program. Student internships teach horticultural best practices and provide community outreach opportunities as well as leadership skills. As stated in their promotional materials, the program seeks to not only serve students and community members with resources and experience necessary to address critical environmental concerns but also to be a world-leading program that engages research, teaching, and public engagement. (U.C. Davis Arboretum and Public Garden b.; Socolofsky, Seger, Burke & Feldman, 2018).

4 INSTITUTIONALIZING LIVING LABS AT RUTGERS

Rutgers Living Labs have evolved through a convergence of efforts, both grassroots and top-down. Particularly on the George H. Cook Campus, the original agricultural college, there was a legacy of faculty using the campus for teaching. The campus animal facilities served animal science students, biology
students collected water samples in the campus pond, and entomology students collected insect species for biodiversity studies. Like many landscape architecture programs, Rutgers Department of Landscape Architecture has a history of using the campus as a site for studio projects. As the curriculum evolved to encourage more design-build efforts, faculty looked to campus opportunities and began to engage students in addressing some neglected parts of the campus landscape. While teaching about design, faculty also reached into disciplines across campus, engaging students in developing pollinator habitats, encouraging use of native plants, culinary and community gardens, and showcasing the university’s plant breeding programs.

There has also been an increased demand by students to engage in environmental activism. A series of Honors theses have addressed campus sustainability, demonstrating student involvement and concern for the future of our campus. Topics include stormwater management, inclusive social spaces, non-vehicular circulation, an ecological rehabilitation of the Rutgers Golf Course, and the redesign of the historic arbor trail. Recently (2018-19), students have actively campaigned for an Office of Sustainability at the university level.

Rutgers University began a strategic planning process that supports a more student-centric focus on learning and experience, as well as environmental sustainability. One of the five university masterplan themes, ‘Creating a Sustainable World Through Innovation, Engineering and Technology’, enjoins the university to “create living laboratories for sustainability by performing discovery and applied research, and by implementing models”, to foster collaboration and innovation and “to support hands-on learning, student-faculty interactions, experiential learning in the field, lab, or archives” (Rutgers University Physical Master Plan, 2015). We see living laboratories as important examples of landscape infrastructure that foster collaboration and innovation. Throughout our case studies, we describe how we achieve these goals within the phases of design, implementation and management of the living laboratories. The Living Lab Initiative also supports goals such as the development of interdisciplinary learning environments, infrastructure that impacts quality of life, and the promotion of environments that engage students in scholarship and intellectual achievement outside the classroom. Although the university’s strategic plan frequently calls upon technology to serve the vision, our work expands the vision to include the campus landscape.

5 THE ROLE OF LANDSCAPE ARCHITECTURE

Our Living Labs Initiative grew out of grassroots efforts: faculty-led projects, student Honors theses, the designed landscape for a new campus building, and Planting Design class. We discovered that Planting Design class was a very productive means for creating living laboratories. Planting Design is co-taught by a landscape architect and an ecologist who initiated a planting practicum to take planting design ‘off the boards’ and into the ground. This idea was partially inspired by students’ responsiveness to various HGTV™ shows that took design through to completion, as well as the realization that a large class could potentially create fairly instant, large gardens as part of its pedagogy: twenty-eight students, working collaboratively, can install their own planting design in a few class periods if managed efficiently. Students were the designers and ‘producers’ of the gardens.

Although we did not initially imagine transforming the campus landscape through the curriculum, the idea of tying together curriculum, experiential learning, and creating sustainable campus landscapes became the ultimate goal. Currently, many of the living lab gardens cluster around a recently completed building, the Institute of Food, Nutrition and Health (IFNH), although our campus living laboratories also include campus community gardens, an historical arbor trail, rain gardens, and a conservation garden (Figure 1). Following, a description of four living lab installations explains how each garden weaves together curriculum, place, and additional practices. Among the four examples, we have mainly focused on the Meadow Project because it encapsulates the variety of challenges we have faced.
Amphitheater Garden: Creation of a Campus Social Space - Our first official living laboratory garden was designed in response to the Academic Dean’s request for a new campus social space in honor of Rutgers’ 250th anniversary. He did not imagine that the space would be designed, built, and promoted by a Planting Design class! A garden of primarily native grasses on a sloped lawn amphitheater transformed a seldom-used space into a backdrop for the new Harvest Café at IFNH and landscaped seating areas where students could eat outdoors. Locating the garden by a popular café created a new campus social hub.

As they installed the new garden, landscape architecture students realized that they would need to “give permission” to other students to occupy this mostly deserted place, so they created an opening party and programmed the space with a student jazz concert, an outdoor yoga class and food and smoothie samples from the café to bring students into the designed space (Rutgers Office of Communications a., 2016).

Culinary Garden - Further improvements to the IFNH landscape included replacing a poorly advertised and erratically maintained green roof garden with a kitchen garden to provide fresh herbs for the café. This garden was designed by a landscape architecture studio and installed by a freshman seminar. (Rutgers Office of Communications b). Stewardship is provided by the recently formed and funded Green Team, a small group of students who perform stewardship tasks such as weeding and watering the Living Labs under the direction of an ecologist and a landscape architect.

Pollinator Garden - Designed and installed by Planting Design students, the pollinator garden plots demonstrate how ecologically-informed plant selection can amplify the conservation benefits of designed landscapes. Students researched plant resources for at-risk specialist bees as well as generalist pollinators and created an experimental array to test whether their garden design could influence pollinator visitation. This garden is the location of a freshman seminar where students monitor the results (see Section 6.2).

Meadow and Meadow Border Garden: Biodiverse Front Yard - The meadow is the “front yard” of the newest building on campus, The New Jersey Institute of Food, Nutrition and Health (IFNH). IFNH is an interdisciplinary research hub with a mission of making NJ the “Healthy State”, a model for the nation. The building and landscape design bear witness to the connection between human and environmental health with energy efficiency, an aerobic digester for food waste, and a two-story green wall.
IFNH perches more than ten feet above street level on a constructed hill. The first roadblock to the meadow arose when Facilities staff said that maintaining the steep slopes would be difficult. They suggested replacing the slopes with a series of flatter lawn areas and 4-foot retaining walls. Facilities staff did not have meadow maintenance experience or protocol either. With a lean staff dedicated to caring for a large campus landscape, they could not accept maintenance responsibility for the new meadow.

Fortunately, others championed the meadow idea. The meadow species included native grasses and wildflowers, with non-native annuals providing seasonal color in the first years, and annual rye grass providing the cover crop for early weed suppression. One faculty member advised that the annual rye grass posed a dangerous fire hazard. The oil-rich seed heads had to be removed by order of the Fire Department, and a mowed lawn edge was widened to act as a firebreak. The lawn border had the benefit of also playing an aesthetic role, providing Nassauer’s orderly frame and cue to care (Nassauer, 1995).

Aesthetic acceptance of this new meadow landscape was not uniform within the Rutgers community. A planted meadow takes several years to mature. During the first two years, many people viewed the meadow landscape as “messy,” asking when it would be properly landscaped— “Did they run out of money?” A 6-foot tall wrought iron fence was installed to separate the sidewalk in front of IFNH from the meadow. No one can say exactly why this happened, but there was a fear that students might sled down through the meadow into the street (however, a shorter fence would provide sufficient safety). This did prevent students from sledding into the street, but also suggested that the meadow’s mowed edge was not completely successful in terms of creating Nassauer’s orderly frame. Perhaps the turf was too low to create a strong edge around the randomized forbs and grasses. Both turf and fence created a ‘moat’, an undifferentiated no-man’s zone separating the viewer from the meadow, and little happened in this interim zone. The upper terrace overlooking the meadow was empty—no one ate there; no one sat down on the bench to take in the view over the meadow and out to the farm; and no one stopped along the long climb up the stairs.

By the end of the second growing season we asked the question: Could the landscape be modified to create more interaction between people and the meadow? Landscape architecture students were asked to envision a new transition between the meadow and hardscape areas to better integrate the meadow while thinking of new ways to use the meadow as a living laboratory. The Academic Dean gave Planting Design studio a budget to transform the stairway edge of the meadow. Students studied the meadow plant palette and combined meadow plants and their garden cultivars. A review team comprised of individuals from campus administration and campus Facilities selected a design, and students installed the design with occasional collaboration from Facilities staff.

The spatial framework of the selected design, seen in Figure 2, extends the stairway platforms into the landscape to create moments of interaction with the meadow at flatter, terraced areas. One surprise outcome of the design selection was the suggestion that the design be modified to showcase different Rutgers turf grass varieties in these semi-circular lawn areas, surrounded by massed meadow perennials. One of the turf demonstration areas is a low-mow fescue that flops over like cowlicks and consistently receives positive feedback. (Rutgers Office of Communications c, 2017). An Environmental Planning course, Ecological Design and Stewardship, intends to use the meadow to learn best management practices, removing invasive plants and augmenting the meadow border. The Green Team and Scarlet Service Day volunteers provide ongoing stewardship. Acceptance of the meadow is not universal, but has grown as
more people participate in stewardship, learn about the ecological benefits, and watch for blooms, butterflies and birds.

6 IMPACTS
The Living Lab Initiative remains a new endeavor on our campus; we have only begun to evaluate the many impacts it has had on our campus community. Future plans include collaboration with social scientists in the Department of Human Ecology to develop course projects to evaluate attitudes and impacts, the Center for Community-based Research and Service to engage in action research associated with the living labs, and the School of Education to assess pedagogical gains. Since we are a campus focused on science-based curricula, we foresee collaborating on monitoring and analysis of landscape performance with courses in ecology, environmental science, psychology, and turf science. We anticipate broadening our interdisciplinarity in the next few years to embrace turf science, fine arts, and engineering and recreation.

6.1 Learning
Current students might be highly educated in theoretical scenarios based on textbook lessons but are often under-experienced in how to solve problems on (and in) the ground. Personally relevant and locally-based experiences create a sense of ownership, place, and importance that can encourage lifelong love of learning and exploration in a wide variety of subjects within or outside of student’s chosen career track. Reality-based education involves interaction with a diverse set of faculty and operations staff, local ecosystem, and campus landscape, and makes students active participants instead of passive observers or memorizers. Our hypothesis is that this type of teamwork education creates skills and expertise in creativity and flexibility so as to prepare successful students in our changing environmental, social and economic circumstances. This hypothesis will be tested in the future by surveying alumni of these programs.

Living Labs reaches a broad student body through the following directives: Scarlet Day of Service (university-wide volunteers who assist with garden stewardship); Green Team (student stewardship jobs); Campus tours of our Living Lab gardens for STEM middle schoolers; Rutgers Day (university-wide community day); classes outside the Landscape Architecture Department (e.g. Freshman seminars and Science Communication, both of which attract students from many majors); Minors in Sustainability and Green Tech. The youngest group touched by the Living Lab Initiative is the Culture of Health Academy Nursery School which has student-constructed vegetable gardens to grow healthy snacks and teach about plants and nutrition.

Figure 3. Living Labs engage a broad student body (2018)
(a) Freshman seminar: Bee identification (b) Scarlet Volunteers (c) Green Team (d) Nursery School

Living Labs are an invaluable opportunity to practice and demonstrate Landscape Architecture on our campus. The Planting Design class, and three freshman seminars have been actively tied to these places as research sites and as design installations. These projects function as living laboratories for landscape architecture students in several ways. As a practicum, students learn how to order plant material from a wholesale nursery (pricing and availability). They take a design from “the boards” to the field, testing and amending the soil, accepting the plant delivery, laying out and planting the material, and stewarding the landscape (watering, weeding). For the meadow border installation, two planting methods were used: killing existing sod and direct planting into it or stripping the dead sod and planting into bare earth. This allows
students to observe differences in weed propagation as the garden is established. Although it is uncommon to see planting crews of twenty-five people, collaboration has been high-level. Students with landscape installation experience mentor fellow students. The large, moderately efficient crew transforms a landscape quickly (similar to HGTV), adding to positive feedback even before project completion. One derogatory comment came from a faculty member who referred to the class as a “chain gang,” but for the most part campus reaction to the modified landscape has been positive and students remain engaged. Students watering and weeding the gardens have received only positive feedback from people climbing the entry stairs to go to work or eat at the café. We believe that receptivity to the landscape is positive in part because of the overt display of the students’ efforts. Installation and stewardship have also created a deeper connection between the students and the garden—a sense of ‘ownership’ that extends to the department level in terms of pride of campus. Students who have graduated come back to visit the gardens they planted—a type of living legacy. Many of the students have also won student chapter design awards for their gardens.

Our goal is to transform the campus landscape into an environment where students are immersed in sustainability with living labs at the heart of this strategy. Each of our landscape interventions supports sustainability in one or more ways (e.g. Amphitheater Garden = social and environmental benefit; Pollinator Garden = environmental benefit; Low-input Turf = economic and environmental benefit. (see Figure 1). To move towards our goal of sustainability, we envision ongoing efforts to describe, measure, and maintain each living lab and through these processes to develop metrics relevant to measuring sustainability. Additional observations regarding use by the larger university will begin to provide feedback on social impact.

6.2 Research Examples

The Living Lab Initiative has already attracted a variety of researchers. Here are some examples.

Arbor Trail - The very first living laboratory, an adaptive restoration of the Arbor Trail at the University Inn and Conference Center, began as an Honors thesis. Research in the university archives revealed an historic garden plan. The estate's early 20th century 'air conditioning system' moved ground water through the building's roof and walls for cooling purposes, releasing the water into a small ravine to create a woodland stream and pool. Student involvement included unearthing the trail network and former stream raceway, mapping existing vegetation, and creating a landscape management and environmental education plan. Since the initial thesis, additional students promoted an adaptive reuse design by replanting and replacing vegetation lost during storms and hurricanes. Through a collaboration with the Rutgers Makerspace, this landscape will be interpreted by a mobile app.

Turfgrass Experiment - A turfgrass living lab demonstration site was installed next to IFNH as part of a multi-institution, USDA-funded study on people's reaction to low-input fine fescue turfgrass in a campus setting. Rutgers was an especially interesting site because we had used no-mow turf in the Meadow Border already. Faculty (e.g. Plant Science, Center for Turfgrass Science, Landscape Architecture, Soils Testing Lab) and Facilities staff were surveyed about this experiment (Nelson et al., 2019).

Rain Garden Case Study - A graduate Landscape Plants class exercise developed a new methodology for assessing rain garden landscape performance. Using on-campus rain gardens, students measured biodiversity, compared stormwater capacity to potential runoff and developed an aesthetic scoring system. The new method was documented and applied to off-campus rain gardens. Students produced a final booklet reporting the methodology and results for the Landscape Architecture Foundation (Hartman & Robison, 2017).

Pollinators and Garden Design - Pollinator gardens, designed by Planting Design students, support the food theme and plant diversity at IFNH. Some of these pollinator gardens have an additional conservation purpose because they support specialist bees which require a specific and narrow plant palette to survive, as illustrated in the student design (Figure 4a). A freshman seminar co-taught by a plant ecologist and a bee specialist monitored the results. Students learned to mark bees to monitor movement among gardens, observe and capture pollinators to assess visitation at different plots, and to identify bees to major taxonomic groups (Figure 4b). Figure 4c shows the pollinator plots at installation.
6.3 Inclusion

Situated on a public campus, we are accessible to a broad population. Our startup has been garden installations. In future development of signage and tours, we intend to provide information and access to all interested parties. More importantly, we hope by the distribution and apparenty of these living laboratories, a diverse population will receive the opportunity to learn more about topics such as sustainability, ecology, and landscape architecture.

During the first two years of this program, we worked to develop relationships with our neighbors. The Harvest Café supports the Rutgers Center for Adult Autism Services by hiring some of its clients. Their clients work inside the Harvest Café in the winter and outside on the grounds in the summer as part of the Green Team when the café is closed. The Green Team is a student group that stewards and promotes the Living Labs Initiative on campus. It has grown from a few Planting Design students from Landscape Architecture to a team of fifteen different majors from four different schools. One of our Green Team members took the Autism Center’s training program and worked side-by-side with the client and his job coach. Horticultural therapy clients may also join the Green Team. While we are not training our students to enter psychology careers, we are exposing them to different modalities of inclusion and valuing the diversity of people in the community.

6.4 Community Transformation

Looking at our collection of IFNH living laboratory gardens, the meadow was the landscape change that generated the most controversy. The student meadow border planting appeared to have helped to ‘change the tide’: many people walking through the construction site on their way to work stopped and commented positively to students about the work. Several other endeavors helped to develop community acceptance by revealing the dynamic nature of meadow biodiversity: a model depicting the meadow as a garden, was placed, like a sculpture, on a student-designed and -built pedestal placed in the café across from a view of the meadow; ecology research interns created Weekly Meadow Bulletins (as exemplified in Figure 5a) which revealed the changing biodiversity of the meadow.

Community interest in the meadow increased. Faculty members occasionally assisted with onerous tasks like mulching in 90-degree heat and planting four 14’ tall, multi-stem Honey Locusts. Initiatives were launched by IFNH personnel to increase appreciation of the meadow landscape. The first initiative came from staff within the IFNH building. As the meadow evolved in its second spring, staff began to champion its flowers on social media. An informal “meadow watch” noted and photographed the increase in bird activity at the site as well as butterflies, dragonflies, and other insects in addition to the changing plants in bloom (Rutgers Office of Communications d). People were starting to admire the meadow as they walked up the stairs or looked out of their windows. To capitalize upon this growing interest, we created a Living Laboratory exhibit at the Harvest Café (see exhibit poster, Figure 5b), showcasing student designs and exposing the gardens’ curricular underpinnings. The Harvest Café asked us to leave the exhibit up for their intercollegiate symposium, “Menus of Change.” Conference attendees remarked on an innovative tie-in between plant-forward menus, food sourced from adjacent gardens, and a plant-based diet.
6.5 University Initiative

At a larger scale, living laboratories are part of a new university-wide initiative nicknamed the Scarlet Pimpernel project that aims to enhance and link hands-on research and education through a network of on- and off-campus resources and experiences in gardens, forests, and biodiversity collections. This new network enhances and innovates college education, promotes lifelong learning, and enriches human lives as part of sustainability and conservation of global natural resources. The project creates connections to arts and humanities, as well as business, engineering, medical programs, and more—within the university and reaching to the world outside of Rutgers, together becoming more than the sum of our parts and serving as a model for how integrative and experience-based learning works inside and outside of the classroom.

7 CHALLENGES

Of course, it’s not all that easy. Challenges to the Living Laboratories—met and un-met—include the following:

Fear of Failure - Living Labs are alive and need continued care. Thus far, creating Living Labs has not proven to be particularly difficult, but stewardship of these sustainable landscapes has been harder than expected. Fear of failure can even preclude the creation of a new landscape as was nearly the case for the meadow. Facilities staff knew they could not care for the meadow landscape, so meadow project maintenance was taken on by faculty and students instead. No one wants to have to contend with negative feedback about a “messy” landscape. Some of the negativity has been alleviated through staff and university communication about the meadow.

The Role of University Facilities Staff - Working with Facilities effectively requires understanding and respect of their staff’s responsibilities and workload. Many of the difficulties derive from a staff shortage on our campus. The Institutional Planning and Operations website mission statement says that they “are committed to serving the university community by providing the appropriate environments for living, learning, teaching and working, all in support of the university’s mission and goals.” (Rutgers Institutional Planning and Operations). As a result, we receive more cooperation with Facilities when we are installing a new garden in a class.

Whereas indoor laboratories have been part of the built environment at campuses for a long time, outdoor labs require new approaches and knowledge. Facilities staff support for living laboratories is critical to the success of the living lab endeavor. They are responsible for the repair, maintenance, replacement, support services, and construction at the university, and their collaboration could make or break an individual project or the overall framework. Many issues make building a positive relationship with Facilities staff complex: understaffing; different aesthetic goals; incompatible maintenance guidelines; and financial accounting by responsibility centers, etc. However, as noted above, we share a common understanding that faculty and staff must both provide support for student learning.

To create better collaborations, we have learned to include Facilities staff in the design reviews, to build project support with pre-construction meetings and follow-up, and to select projects where we can work together with Facilities staff to solve campus problems. Facilities staff are thus becoming both groundskeepers and educators. We have found the younger staff to be particularly enthusiastic about
interacting with students, but they lack authority to make decisions about time allocation. Facilities staff have removed trees and heavy structures from our garden sites, when requested, but we have needed to hire outside contractors for grading, planting large trees, and other highly skilled labor or specialized equipment.

Traditional Maintenance Practices - Challenges inhibiting our success include conflicting definitions of landscape stewardship, incomplete knowledge of standard best management practices, and how to work with natural ecological dynamics. Here are some of the remedies we are trialing: continuing education classes for the grounds staff in Landscape Best Management Practices developed and taught by the Director of the Rutgers Soils Testing Lab and other university faculty; a student Green Team to maintain the teaching landscapes; a spirit of goodwill and face-to-face communication.

Student Stewardship - Stewardship by students is not perfect, either. The student body in residence on campus shrinks in the summer, and the Green Team has fewer active members, making student maintenance trickier during the hottest, weediest months. Landscape stewardship has other employment issues during the academic year: there is a seasonal component in the winter when the landscapes are dormant; employment is also somewhat weather-dependent since few students want to work in the rain or very cold temperatures.

Communicating the Living Labs Initiative - Communication at all levels requires continued effort. This includes improved and broader communication with Facilities staff as well as greater public engagement and increased community involvement with the living laboratories. Communication of Living Labs’ dynamic natural history and role as sustainable landscapes is also vitally important. Creating a signage system is a design project unto itself and will begin with a student Honors thesis.

Aesthetics - Sustainable landscapes are not everyone’s preferred aesthetic. However, improved communication and explanation may sway more people to understand the naturalistic style of some living labs (see Section 5, Meadow and Meadow Border Garden: Biodiverse Front Yard). In addition, developing more formal designs for some of the living labs may show that ecological functionality is not dependent on design style.

Faculty Involvement - Faculty involvement should grow to include other faculty using our living laboratories for instruction and research, and ultimately proposing their own projects.

Assessment - As mentioned earlier, development of multiple avenues of assessment for these new landscapes is needed.

Funding - As a bottom-up effort that is not institutionalized, funding is also a constraint. We do not have an Office of Sustainability or Green Funds to support this work, so our Living Lab endeavors have been supported by the academic teaching budget. Although it is clear that we can create these new landscapes inexpensively with wholesale plant materials and very low labor costs, maintaining them has proven to be an unforeseen cost with unusual constraints, although we can achieve much with sporadic volunteer assistance.

Scaling it Up - Given the many challenges, institution-wide change will require more cooperation, increased funding and visibility, and broader involvement.

8 CONCLUSION

As Paul Selman said ten years ago, there is much confusion still about the definition of a sustainable landscape (Selman, 2008), depending upon your point of view (educator, practitioner, researcher, government official). Within these categories of difference are further differentiations by discipline: landscape science; landscape design; landscape management; landscape planning; landscape history. The Living Lab Initiative creates a mechanism for students and faculty to investigate this question.

It came as no surprise that resistance to these non-traditional landscapes arises from some staff and Facilities personnel. In comparison to mowed lawn, these new landscapes require more weeding and watering, and compared to formal gardens, the naturalistic style can seem messy and disorganized. Management of biodiverse plantings such as the meadow require much higher levels of ecological knowledge. One solution under consideration is a partnership between the student Green Team to work in conjunction with Facilities staff to maintain these new landscapes. Because these new landscapes represent and reflect the campus’ core values, and because they have pedagogical importance, our campus administration is willing to continue funding their upkeep, even if it means devising new types of maintenance delivery.

The parsing of what is an acceptable campus landscape is a bonus of these new built projects. Reception of these landscapes by students has been less fraught than by some faculty and grounds staff.
who may be trained to “see” and understand plants differently than a lay person. The discussion of what is a ‘good plant’ has ensued: Should we be planting native plants only to restore degraded natural ecosystems? Are cultivars of native plants worthy of positions in these landscapes? What is the role of ornamental plants? What about weeds and novel plant assemblies? Thus, the social dimension of the plantings has great nuance and has generated discussion and even conflict while interdisciplinary collaboration (e.g. landscape architecture, turf science, urban forestry, ecology) has occurred in the design and even installation phases of the project. Perhaps the campus landscape can continue to develop in ways to more effectively demonstrate these different epistemologies and to deepen the campus dialogue as we endeavor to answer the question: what is a sustainable campus landscape? We want this discussion to be campus-wide and ongoing.

8 REFERENCES


9 ACKNOWLEDGEMENTS

This paper represents a great deal of work by many people over several years. We want to acknowledge all the students and TA’s who designed, planted, and weeded the living labs (some faculty and staff also volunteered to help with weeding). Arianna Lindberg and Richard Alomar directed the studio that designed the culinary garden. Richard Bartolone’s class designed and built one of the rain gardens in the research project. Chef Ian Hamilton from the Harvest Café at IFNH has been a champion of the projects around his building. Kimberly Russell co-taught the pollinator course that identified garden pollinators. Jim Murphy contributed our special turf varieties in the Meadow Border Garden and taught students how to plant turf. Stephanie Murphy teaches each Planting Design studio how to test soil. Jason Grabosky oversaw planting the Honey Locusts. Clifton Landscaping provided additional landscape construction expertise. Rutgers Institutional Planning and Operations Facilities Group for Grounds Services staff have been patient, practical and helpful in implementing living lab projects. Cindy Rovins and Jennifer Chudy Simon wrote great newsletter articles about these installations. SEBS administrators, including Dean Robert Goodman, Associate Dean Lisa Estler, and former Academic Dean Richard Ludescher, provided funding and support at various stages of the program’s development. Two anonymous reviewers provided useful comments in developing this manuscript. Diagram provided by Laura Lawson; photographs are courtesy of Holly Nelson and Christina Kaunzinger.
SUSTAINABILITY

Edited by Mintai Kim & Sohyun Park
An Urban Climate Design Framework for More Thermally-Comfortable and Equitable Communities

Coseo, Paul, PLA, PhD
Arizona State University and pcoseo@asu.edu

1 ABSTRACT

Over the past 150 years, societies have been excellent at designing cities that produce extreme and dangerous thermal conditions. Extreme heat and cold kill more U.S. residents than all other weather related phenomena combined. Yet, these hazards do more than kill. They disrupt residents’ routines, steal income through high energy costs, degrade quality of life, and create challenges for urban sustainability and resilience. The design professions must move toward a more comprehensive way to design better urban climates to support more sustainable and resilient communities. This study reviews the history of urban climate as a theme of landscape architecture research journals using a systematic review method. The review measures the existing landscape architecture against 1) social, 2) ecological, and 3) technological dimensions of city design. Based on the outcomes of the review, this paper then discusses the concept of Urban Climate Design (UCD). UCD is a comprehensive planning and design approach to intentionally reshape our urban atmosphere for more thermally-comfortable and equitable communities. From the search, I discuss a series of UCD recommendations addressing each of these three dimensions to move landscape architecture toward design processes for creating more thermally-comfortable and equitable communities.

1.1 Keywords

Urban climate, extreme temperatures, sustainability, adaptation, resilience
2 INTRODUCTION

Cities modify their atmospheres (Oke, 1988). Urban climate is term developed to describe this modification. The most common urban climate phenomena, urban heat islands (UHI) or locally warmer neighborhoods, result from pavement, buildings, novel ecosystems, and the accompanying human activities. There is no need to wait for global climate change to experience extreme weather brought about by human’s influence on our atmosphere. In many of our city neighborhoods, urban-induced climate change is already here in the form of UHIs. As Brian Stone writes in his 2012 book, we have already altered the climate in the places we call home – our cities (Stone, 2012). Over the past 150 years, societies have been excellent at designing cities that produce extreme and dangerous thermal conditions. Extreme heat and cold kill more U.S. residents than all other weather related phenomena combined (Berko, Ingram, Saha, & Park, 2014). The ways in which we design our urban neighborhoods impact the occurrence of both heat waves and cold snaps. Yet, these hazards do more than kill. They disrupt residents’ routines, steal income through high energy costs, degrade quality of life, and create challenges for urban sustainability and resilience. At the regional scale, how we build our cities sometimes manifests in uneven thermal impacts and equity issues of who bears the brunt of extreme thermal conditions. Extreme heat and cold discriminate by individual or social factors – targeting the most vulnerable amongst us (Harlan, Brazel, Prashad, Stefanov, & Larsen, 2006). Mitigating extreme microclimates without prioritizing vulnerable communities can amplify the inequitable distribution of risk making underserved and low-income communities more disproportionately burdened with extreme climate conditions. Landscape architects must move toward a more comprehensive way to design better urban climates to support more equitable, sustainable, and resilient communities. Yet, the complexities of urban climate issues is a barrier to action.

Landscape architects struggle to find relevant and generalizable strategies to this complex environmental problem. Unlike other environmental problems, thermal extremes are invisible and we sense temperature in complex ways through nerve-endings that are affected by exposure to air temperature, radiation, wind speed, and relative humidity. Thus, the sensing of how it “feels” out or our personal thermal comfort experience is quite subjective, modified by physiology, psychology, acclimation, clothing, and design of spaces (Wong & Chen, 2008). No wonder those involved with addressing extreme temperatures in cities struggle to find meaningful strategies. Outside of landscape architecture literature, urban climate is a growing theme that is being dominated by climatologists, engineers, urban ecologists, and geographers. Landscape architects already play a dominate role in urban climate regulation in cities through green infrastructure design, low impact development, and other greening activities. Designers have created more bioclimatic and adaptive park spaces with regionally appropriate trees and replacing lawn with native understorey species such as Burnham Wildlife Corridor on Chicago’s Lakefront Trail. These parks can assist cities adaptation to both UHIs and climate change. Landscape architects design streetscapes with extensive bioretention systems that increase the health of urban forests so that the street trees provide greater shade and evapotranspiration cooling power. Cities such as Portland have led this movement with their Green Streets Policy. However, urban climate regulation typically takes a secondary priority to stormwater, ecological enhancements, walkability, and other social and environmental priorities. This may be because academics and practitioners struggle with understanding the complex fluid dynamics of the atmosphere as it interacts with urban features not to mention the diurnal and seasonal patterns of urban climate processes that make designing for more thermally comfortable spaces so difficult. Although the theme of urban climate has been present in the landscape architecture specific literature over the last 40 years, our current climate crisis requires the acceleration of research on urban climate and a practice of urban climate design. Our cities need us and its time we broaden our impact in the urban climate design of cities.

This article describes the state of urban climate as a theme in landscape architecture through a systematic review of literature in four landscape architecture journals. I argue that urban climate as a theme in the landscape architecture literature is underrecognized and underdeveloped for the 21st century practice of landscape architecture. The systematic review helps shed light of the rich lineage of existing urban climate studies in landscape architecture. Those urban climate focused landscape architecture articles are then filtered through a Social-Ecological-Technological Systems (SETS) framework (Grimm et
(al., 2017) to evaluate their breadth. At the end of the article, I define a new concept called *Urban Climate Design* (UCD). UCD extends from both the analysis of social, ecological, and technological aspects of the systematic literature review and integrates my experience working with an interdisciplinary team of urban climatologists, computer scientists, urban planners, architects, and city officials on planning and design for urban climate.

2.1 Urban Climate and Its Presence in Landscape Architecture Literature

Although much attention is paid to global climate change, most cities are already living through substantial localized urban-induced atmospheric change or urban climate change. The two separate processes compound each other. Global climate change is caused through the release of greenhouse gases, while urban climate change results from conversion of undeveloped landscapes to urban land covers and uses (Stone, 2012). Global climate change modifies regional, continental, and global atmospheric patterns, while urban climate change modifies regional, city, and neighborhood atmospheric heating and cooling energy budget (figure 1). In many cases, urban areas have already seen temperature rises. Urban climate change impacts people’s life today. Warmer neighborhoods are already their everyday reality, impacting their routines, health, experience of place, and ability to enjoy their neighborhood landscapes.

Urban climate is not driven by the same forces as global climate change. Climatologist like to use the term global greenhouse gas (GHG) forcing of the atmosphere as a more accurate way to describe global climate change warming. That is because global GHG forcing is driven by greenhouse gas emissions from fossil fuels built up in our atmosphere. Shortwave radiation, coming from the sun hits the earth’s surface, it is absorbed by soil, trees, water, and other surfaces. That shortwave radiation is absorbed and transformed in the surface materials and it is reradiated as longwave radiation. The more GHG in the atmosphere, the more longwave radiation is trapped and that longwave radiation takes the form of heat. It is the longwave radiation that is responsible for warming of our global atmosphere. Thus, for landscape architects to help reduce global GHG forcing, we can design low energy and low carbon landscapes, work on creating transit oriented developments, and provide ideas for more walkable neighborhoods. The USGCRP (2017) reports that global near surface air temperature in the U.S. since 1901 have increased roughly +1.0°C (+1.8°F), with a likely increase of up to +1.4°C (+2.5°F) across the nation between 2021-2050 relative to the 30-year average (1975-2005). So, although landscape architects should address the drivers of global GHG forcing, the worst impacts are yet to come. However, as a profession, we are not adequately addressing a more urgent and immediate climate issue – our urban climates.

Urban climate is local phenomena (neighborhood 1km² to metro area 20,000km²) driven by land cover change and has already caused many of our urban neighborhoods to be from +4 °C to +10°C warmer than adjacent locations (Coseo & Larsen, 2014; Memon & Leung, 2010). Again, this is a separate process from global climate change, so global GHG forcing will only add to the problem of urban-induced thermal extremes. When cities’ replace green fields with pavement, buildings, and other artificial urban materials, we alter the energy balance. More incoming shortwave radiation is absorbed, more of that energy is converted to longwave and sensible heat than on a green field. Figure 1a shows incoming shortwave radiation hitting various urban surfaces. Urban materials reflect only 15-20% of incoming radiation (Taha, 1997), that means 80-85% is absorbed into those urban materials. Figure 1b illustrates that absorbed energy is then emitted as one of three forms of energy: 1) longwave; 2) sensible heat; or 3) latent heat (Hutchison, Taylor, & Panel, 1983; Stone, 2012; Taha, 1997; U.S. Environmental Protection Agency, 2012). It is the longwave and sensible heat that contributes to heating of the lower atmosphere called the urban canopy layer (Oke, 1988). The urban canopy layer occurs from the top of buildings and trees (the highest objects) to the ground. The urban canopy layer atmosphere is highly modified by the physical characteristics surrounding it. That means places with high percentages of concrete, glass, and steel will be hotter than areas with high percentages of trees, shrubs, and groundcovers. Stone (2012) examined 50 cities in the US and showed that urban areas are warming faster than rural locations due to the urban-induced heating. Our design choices matter for local climate conditions. Our land use policies...
determine local thermal conditions. Landscape architects have a key role in creating urban climates and leading a revolution on how society creates better urban climates.

Figure 1. The illustration on the left (1b) depicts urban-induced atmospheric change where incoming solar shortwave radiation is either reflected by, absorbed by, or transmitted through urban features. On the right depicts how the absorbed radiation is released. Longwave radiation and sensible heat raise air temperatures. Photo and illustration by author.

Landscape architecture researchers have fallen behind in our contribution to urban climate research and discourse relative to other disciplines. Landscape architects must make a meaningful contribution to urban climate research to shape the academic discourse and not cede the framing and discourse to climatologists, engineers, urban ecologists, and geographers. This contribution can be made by partnering with urban climate experts, studying urban climate dynamics, or mentoring students who want to integrate landscape architecture and urban climate. Cushing & Renata (2015) reviewed 441 research article abstracts from Landscape Journal, Landscape Review, and the Journal of Landscape Architecture to identify trends over a 31 year period (1982–2013). They used 44 codes to put the abstracts into themes. Not one theme explicitly referred to urban climate. The most similar themes were:

- **Sustainability and Green Infrastructure** articles represented 8% of 441 articles or ~35 articles
- **Water/Hydrology** articles represented 2% of 441 articles or 9 articles
- **Climate Change** articles represented 0.5% of 441 articles or 2 articles

Academia sometimes leads key trends in practice or sometimes it has to catch up to create research that practitioners need to be more effective landscape architects. Cushing & Renata (2015) found a mismatch between published articles and practitioners’ interest. The researchers used participation as part of the Professional Practice Networks (PPNs) with ASLA as an indicator of practitioner interest. They found that 19% of total members in the PPNs were part of the Sustainable Design and Development network. Although 19% of practitioners were interested in sustainable development, it represented only 8% of research articles. Urban climate was not explicitly delineated as an area of research or practice and it probably fell into one of the three themes above. This is not to say that urban climate is not being addressed by landscape architecture academics and practitioners. Urban climate research has been featured in interdisciplinary planning and design journals for decades, but not as extensively in landscape architecture specific journals. Interdisciplinary journals, such as Landscape and Urban Planning, publish many articles on urban climate planning and design such as important pieces by landscape architect academic Robert Brown on microclimatic planning and design (Brown, 2011). For this study, I examine the question of how extensive is urban climate as a theme in landscape architecture specific journals.

3 METHODS
3.1 Systematic review

This study reviews the history of urban climate as theme in landscape architecture research using a systematic review method developed by Pullin & Stewart (2006). The review is intended to collect landscape architecture articles that explicitly address urban climate issues such as urban heat islands and air pollution. I used a technique similar to Cushing & Renata (2015) for reviewing the state of literature from landscape architecture peer-reviewed articles. I acknowledge that additional journals, which Cushing & Renata (2015) did not use, such as *Landscape Research, Urban Forestry, and Urban Greening* would be appropriate to deepen this landscape architecture focused analysis. The journals examined were: *Landscape Journal* (1982-2018); *Landscape Review* (1995-2018); *Landscape Research Record* (2013-2018); and *Journal of Landscape Architecture* (2006-2018). I used each journal’s webpage to search keywords related to urban climate including: 1) “Climate”; 2) “Heat”; 3) “Microclimate”; 4) Urban Climate”; and 5) “Urban Heat Island”. This method caught articles from all the journals except *Landscape Research Record*, so I manually examined *Landscape Research Record* number 1-7 for articles. I opened each year of *Landscape Research Record* starting in 2013, filtered by titles that had a climate or environmental theme, and then opened each of those articles to search for the same five keywords. After all the articles were collected, the second step in the process was to screen the article abstracts for discussion of areas of urban climate. Based on the abstract, I coded the articles 1 through 5 in their dominance of urban climate as a central focus of the paper: code 1) urban climate; code 2) other urban environmental; code 3) climate change; code 4) regional climate; code 5) non-environmental use of the term climate such as political climate. Conference reviews, discussions, book reviews, or books were excluded from the review.

The articles were then put through a qualitative review for how their study aligned with a Social-Ecological-Technological Systems (SETS) framework in their data collection. Outside of landscape architecture, urban ecologist, engineers, and climatologist are beginning to use a SETS framework (Grimm et al., 2017) to understand complex urban systems. They argue that social-ecological frameworks that have been used for the last two decades are missing the engineering perspective that dominates urban infrastructure. A more complete framework is to integrate concepts of social-technological and social-ecological into a more complete SETS framework. For Grimm et al. (2017), the social components range from individual to collective decision makers including households, social groups, and government officials plus their norms and behaviors. While the ecological components are those biological, living systems ranging from humans, plants, animals, and microbes. Technological components are built architectural structures and infrastructure such as roads, rails, pipes, wires, and media that maintain societal function. The creation of dangerous urban climate conditions lies at the intersection of social, ecological, and technological components. For instance, the distribution of healthy urban forests, which provide shade and cooling, is largely the result of property owners’ decisions, tree and shade policy incentives or mandates, and public investment decisions (social component) in the planting, irrigation, and maintenance of those forests. In hot arid regions (ecological component), this is distribution is reliant on irrigation to survive (technological component). Since trees make neighborhoods cooler, the intersection of social, ecological, and technological component can result in some neighborhoods being hotter than others or the uneven distribution of heat (Harlan et al., 2006). This uneven distribution of heat many times follows and compounds other equity issues creating thermal inequity between resource-rich, ‘cool’ neighborhoods that can support urban forest and resource-poor, ‘hot’ neighborhoods that cannot.

3.2 Findings

*Landscape Journal* (1982-2018), not surprisingly, had the most returns when putting in the keyword “climate” with 328, but many of those returns were conference reviews, book reviews, and introductions. After removal, it brought the number down to 166. Using more targeted term such as “urban heat island”, brought up 17 returns and only four were articles. “Microclimate” produced 43 returns, but only 24 were articles. While, “Urban climate” captured six returns, four of which were articles.

In all four journals, 212 articles were captured using the systematic review method. After I collected those articles, I read through the abstracts to determine and code the focus of each article. Especially the word “climate” can have multiple definitions that are unrelated to urban climate. Of those 212, I judged 53% or 112 articles used the keyword “Climate”, but used it in a non-environmental context such as political climate (figure 2). While, 18% or 38 of the articles may have had one of the five keywords...
in the text of the article, the real focus of those articles was other urban environmental issues such as stormwater management with implications for urban climate or climate change. Global climate change (global GHG forcing) was the focus in 9% or 19 articles in total. While, regional climate as a basis for design was found in 8% or 17 articles. Articles that directly examined issues related to urban climate made up 9% of the articles or 20 of the 212 articles.

Figure 2. Illustrating the 212 articles found through the systematic review. Percent of all articles found in four landscape architecture journals that fit into a variety of climate-related themes

Landscape architecture academics have engaged in scholarship with an urban climate focus since the beginning of the examination period. Hutchison, Taylor, & Panel, (1983) describe the long history of human modification of the land to create more desirable microclimatic conditions. Figure 3 illustrates the distribution of articles by year. Starting in the year of Landscape Journal’s first publication in 1982. The data shows that interest in urban climate as a research topic in landscape architecture has been present, but scarce, with only 20 articles over the 36-year period with a slight uptick since 2012. Only one article was inaccessible, and it was excluded from the analysis (Sarkar, 2006). This left 19 articles to examine in more detail. The articles represent a diversity of urban climate focused work from articles on ‘topoclimate’ (Baxter, 1982), ‘terraforming’ (Klosterwill, 2018), air pollution (Chen, Dai, & Zhu, 2018), and ‘climate-revelatory’ design guidelines (Lenzholzer, van den Brink, & Klemm, 2017).

Figure 3. Urban climate focused articles published in four landscape architecture journals by year.

Table 1 lists all 20 urban climate focused articles and uses this SETS framework to qualitatively evaluate the data against the SETS framework. Most articles hit two of the three dimensions of SETS, but not surprisingly many do not address either the social or the technological dimensions in the data that they collect. The focus of the 19 articles reviewed shifted from ecology and technology in the form of energy conservation in the 1980s. toward broader benefits of social, ecological, and technological aspects in the 1990s. While, more recent articles have tended to shift away from the 80s focus on ecology and technology, a few remain (Kent, Shultz, Wyatt, & Halcrow, 2006; Wang & Lebleu, 2018; Zong & Pu, 2017). Many researchers recently have taken a more social and ecological approach (Klosterwill, 2018; Lenzholzer, 2008; Lenzholzer et al., 2017; Tavares & Swaffield, 2017), yet not including much on
technology. However, several recent authors’ work aligns more with a SETS approach (Cerra, 2016; Klosterwill, 2018; Li, Dvorak, Luo, & Manskey, 2014; Tavares & Swaffield, 2017; Yu & Walliss, 2017).

**Table 1: Qualitative evaluation of 19 urban climate focused articles from four landscape architecture journals**

*could not obtain this article for evaluation

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Social</th>
<th>Ecological</th>
<th>Technological</th>
<th>Computer modelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baxter, V., 1983</td>
<td></td>
<td></td>
<td></td>
<td>CHICO Model</td>
</tr>
<tr>
<td>Hutchison et al., 1983</td>
<td></td>
<td></td>
<td></td>
<td>SOLEST Model</td>
</tr>
<tr>
<td>Thayer et al., 1983</td>
<td></td>
<td></td>
<td></td>
<td>SOLPLOT program</td>
</tr>
<tr>
<td>Wagar, 1984</td>
<td></td>
<td></td>
<td></td>
<td>MICROPAS and TEP Models</td>
</tr>
<tr>
<td>Parker, 1987</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McPherson, 1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reynolds, 1996</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarkar, 2006*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kent et al., 2006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lenzholzer, 2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>John-Aider, 2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li et al., 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerra, 2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lenzholzer et al., 2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yu &amp; Walliss, 2017</td>
<td></td>
<td></td>
<td></td>
<td>Computational Fluid Dynamics model</td>
</tr>
<tr>
<td>Zong &amp; Pu, 2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tavares &amp; Swaffield, 2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chen et al., 2018</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Klosterwill, 2018</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang &amp; Lebleu, 2018</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To unpack some of these studies, I briefly summarize a few select articles to illustrate the depth of urban climate focus in landscape architecture literature. Many of the early writings (Baxter, 1982; Hutchison et al., 1983; Parker, 1987; Thayer, Zanetto, & Maeda, 1983; Wagar, 1984) were associated with concerns for energy conservation of buildings. A key element for many of these studies was using computer models to quantify the impacts of landscape features on energy use/costs. The site was a feature of concern as it impacted the building’s performance. Coming in the early 1980s, this is not surprising with the larger societal crises of energy and geopolitical vulnerability to nations that supplied those resources. Baxter (1982), Hutchison et al. (1983), Thayer et al. (1983), Wagar (1984), Parker (1987) contained all ecological and technological dimensions of the SETS framework. The earliest paper, Baxter (1982), examined Chaco Canyon, New Mexico and the site’s passive heating and cooling design that was built by Puebloan communities dating back to the mid 800s. He developed a computer model, he called CHACO, to study the site’s intense solar insolation or a surface’s total amount of solar radiation received. He was interested in how the Chacoan people designed with the natural heating-cooling mechanisms of the Colorado Plateau Semidesert. For Baxter issues of urban climate were central to landscape architects skillsets. “Landscape architects are specialists in the effects of the cyclical forces of nature on outdoor and indoor environments, and accordingly they can design and plan urban forms to take full advantage of the wind, sun, shade, and air” (Baxter, 1982: 85). He also emphasized the heritage of urban climate work in design, drawing upon earlier work of Olgyay (1963). Baxter’s work with computer models is also continued.
today with such programs as ENVI-met ("ENVI-met," 2019). However, as current ENVI-met models examine neighborhood scale landscapes, the use of computer models in the 1980s were focused on the impact of site scale landscapes on a building’s energy use.

Hutchinson (1983) integrates the work of Oke (1975), considered by many urban climatologist to be the father of urban climatology. Oke’s (1975) piece called “Inadvertent Modification of the City Atmosphere and Prospects for Planned Urban Climate”, was an early call to more intentionally plan and design our urban climate at the site scale. Hutchinson (1983) landscape design recommendations included: “(1) vegetative alteration of radiative energy exchange; (2) vegetative alteration of convective energy exchange; (3) mesoscale effects of vegetation-induced latent heat exchange upon urban air temperatures; (4) effects of building and use characteristics on space-conditioning energy requirements; (5) effects of climatic factors on building space-conditioning energy requirements; and (6) implications of psycho-social phenomena involved in the perception of comfort to energy conserving landscape design.”(Hutchison et al., 1983: 33). Early authors clearly were linking to and influenced by new scientific discoveries in bioclimatology and urban climatology. More recent contributions build upon this urban climate heritage in landscape architecture. McPherson’s (1990) article serves as a turning point to examine the multiple benefits of more intentional design of urban climate for reducing both energy and water use.

This century, Lenzholzer’s (2008) article on the history of public square design addresses social and ecological dimensions of SETS. She illustrates the pathways of design practice that lead to public plazas in the Netherlands being designed as what she terms the “city as a building” approach, where the plazas are the rooms of the city. The urban climate consequences of having these rooms or “…void” squares is thermal discomfort. They offer no shade or shelter, and thus no microclimate variation; users are left with no choice between microclimate zones”.(Lenzholzer, 2008: 49). She also describes the lineage of Dutch squares as ‘hard places’, tracing them back to the influence of French and Catalan’s ‘placas duras’ or ‘hard places’. Squares that, by tradition, are constructed of stone, tiles, enamel, glass, and metal with minimal plants. “The ‘hard places’ have a typically harsh microclimate that aggravates peak air temperatures because stony surfaces store heat and emit them via long-wave radiation (Santamouris 2001:160-165). Also the ‘touch’ of the hard materials with their heat conductivity properties plays a role. Stony materials, steel and glass are generally very dense, with comparatively high conductivity (Givoni 1998:119-122). These materials feel quite cold in cooler climatic circumstances, but in warm circumstances can become very hot. These thermohaptic properties of the materials and the accentuated peaks in air temperatures do not serve the human need for thermal comfort” (Lenzholzer, 2008: 50). Lenzholzer questions why we still build these types of squares today. She suggests that it may be a combination of designers detachment from place, their preoccupation with visual effect, or that “…the complex nature of urban microclimate processes is considered incomprehensible by designers…” (Lenzholzer, 2008: 54). She suggests that there is a lack of simple, yet regionally appropriate urban climate design guidelines. She also expresses the notion that existing design approaches for urban climate are climate-responsive, which does not go far enough. She advocates for a "city as landscape' approach using 'climate-revelatory' designs that more holistically and intentionally modify radiation patterns, ventilation, and moisture for human thermal comfort.

More recently, Cerra (2016) discussed an approach they took for a Cornell landscape architecture studio course on Climate-Adaptive Design. Although the majority of the piece was centered on impacts from global GHG forcing, they did include a section on UHI mitigation. “Through strategic placement of trees, other vegetation and green infrastructure…, climate-adaptive design projects can respond to intensifying urban heat island effects due to climate change” (Cerra, 2016: 51). Although they might also agree that it can improve our urban climate today, they frame the urban climate issue as in the future. Cerra (2016) suggests that trees can shade impervious surfaces and reduce heating demand if sited properly. While green roofs, cool roofs and pavements can fight UHI. Since these have been shown to reduce UHI, they can also be useful metrics such as proportion of vegetative cover, impervious surface shading, and cool roof/ pavement, along with such measures as reduction in area of impervious surfaces.

Chen, Dai, & Zhu (2018) offer a slightly different framing of urban climate issues when they examined green infrastructure in relation to distributions of PM_{10} and PM_{2.5} at 10 monitoring stations in Wuhan, China. They developed class indices for green infrastructure patch size (total area and dominance of the core), shape (irregularity of the perimeter of patches), concentration, and fragmentation (the extent of fragmentation and separation of patches). Of the four indices, they found that the patch size was the most significant and explained 82.4% of reductions in PM_{10} and 75.6% of reductions in PM_{2.5}. In other
words, the green infrastructure size likely contributes to reductions in air pollution more than its shape, concentration, and fragmentation. The researchers suggest to reduce PM$_{10}$ and PM$_{2.5}$ designers should: 1) increase green infrastructure total area and 2) decrease the distance between patches.

Klosterwill, (2018) adds to the diversity of thinking in landscape architecture as he conceptually links landscape architecture to terraforming to create intentional urban microclimates. Klosterwill, (2018; 89) suggests, “[t]he range of sites and scales that these terraformers engage with is equally broad, from the tissues of the human body to regional ecosystems and the global atmosphere. In the middle ground, terraforming refers to more familiar and localized scales of site design and microclimate manipulation… which describes the creation of favorable gravitational, thermal, and atmospheric conditions, implies that site emerges in relationship to the environmental conditions desired, and the systems that produce those conditions”.

A key leader in advancing urban climate as a central theme in landscape architecture has been Sandra Lenzholzer (Lenzholzer, 2008; Lenzholzer et al., 2017). This is not surprising as she also has been influential in more interdisciplinary journal venues on urban climate (Lenzholzer, 2010; Lenzholzer & Brown, 2013, 2016; Lenzholzer, Klemm, & Vasilikou, 2018; Lenzholzer & Koh, 2010). Lenzholzer has lead a group of researchers publishing articles that begin to define and integrate urban climate as a priority issue for landscape architecture.

In 2017, Lenzholzer, van den Brink, & Klemm, (2017), followed up the Lenzholzer (2008) study with design guidelines for urban climate adaptation focusing on the microclimatic regulation provided by green infrastructure. The researchers integrated an evidence-based design in two studios using a participatory ‘Research through Design’ approach. They pulled from existing urban climate scientific literature, then created preliminary design guidelines and had them assessed by the design studios using two criteria: 1) usefulness and 2) a questionnaire measuring participants appreciation, comprehensibility, applicability, and feasibility of the guidelines. The urban climate design guidelines were developed for three scales: 1) city scale; 2) park scale; and 3) street scale. A key finding from working with the practitioners is that…”[i]n a general perspective, this study showed that climate-responsive design is a new topic in urban design and when it came to creating a balance between competing functional demands in the design process, focus on the microclimate seemed to have lower priority. The limited sense of urgency about urban climate issues experienced by the participants confirms earlier studies36. Campaigns to enhance the sense of urgency for (public) commissioners of design assignments as well as for urban designers are needed, and additional advice by microclimate experts during design processes may activate a consciousness of climate-responsive design in future design processes. Last but not least, education – also in life-long learning settings – can help to increase the incorporation of climate-responsive design strategies in urban design practice. Therefore, we recommend teaching climate-responsive design to students and professionals in design studio learning environments, and supporting them to apply this knowledge in site-specific conditions. This learning ‘on the task’ helps to create tacit and ‘embodied’ design skills that incorporate climate-responsive elements in a natural way” (Lenzholzer, van den Brink, & Klemm, 2017:70). Even though we have a good foundation for a landscape architecture approach to urban climate design, key gaps remain. The existing literature lacks a more nuanced integration of social, ecological, and technological dimensions of urban climate. On the social side, there is a missing focus is on thermal equity of outcomes for vulnerable people and communities. On the technical side, there is a missing focus is on technological maladaptation, the risk of creating overly complex technical responses that are prone to catastrophic failure, and overreliance on technological systems that residents cannot afford (e.g. irrigation, air conditioning systems).

3.3 An Urban Climate Design Framework

To build upon the existing urban climate focused landscape architecture literature, I argue we need a more intentional approach to designing for better urban climates. An approach informed by landscape architecture can help address the social and technological gaps identified above. I suggest a new concept called Urban Climate Design (UCD) that aims to intentionally reshape our urban atmosphere for more equitable thermal outcomes by better integration of social vulnerability and technological challenges and risks. UCD brings together four dimensions of 1) urban climatology, 2) urban ecology, 3) thermal equity, and 4) social learning through participatory research and design processes under a landscape architecture approach to more intentionally design our urban climate.
Many in urban climatology focus on mitigation or reducing the drivers of uncomfortable urban climates. Like Hutchison et al. (1983), we should leverage, expand, and work with research and researchers from urban climatology to expand our urban climate literacy and fluency in landscape architecture. This greater literacy and fluency on topics of urban climate would fit into and support Spirn's (2003) concept of landscape literacy and fluency. Like Lenzholzer (2008), I argue for pushing past the term "mitigation" or strategies to simply reduce thermal extremes to a landscape architecture focused UCD that advocates more holistically co-investigating and co-designing with residents, government officials, and designers to create better and more moderate urban climates in cities. UCD integrates urban ecological approaches to move past simply being less bad with single solutions (e.g. cool roofs) and advocates multipronged strategies to simultaneously improve a neighborhood’s thermal environment, quality of life, health, and equity of outcomes. UCD involves issues of thermal equity to address uneven impacts for extreme thermal conditions. UCD should prioritize equitable, accessible, and empowering research and design processes to help residents not only understand the complexities that create neighborhood thermal extremes, but more importantly help residents spearhead private and public actions that will reduce their vulnerabilities. UCD uses the concept of social learning through participatory research and design. UCD should be practiced to increase the exchange of knowledge between residents, scientists, government officials, and designers that could identify and address inequities, technological maladaptation, overly complex engineered solutions that are vulnerable to failure, and unaffordable reliance on technology for thermal comfort. Through this learning exchange, residents can increase their knowledge of urban climate processes, so they can make more informed personal decisions, be a part of UCD processes, and advocate for governance and institutional change.

The goal of UCD is to support successful adaptation to extreme heat and cold due to 1) natural variation in climate, 2) urban-modified atmospheres, and 3) global climate change. To date, design processes have resulted in unintentional modification of our urban atmospheres; UCD promotes a different design process aimed at creating more moderate urban climates that are equitably distributed across metro regions. The UCD approach leverages the best methods for sensing and documenting urban atmospheric dynamics from urban climatology and combines this with more grounded, experiential, and participatory practices from landscape architecture.

Recommendations:
1. Document urban climate trajectories –
   a. Social – create in-person and online social networks, especially in the most vulnerable neighborhoods, to help residents answer the question, is my neighborhood having more or less thermally dangerous hours/days per year? How is the neighborhood urban climate changing?
   b. Ecological – Document existing urban ecology system that drive the neighborhood’s thermal comfort (e.g. amount of shade, percentage of tree canopy, and tree species).
   c. Technological - Set up smart weather station network or have residents record temperatures in their back yard and report to an online dashboard for real-time temperature data sharing.
2. Collect thermal stories –
   a. Social - Nurture a culture of thermal storytelling (heat stories or cold stories) to advance residents’ understanding and narrative of place-based, thermally comfortable neighborhood discourse. This should be expert facilitated, neighborhood driven. Document and acknowledge past urban climate injustices.
   b. Ecological – Discuss and collect stories on plant preferences, important culture connections with nature, and the ecosystem services and disservices associated with those choices for thermal comfort including other ecological tradeoffs such as water use.
   c. Technological – Discuss and collect stories on the multiple ways people stay cool in summer or warm in winter using technology including use of air conditioning and other technological coping mechanisms.
3. Learn by doing –
   a. Social - act to learn– start by creating small projects to illustrate and make real the science and most importantly the experience behind thermal comfort. Create intentional activities to support social learning about urban climate through design. This is aligned
with the spirit of Lenzholzer et al. (2017) ‘Research through Design’ approach. Create relatable and easy to engage in activities around changing neighborhood features to reduce thermal extremes. Actions and discussions must be accessible to all audiences and relevant to their lives.

b. **Ecological** – Utilize “designed experiments” and integrate with citizen science. “Designed experiments” are based on a concept by Felson & Pickett (2005). They are ecological design interventions used as opportunities to learn through science. Monitoring should occur before and after interventions to better understand the efficacy of ecological actions.

c. **Technological** – Take a Smart technological approach to monitoring interventions to ensure efficacy of the “designed experiments” and to improve social learning.

3.4 **Acknowledgements**

This material is based upon work supported by the National Science Foundation under grant number DEB-1637590, Central Arizona-Phoenix Long-Term Ecological Research Program (CAP LTER) and Smart and Connected Communities Planning Grant (Abstract Award 1737617). Special thanks goes to Zoe Hamstead, Nicholas Rajkovich, David Hondula, and Ariane Middel, who inspired much of this work.

4 **REFERENCES**


Klosterwill, K. J. (2018). METAPHORS WE SCAPE BY : THE POSSIBILITIES OF TERRAFORMING AS A NEW DESCRIPTOR OF LANDSCAPE. *Landscape Research Record, (7).*


Li, M., Dvorak, B., Luo, Y., & Manskey, J. (2014). “ PARK SEVENTEEN ” RESIDENTIAL ROOF GARDEN : LANDSCAPE PERFORMANCE AND LESSONS LEARNED Environmental Benefits Examples : Improve air quality Improve resiliency in urban watersheds Examples : Create new jobs Increase property value Economic Benefits Examp. *Landscape Research Record, (Figure 1).*


Wang, R., & Lebleu, C. M. (2018). EXPERIENCE WITH COLLABORATIVE RESEARCH ON THERMAL CHARACTERISTICS OF LOW IMPACT DEVELOPMENT STRATEGIES. *Landscape Research Record, 7*.


Dear CELA Authors:
Please consider include in this space a research summery in 100 words or less that would best describe your topic, its principal results and/or impacts, written in clear language that would be of interest to public media outlets. In addition to the research summary, you may provide an optional graphic abstract that further explains the topic.

Title of Paper or Research:
An Urban Climate Design Framework for More Thermally-Comfortable and Equitable Communities

Author:
Coseo, Paul, PLA, PhD
pcoseo@asu.edu

Institution or Professional Affiliation:
Arizona State University

Authors please select one of the following: I DO _X__ DO NOT_____ want to prepare a media statement for general release from the 2018 CELA Conference. (If you choose DO NOT, you do not need to prepare a media statement).

Media Statement (100 words max.):
Over the past 150 years, societies have been excellent at designing cities that produce extreme and dangerous thermal conditions. Extreme heat and cold kill more U.S. residents than all other weather related phenomena combined. The design professions must move toward a more comprehensive way to design better urban climates to support more sustainable and resilient communities. This study reviews the history of urban climate as a theme of landscape architecture research journals using a systematic review method then discusses the concept of Urban Climate Design as a path to create more thermally-comfortable and equitable communities.

(Optional) Graphic Abstract: please insert the illustration below.
Authors: please seek copyright permission if copyrighted materials are used.
RESEARCH BY DESIGN

Edited by Brett Milligan, Kristi Cheramie, & Robert Holmes
THE ETHICS OF FORM: DESIGNING NEW LANDSCAPE HISTORIES THROUGH AN ALTERNATIVE PEDAGOGY

BYRNE, FIONN
Assistant Professor, The University of British Columbia (UBC), School of Architecture + Landscape Architecture (SALA), fionn.byrne@ubc.ca.

1 ABSTRACT
This paper presents the work of an advanced graduate level studio from the University of British Columbia that engaged disciplinary history as a site of research through speculative design. Fourteen students working in teams of two explored the relationships between physical form and social function in canonical works of building and landscape architecture completed in the eighteenth century at Stowe house, grounds, and park in Buckinghamshire, England. They used design as a tool to envision alternative proposals which give form to a set of contemporary ethics.

Stowe was critical in the development of the discipline of landscape architecture, as it provided the location, labor, and funds for William Kent and Capability Brown to formalize a new aesthetic, later called the “English landscape garden.” This design direction moved away from an ordered geometric design and toward a less formal, more picturesque approach. This landscape tradition also anticipated the rise of ecological design and an ethic of environmental responsibility.

Beginning with this historical narrative, this design studio asked, “what are the physical forms that other ethical commitments would have taken?“ This question is particularly important in academia today, where social justice and activism are attracting increasing attention. This paper discusses how design was used as the method to research these historically celebrated works at Stowe, and critically engage with history through the proposal of alternative designs.

1.1 Keywords
design studio, research by design, history and theory, ethics, Stowe.
2 PURPOSE

Landscape today is pre-eminently the domain either of scientific study and land planning, or of personal and private pleasure. It no longer carries the burden of social or moral significance attached to it during the time of its most active cultural evolution. (Cosgrove, 1998, p. 2)

This design studio was motivated by a desire for useful critique of the history of the discipline. Research by design was the method employed by this studio to interrogate historic works of landscape and building architecture, where the focus was not on unearthing entirely new histories, but on challenging and uprooting the accepted history. It is increasingly recognized that the history of landscape architecture has been disproportionately focused on a Western gardening tradition, which traces the development of the field from the French formal garden, to the English landscape garden, and to its culmination in the American park. Most canonical works in the field are projects owned and paid for by an elite wealthy ruling class, while at the same time questions of labor, access, and discrimination are underrepresented. A publication like Jill Francis' Gardens and gardening in early modern England and Wales, 1560 - 1660 (2018) points to the important research needed to expand discussions of disciplinary history beyond the "extravagant showpieces of the nobility," yet it also highlights the lack of such scholarly work.

A typical curriculum at the graduate level in landscape architecture has required courses in both design studio and history and theory. While design studio is primarily taught in a one-on-one teaching environment to explore solutions to a goal-oriented project, history education in landscape architecture is most often presented in a narrative form by way of lecture or seminar courses. This paper presents the work of an advanced level studio from the University of British Columbia, Canada, that merged these two goals and engaged disciplinary history as the site of design research. Broadly, this allowed for two ways of learning. First, the students were required to understand at a detailed level the design work discussed in typical history classes. This meant that precedent projects were not only shown as stock slides but were drafted in measured drawings. Secondly, the students were required to critically engage with disciplinary history. The past was not presented as a stable monolith but was subject to changing definition dependent on one's contemporary perspective and as a result, students actively participated in defining new historical narratives.

This way of framing a studio project, where disciplinary history is the site of design, has drawn inspiration from the contemporary American artist Fred Wilson. For the 1992-3 exhibition Mining the Museum: An Installation by Fred Wilson, Wilson organized the objects from the archives of the Maryland Historical Society in such a way as to create friction between adjacent pieces and demonstrated that history is never objective, static or simple. Furthermore, the exhibition showed how an artist can construct new historical narratives from existing objects. Speaking more generally about his approach to the display of artifacts in museums, Wilson has said, “I try to bring out the meanings that I see in the objects, often the ones that, for one reason or another, are hidden in plain sight. This is not to replace the museum’s view of the object’s meaning with my own, but to let both meanings or multiple meanings be present at the same time” (Graham, 2011, p. 321). This is an assertion that the canon need not be discarded, but that it must be opened to critique, allowing the voices of the disenfranchised to speak through historic works. So, while the discipline of landscape architecture should continue to teach precedent projects drawn from a Western elite gardening tradition, designers can re-envision these works to address historic injustices and give form to alternative meanings. In other words, while the form of a historic garden is useful disciplinary knowledge, if this form expresses or is the product of an unjust world view, then instead of recreating it, landscape architects today must be prepared to explore new formal designs.

Following this way of thinking, the approach of this type of studio is twofold. In simplest terms, the first design exercise is to define multiple social and moral meanings attached to the physical formation of a historic landscape or building. This is a critical step because linking social meaning to the particulars of a project as built will ensure the forthcoming critiques remain grounded and respond in kind, that is with physical form embodying the social critique or the alternative moral position. It of course follows that the second design exercise is to propose alternative forms that signify alternative social or moral positions. These counter-proposals render a new disciplinary history more inclusive and relevant to contemporary practice. In the end, the design work of such a studio seeks to confirm Cosgrove’s opening remarks, that landscape has become more interested in either a scientific or phenomenological approach to design, and the consequence has been a silencing of the social and moral implications of the work. It is here argued that this position must be countered, as social and moral significance is not a burden to be avoided. Rather, it must be understood as a consistent and critical component of any design work.
3  BACKGROUND

Alexander Pope’s dictum to “consult the genius of the place in all” are words well known by every landscape architect (1751, p. 42). This famous line is part of a poem that describes the house and grounds at Stowe in Buckinghamshire, England. Stowe is a landscape that would become nearly as famous as Pope’s words and is a central project in the development of the discipline of landscape architecture. This one phrase represents the most concise written summary of a new design aesthetic pioneered at Stowe and later called the “English landscape garden,” which sought to move away from an ordered geometric design to a more picturesque, less formal approach. Pope’s words also anticipated the rise of ecological design that continues to attract contemporary designers. The “genius of the place” is today referenced interchangeably with notions of site-specific, context based, and environmentally sensitive design work.

Pope’s poem was published in 1731 at a time when the garden designer Charles Bridgeman and the architect John Vanbrugh were just starting to experiment with new design directions at Stowe. Previously, the site was an exemplar of the Georgian formal garden and shared more in common with the French style of André Le Nôtre than the naturalistic style that would follow. What Bridgeman started at Stowe would be continued and significantly advanced by both William Kent, who arrived in 1730 and took over as head of garden design in 1735, and by Lancelot Brown, who served as head gardener from 1741 until 1751. As Kent and Brown worked on the landscape, they were joined by the architect James Gibbs. And while Bridgeman may have launched a new design direction, credit today is given to Kent, Brown and their successor Humphry Repton for defining and popularizing a new landscape aesthetic. This new organic or informal style sought to design with nature instead of seeking to arrest and control it. Kent removed any potential misinterpretation of Pope’s poetic dictum when he stated: “nature abhors a straight line” and this design directive remains as relevant today as when it was first professed. (Price, 1842, p. 165)

Indeed, Ian McHarg’s influential book Design with Nature, published in 1969, advocated for designers to return to a naturalistic aesthetic legitimized through a continuity with the design work first developed by Kent, Brown, and Repton. McHarg summarized the attitude of the eighteenth century landscape gardeners by arguing that their close observation and imitation of nature corresponded to a respect there for.

There is another great bridge, the 18th-century English landscape tradition. This movement originated in the poets and writers of the period, from whom developed the conception of a harmony of man and nature. The landscape image was derived from the painters of the Campagna – Claude Lorraine, Salvator Rosa and Poussin. It was confirmed in a new aesthetic by the discovery of the Orient and on these premises transformed England from a poverty-stricken and raddled land to that beautiful landscape that still is visible today. This is a valid western tradition, it presumes a unity of man and nature, it was developed empirically by a few landscape architects, it accomplished a most dramatic transformation, it has endured. Yet the precurory understanding of natural processes that underlay it was limited. A better source is that uniquely western preoccupation, science. (1969, p.28)

McHarg argued that this latent respect for nature found in the eighteenth century English landscape garden was paralleled in the 1960s, where observation of nature was enabled by the science of ecology and respect for nature was a product of the new environmental movement. Yet in both cases this respect for the environment did not develop independently of larger landscape and social changes. In retrospect it has been claimed of the eighteenth century that it is no coincidence that the move to a design style more sensitive to the forces and flows of nature happened in conjunction with the development of the agrarian and the industrial revolution in Europe. These large-scale social and landscape transformations saw private properties expand, farms growing larger, forests being felled, and the population in cities increase as urban areas expanded to cover more land. Correspondingly, the effects of pollution were starting to be seen in the air and water. It makes sense that McHarg would share an allegiance with the eighteenth century landscape designers, as in his time and so too in ours, we are living through accelerating rates of environmental transformation, with continued privatization of land for access to resources, the growth of megaregions, the felling of rainforests, and of course, as a consequence of this planetary urbanism, an overall warming of the globe. As nature continues to be degraded, designers continue to work in a style that optimistically adopts characteristics of the threatened landscapes. The sinuous paths and curving planted areas of contemporary practitioners share more in common with those of Kent or Brown than just stylistic similarities. As it was in the eighteenth-century, so too does it remain true today that to design with
nature is an aesthetic act rooted in an ethical attitude towards the environment. The naturalistic aesthetic associates well with a contemporary concern for global warming.

Undoubtedly a concern for the environment remains a major motivation for designers today, but so too are new ethical imperatives. It is increasingly common to hear designers speak about social justice, economic inequality, gender discrimination, racism, and the rights of nature for example, none of which would have concerned Kent or Brown. Indeed, as Raymond Williams has provocatively written, at times the English landscape gardeners were practicing in ways and supporting a social system which we would find objectionable, yet unfortunately, at times still common today:

Significantly, also, the history of English landscape in the eighteenth century has been, in the standard accounts, foreshortened. Reading some of these histories you might almost believe — you are often enough told — that the eighteenth-century landlord, through the agency of his hired landscapers, and with poets and painters in support, invented natural beauty. And in a way, why not? In the same ideology he invented charity, land-improvement and politeness, just as when he and his kind went to other men's countries, such countries were 'discovered'. (1973, p. 120)

And here then we arrive at a central question of this studio: if the organic style, otherwise called designing with nature, is the best physical expression of an environmental ethic, what designed forms can other ethical imperatives take? Or even more generally, our question is, how do formal design strategies express ethical values? What are the relationships between physical form and social or moral function?

It is worth remembering, for example, that throughout the eighteenth century acts of enclosure were dispossessing many poor of their ability to live off the land and forcing a migration into city centers; trees were most often seen as a resource to support the empire's navy; women could not vote; homosexual acts were punishable by death; and England still participated in the slave trade — not passing the Act for the Abolition of the Slave Trade until 1807. Even a social moderate with today's mores would appear as a radical three hundred years ago. So, by imagining oneself back in time and in competition with Kent or Brown, students are giving a comfortable distance to launch a design and social critique of famous built works, and more generally of the history of the profession. This studio leverages a forced moral discontinuity experienced by students to motivate speculative alternative design proposals.

Richard Neustadt and Ernest May's 1986 book, Thinking in time, argues that the careful study of history can usefully inform future decisions. In the introduction to their book they state that the "use of history can stimulate imagination: seeing the past can help one envision alternative futures" (1986, p. XV). So too, this studio allowed for a critical engagement with disciplinary history in an effort to better understand contemporary design trends, to explore a greater diversity of formal strategies, and to advance landscape architectural theory. Furthermore, with an underlying aim to decolonize landscape architecture and critique the profession's Eurocentric lens, this studio acknowledged that the design and organization of space, at any scale that affects the configuration of the social and natural world, is necessarily political.

4 METHOD

This course asked students to imagine themselves in the eighteenth century England, 1731 to be exact. Students did not need to pretend to have no knowledge of the present and were even encouraged to speculate on how their projects designed in the eighteenth century would affect us today, but the studio was not concerned with time travel. The method of arriving in the past or seeking ways to return to the present were not considered interesting. Instead students were asked to be solely concerned with presenting a design proposal to Richard Temple, 1st Viscount Cobham, the owner of Stowe House, Landscape Gardens, and Park.

These alternative design proposals had to respond to two main charges. First, the design should address an ethical imperative, uncommon or foreign to the eighteenth century but commonplace or topical to today's society. Second, the proposal should be imagined as an alternative to a historically documented work. In other words, students were designing the antithesis to any work of Charles Bridgeman, John Vanbrugh, William Kent, James Gibbs, or Lancelot Brown, completed any time in the eighteenth century at Stowe. Additionally, due to the design work being completed a few hundred years ago, it was productive to consider both the technology and methods of landscape representation and construction.

While this studio placed an emphasis on developing a compelling final design project, the course also devoted substantial time to research. And so, an additional aim of this course was to demonstrate how research and design are self-supporting acts. It is believed that strong research will coincide with strong design propositions. In the case of this studio, the context was foreign to most students, having less...
knowledge of the eighteenth-century than of today. Yet it was argued that while not temporally displaced, it is often the case that designers will be required to work in foreign contexts and with foreign cultures. Thus again, the format and methodology of this studio was to be more broadly applicable.

This single-term studio was open to all eligible second- and third-year graduate students at the School of Architecture and Landscape Architecture (SALA) at the University of British Columbia (UBC), Canada, in the fall term of 2018. A group of fourteen self-elected to enroll in the course. The composition of the class was split between six graduate level architecture students (March), seven studying landscape architecture at the graduate level (MLA), and one dual-degree student (MARCLA). The studio was thirteen weeks long, with six reviews, followed by a final review in the fourteenth week of the term. Students worked in teams of two for most of the term, but some selected to work individually after the mid-term. In typical studio format, the majority of class time was scheduled for desk critiques, where teams would meet individually with the teaching faculty. The course was scheduled for two meetings a week of four and a half hours each.

5 FINDINGS

The course proceeded through three quick research by design exercises of two weeks each before focusing greater attention on one design project that was followed to the end of the term. The following discussion will describe each exercise in turn, with an introduction to the theory and structure of the exercise, along with the description of a sample student project to give a sense of the design work produced during the term.

5.1 Exercise one: “Stops: the house and temples.”

The aim of the first research exercise was to study the architectural elements of Stowe. It was the position of the studio that each discrete architectural object in the landscape can be investigated in two ways. On the one hand, the objects are built works and can thus be reduced to a set of structural, material, and maintenance decisions. In this regard, form and program are of paramount significance and measured drawings are best used to communicate the quantitative, objective reality of these structures. This is building and landscape architecture as an objective project and as a subject of scientific study. Historical texts and images served as the foundation for research and as this exercise proceeded, students were required to produce original illustrations, which included developing plan, section, and axonometric drawings of a selected architectural object in the landscape. Undoubtedly, at this stage the students would have benefited from a field excursion to visit Stowe, but the cost was decided to be prohibitive.

On the other hand, a second way to research these architectural objects is through studying their symbolic function. Building and landscape architecture of the eighteenth century, particularly in England, was focused on the symbolic meaning of design. Projects were overtly political and ideological and were intended to have direct and controllable impacts on the social and moral environment. Jonathan Lamb framed well the question posed to the students in this exercise, writing of Richard Temple, 1st Viscount Cobham, the owner of Stowe:

The material result of Cobham's indulgence of these heterogeneous notions, traced in memorials of friendship and icons of duty and pleasure, was a remarkable proliferation of structures: "Triumphal arches, Chinese houses, temples, obelisks, cascades, fountains, without end ... cupolas, spires, columns, carvings, statues, vases," "Temples, Pillars, Piramids [sic] and Statues." Walpole said, "Half as many buildings would be too many, but such a profusion gives inexpressible richness." The question is, what kind of richness, and for whom? (Lamb, 1996, p. 62)

And in this respect, the house, gardens and grounds of Stowe are a perfect study, being highly influenced by the social changes taking place in rural England and by projecting an enormous social impact on the eighteenth century and beyond. Yet, a representational challenge emerged quickly, as the symbolic function of building and landscape architecture is more difficult to illustrate than its structure. The primary purpose of a measured drawing is to communicate constructability, not symbolic effect. This studio sought to develop a qualitative drawing type, provisionally referred to as an “evidentiary collage” which could communicate this meta-structure of any project. Research began to answer, and subsequently illustrate, why projects were built, by whom, and under what conditions. In addition, students were asked to consider, for example, how the project communicates its meaning, at what scales it operates, how it was perceived, and then subsequently understood.
Divine Ndemeye, a third-year landscape architecture student, conducted research by design and investigated the Temple of British Worthies. Designed by William Kent in 1734, this temple housed sixteen busts of those who Richard Temple considered the most worthy British citizens. Included are monarchs, military figures, poets, natural scientists, and others, all of whom were men of European decent, with the exception of Queen Elizabeth I. Carved of stone and protected in niches which form an exedra, these busts remain in place today. Ndemeye sought not to propose an entirely new structure but to challenge the permanence of these monuments. It was important to recognize that while the figures represented have each made a significant historic contribution to British culture and our shared history, these individuals, as with all others, were fallible and contributed also to some social injustice and human suffering. Proposing that the busts be carved out of sugar, Ndemeye envisioned a temporary monument that forced a recognition of the role of the Atlantic triangular slave trade in the accumulation of wealth by elite Europeans. As the busts weathered, the carved faces would deteriorate, and sweet water would mark the face of the temple. The planting strategy proposed flowers of African origin be used to intercept the run-off before it entered the lake of the Elysian Fields (see Figure 1).

Figure 1. Addressing the worthiness of those in the Temple of British Worthies (2018). Image by Divine Ndemeye.

Working in this way, students gained a comprehensive understanding of existing built structures and their relationship to their surrounding landscape. They then responded with speculative design alternatives that illuminated previously unconsidered points of view. Ndemeye’s project made clear the link between material selection and social significance. Proposing the use of sugar instead of stone completely transforms the moral meaning of the temple and challenges future designers to consider the political dimensions of specifying materials for built works.

5.2 Exercise two: “Walks: the garden and grounds.”

While the first exercise was focused on discrete architectural objects, the second expanded the scale of investigation and turned attention to Stowe landscape gardens. As the research moved up in scale, from discrete temples to components of the landscape, a significant change was noted by the studio in how the symbolic function of projects were understood.

It was argued in the first exercise that the physical formation of the architecture and its social significance were inseparable. Symbolic meaning was given form and communicated to a target audience through a controlled visual interaction. Most often it was statements about the status of the elite that were reaffirmed through a viewer’s passive consumption of an image of an object. This method of communication through landscape formation was popular during the seventeenth century, especially in France for example, as Chandra Mukerji has explained, “the political culture of land control that was transforming the French landscape into a marker of the state’s power was showcased around the royal residences, particularly Versailles, in the formal gardens that mobilized the same technologies of material power used throughout the state but that employed them to create dramatic visual effects from natural force” (1994, p. 652).
The English landscape garden of the eighteenth century is however different. Certainly, at times the physical form has direct symbolic and moral significance, yet in other instances it is the performance of the landscape itself that is most imbued with meaning. The English landscape garden indexes not only a material domination of nature, but also displays an extended control over those who work the land. For example, the fields for which Kent, Brown, and Repton would become famous required a significant labor force to work the land. Participants act out the landscape in well-defined roles over and over again. Of course, the ability to correctly perform requires a specific physical formation of the landscape, but in this case, the landscape is acting as intermediary between physical form and moral significance via the performance of actors. Consider for example the overall dimensions and solar exposure of a field, where advantageous growing conditions necessitate a greater investment in labor to maintain the landscape as a well-kept lawn. Thus, in this example, planting strategy, slope angle, and overall dimensions are all intrinsically linked to a hierarchical social structure, acted out each time the field is mown. Planting trees for shade, a topography which captures standing water, or maintaining a lawn at half the overall dimensions would each contribute to an alternative relationship between landowner and landscape laborer. Students kept this distinction in mind as the research progressed.

Alena Pavan & Michelle Gagon-Creeley, graduate students in architecture and landscape architecture respectively researched the Grecian Valley. The valley was built on previously farmed land in an area captured by the expanding Stowe garden perimeter. Lancelot Brown designed a large sinuous excavation intended to fill with water and flood an artificial river valley. Unfortunately, the project was a failure. The site did not provide or hold enough water to produce the lake.

![Figure 2. Precision and labor in the Grecian Valley (2018). Image by Alena Pavan & Michelle Gagnon-Creeley.](image)

Yet, it is exactly this failure that Pavan & Gagnon-Creeley used to provoke some intriguing discussions. First, it must be recognized that Brown did not build the valley himself. He employed many laborers working long hours to manually move vast volumes of soil. In this project their effort was a failure relative to the designed intent. Yet, in addition to understanding the project as a failure, from their perspective in the present Pavan & Gagnon-Creeley noted that the Grecian Valley is a much-loved landscape of the Stowe garden. The consequent dry riverbed has been celebrated by landscape architects and the general public alike. As a response for this design research exercise the students used techniques of photo manipulation to render what the lake would have looked like had the project succeeded (see Figure 2). This effort questioned the degrees of tolerance and precision in landscape design. When viewing this work, one asks how it is possible that a failed lake could be equally celebrated as a vegetated valley. More generally it asks how we define failure in landscape architecture. We wonder, for example, if Brown had planned for the excavation of half the quantity of soil, would the project still have remained a success? Certainly, fewer hours of labor would have been committed to transporting soil across the Stowe garden.
5.3 Exercise three: “Drives: the park and woods.”

The third exercise again scaled up the scope of research. While exercise one focused on discrete architectural objects, and exercise two studied the grounds surrounding Stowe house, exercise three required the design research to move beyond the perimeter ha-ha to investigate the expanded landscape. Students explored how landscape organized infrastructure and urbanism in the eighteenth century. Yet, while the scale of landscape investigation increased, this exercise also focused on the technologies of landscape control. It was argued that the formal arrangement of larger landscapes have properties in plan and section that cannot be reduced to a useful typical. The arrangement of these landscapes are always site-specific and unique in every instance. However, while the overall formal geometry is less subject to a designer’s desires, the technology and material properties used in these landscapes have a significant and legible impact on the ground. For example, while every forest is different, planting equipment influences tree layouts, and while no two fields are the same, farming technology affects plant spacing and microtopography. The same is true of mines, where mining equipment determines a site’s surface impacts, and swamps, in which land drainage tools affect a swamp’s hydraulic regime, as well as many other landscapes.

To test this proposition, this research exercise began by drawing details of the newly invented technologies of landscape manipulation that influenced the spatial expression of a set of selected landscape types of the eighteenth century. In addition to the detailed drawings, a second drawing type was required to render this technology in use, illustrating its influence on the landscape in an exaggerated way by juxtaposing a certain area under technological control against an area without its influence. Lands brought under the influence of these newly acquired technological innovations were said to be improved. Ann Bermingham describes this environment well:

At the same time the improvement of the real landscape, increasing its agricultural yield, raised its commercial and monetary worth. Estates were valued not just because they conferred and embodied the prestige of lineage but also because they promised financial gains unknown to the grandfathers and great-grandfathers of the enclosing landowners. As a result of its new economic value, land at the end of the eighteenth century acquired new social and political value as well. (1986, p. 1)

Figure 3. Hedgerow urbanism, occupying the border (2018). Image by Jiahui Huang.

In response, Jiahui Huang, a third-year landscape architecture student decided to study the related issues of land enclosure and agricultural improvement. She began by focusing on the development of field technologies, such as the ever more efficient plow. Detailed drawings were used to show how the technology had consequence on the overall aesthetic of the fields, including plant spacing, furrow depth, and overall orderliness. As a design response, Huang wished to address the displacement of local residents resulting from acts of enclosure. Thus, Huang also studied in detail quick and dead hedges used during the eighteenth century to delineate field boundaries. By thickening this line, Huang developed a design proposal for a border condition beyond view (see Figure 3). This hidden linear occupiable space would serve as a free territory for the laborer or any others wishing to avoid the gaze of the landed gentry.
The conclusion of this project was the recognition that the organization of space conditions social structures. The expansion of fields through acts of enclosure that were dispossessing many poor of their land did not just change the physical world but modified also the political structure of society. Huang's design move, to return land for free expression and gathering, allowed the studio to envision alternative possibilities for the development of the agrarian revolution and reflected the contemporary organization of our own democratic and capitalistic society in a new light. To our benefit, this provoked the class to question both what spaces are missing and what new spaces could be designed to make for a more just and equitable society today.

5.4 Exercise four: “Retrospective radicalism.”

Speaking to designers at the Harvard Graduate School of Design in 2017, DeRay Mckesson reminded them of their critical role in imagining alternative futures, showing society how those futures could be built, and then lived. While Mckesson, a social activist and leader of the Black Lives Matter movement, continues to fight for justice, designers are needed to help show what a more equitable society could look like. If the role of the activist is to lead a movement, then it is left to the designer to envision and help build the destination. Mckesson put it in these terms:

If you can't imagine it, then you can't fight for it. It is a question of what does it look like? What does it feel like? What does it sound like? These are the things that I want to believe that our artists and designers actually do for us. That we think about art as both a window and a mirror. A window helping us see what could be, and a mirror helping us see who we are. (2017)

Undoubtedly, we live in a time of rapid social change. While Mckesson is an outspoken supporter of the Black Lives Matter movement, his words above could apply to many other organizations, from #MeToo to the LGBTQ social movement, the Occupy Movement, 350.org, the Water Protectors, or Idle No More, to name only a few. As a powerful sign of hope for future generations, many designers who enter academia are motivated by a desire to lead social change. While multiple course offerings currently discuss social justice, it is uncommon to explore the direct links between design and social activism, and specifically the relationships between physical form and social function, which can be hard to theorize and even more difficult to project the future impacts thereof.

If is often thought that environmental subtleties become more visible at extremes, with small changes having exaggerated effects. Many studios use these environments such that the impact of design will be most evident. This studio followed the same strategy yet explored social extremes. The moral and social landscape of the eighteenth century was entirely different from today. In that century, even the least radical student would find many of their opinions rejected by popular society. Back then, anyone designing with today's mores would be considered an activist. It is the goal then that by setting this studio into the past, not only will students observe the powerful links between physical formation and social function, but that contemporary design will be seen with new eyes. In this studio, students final design projects advocated that the social and moral significance of design is not a burden, but an absolute necessity that we must re-enerliven in a time of immense social change.
Lisa Kusaka and Valia Puente Flores, two architecture students developed a project that designed a series of spaces for the cohabitation of multiple species. Their three designs included a stable re-designed to accommodate an aviary and a fox burrow; a landscape bridge re-designed to provide waterfowl habitat, safety for hunted deer, and drinking water for livestock; and finally, a dovecote layered with housing for sheep and with a fish well at the bottom (see Figure 4). The spaces they designed supported mutualistic opportunities for collaboration between species, where, for example, the heat generated by the sheep warmed the dovecote, and surplus bird seed would feed the housed carp. They argued that environmental activism was non-existent in the eighteenth century, and the treatment of nature and non-human subjects was deplorable. Their set of hybrid spaces destabilized the familiar human to animal relationships and instead flattened hierarchies while still serving as usable architectural proposals. Through this work they argued convincingly that the spatial configurations of building and landscape architecture affect our ethical attitudes towards nature.

As a final example, Vincent Perron pursuing a degree in architecture, responded to the studio brief by proposing a retrofuturistic technology entitled the “happy helmet” (see Figure 5). In this provocative project, Perron traced the development of representation in the field of landscape architecture and noted that the ability to simulate nature through digital means has developed concurrently with the devastation of nature by human technology. Contextualizing this contemporary conclusion in the eighteenth century, Perron speculated on what would have happened if fully immersive sensory experiences were accessible to the average citizen. Instead of facing the challenges of the agrarian and industrial revolution, for example moving to an urban center and being displaced from the land, the proletariat could opt out of this failed future and instead willingly commit themselves to experiencing a permanent illusion. Landscape painters, landscape gardeners, and landscape architects would be hired to mass produce immersive representations of an idealized nature for consumption. The projected consequence of the proposal is a generation dislocated from the land, oblivious to the radical transformations of their environment, and committed to consuming images of nature rather than experiencing it.

These five exemplary projects demonstrate the success of research by design, where it is the act of designing that provokes theoretical questions and moves forward a research agenda. In the case of this studio, the goal was to achieve both a wider understanding and a critical re-examining of the history of landscape architecture.

This paper opened with a quotation from Denis Cosgrove writing in 1998 that landscape today falls within the domain of either the scientific study or personal pleasure. These words are mirrored by Karen M’Closkey, a landscape architect who teaches at the University of Pennsylvania, writing in 2014:

“We are left with an enormous gulf between the “planner and the poet,” between analysis and design, because the methods used to translate information into physical formations remain largely...
unexamined… It remains necessary to develop design responses that give physical and aesthetic expression to information in the digital realm beyond the pictorialization of processes or its quantification into graphs, maps, and charts. (p. 125)

When we read M’Closkey’s words we are left with a challenge – how can research inform design? Or more specifically, how does the collection of information and the use of data inform a contemporary aesthetic? Yet to ask these questions assumes that the primary determinant of aesthetics is information and, furthermore, that design is about finding the greatest fidelity between the two. In this studio we were attempting to step around this question and ask perhaps a more critical question – that of ends, not means. In M’Closkey’s characterization, the usefulness of information is for greater performance, but we should also ask what the objective of this performance is. Interestingly, this quotation also points to the fact the dominant aesthetic in the field of landscape architecture has changed little over the years, while at the same time, technologies of analysis and representation have advanced dramatically. This observation that the aesthetics of the work have changed less than the technologies with which we work, is perhaps a more important provocation. It leads us to question, if information has not had a direct and noticeable impact on the field then what other factors, which have presumably remained stable, could be affecting dominant landscape aesthetics?

For both M’Closkey and Cosgrove, we see the same characterization of the design field with an apparent rift between the scientific planner and the pleasure driven poet. Yet, if social and moral significance is a strong determinate of aesthetics, then searching for a link between objective science and subjective pleasures will necessarily be an incomplete project. The central proposition of this studio remains that physical formation is inextricably linked to social signification and that the ethical motivations of a work should have legible consequence on the aesthetic expression. Focusing on a false binary between the objective, amoral scientist and the biased, individualistic poet is not productive. Our current environment calls for the education of the ethical designer, concerned with their individual actions and cognizant of their responsibility to the larger collective.

In this studio, design was the method to rigorously and systematically study landscape history. Research was not limited to quantitative expression, nor seen as the sole domain of the scientist. Instead design research, as a method to study disciplinary history, taught an appreciation for the measured details of past built works while also translating these physical lessons into contemporary forms and expressions. A comprehensive understanding of what was built enabled speculative but grounded alternative proposals. The result is an approach to the canon which both recognizes its Eurocentric and elitist lens, but also welcomes and embraces diversity and ongoing critique. As new ethical imperatives and social injustices come to the fore, designers will be required to find new and appropriate physical forms to give shape to their social and moral significance.

7 REFERENCES

Title of Paper or Research: The Ethics of Form: designing new landscape histories through an alternative pedagogy

Author: Fionn Byrne

Institution or Professional Affiliation: Assistant Professor, The University of British Columbia (UBC), School of Architecture + Landscape Architecture (SALA)

Authors please select one of the following: I DO X DO NOT want to prepare a media statement for general release from the 2018 CELA Conference.

Media Statement: The history of landscape architecture has been disproportionately focused on a Western gardening tradition, which traces the development of the field from French formal gardens, to the English landscape garden, and finally to the American park. Canonical works in the field are overwhelmingly designed for an elite ruling class, while at the same time questions of labor, access, and discrimination are underrepresented. This research shows how design can be a method to interrogate historic works of landscape and building architecture, with a focus not on unearthing entirely new histories, but on challenging and rethinking the accepted history.

(Optional) Graphic Abstract:

DESIGN RESEARCH BASED DEVELOPMENT OF CAMOUFLAGE LANDSCAPE FEATURES TO PREVENT CRIMINAL UAV ACTIVITY

HEWITT, ROBERT
Clemson University email Hewitt@clemson.edu

NASSAR, HALA
Clemson University email Hassar@clemson.edu

1 ABSTRACT
The popularity of small consumer drones (UAVs) has prompted increased use of these vehicles in and around public outdoor spaces, with expected commercial drone numbers to reach nearly 7 million by 2030 (FAA). Research in landscape architecture related to UAV (drone) use in public space to date, has just begun to address conceptual approaches to landscape assessment, representation, and park user behavior (Kullmann, Park). While research related to the development of countermeasures for security purposes is more extensive, no research to date addresses the development of landscape countermeasures for the use of UAVs in criminal activities. The paper presents design-based research (DBR) methodology and findings funded by a multiyear, multidisciplinary NSF grant to develop landscape architectural interventions that discourage the use of UAVs for criminal purposes at correctional facilities.

Consistent with design based research (DBR) models (Brown), this project is complex, incorporating the development of a) landscape assessments for potential UAV launch and landing sites around prisons; b) the creation of UAV tracking and monitoring systems, and c) the development of model countermeasures. The paper describes design and placement of embedded landscape features utilizing landscape camouflage principles for UAV detection systems in forested upstate North Carolina. Modelled camouflage mimicked landscape features and were fabricated in two stages: 1) landscape superstructure, and 2) landscape camouflage. The embedded landscape features incorporated a launch warning system capable of alerting prison officials of drone launch locations, identifying future drone operators, and predicting drone flight paths.

Keywords: Design Based Research, Drones, Prisons, Security Countermeasures
2 INTRODUCTION

The development of small consumer drones (UAVs) has prompted increasing use of these vehicles in and around public outdoor spaces, such as parks, stadiums, outdoor amphitheaters, and festival grounds, with expected commercial drone numbers to reach nearly 7 million by 2030 (FAA, Beasley). Anticipated novel uses of commercial UAVs is projected to follow this trend, extending UAV use to the delivery of small commercial payloads across long distances over short periods of time, akin to proposals by Amazon’s PrimeAir service (BBC News). UAV ability to deliver such payloads quickly and over long distances, however, appears likely to extend to a broad spectrum of quasi-legal and clearly illegal activities, as well, including the smuggling of contraband.

Given the high demand for contraband items like cell phones, drugs, weapons, and alcohol in prison settings, the potential for UAV-related smuggling is raising awareness and concern about potential gaps in prison security planning worldwide (Guardian, Welch). For example, correctional facility authorities show increasing concern that smugglers can easily take advantage of existing surveillance blind spots using drone counter surveillance to guide contraband drops with little fear of being detected. This concern is reflected in recent sharp increases in overall reported prison smuggling incidents (Titheridge), in recent reports that UAVs are airdropping contraband into prisons (Rosenwald), and in reports that prison insiders are using cell phones to notify smugglers when and where to airdrop contraband from nearby hidden locations (Kalinich). Because available drone technology is constantly improving, authorities are especially concerned that drones will become more difficult to detect over time.

2.1 Background

The paper addresses findings from the first year of a multiyear, multidisciplinary NSF grant to develop countermeasures that discourage unauthorized use of UAVs in public space (including uses for criminal purposes). As part of that grant, design and research faculty from Clemson and Duke Universities examined threats posed to prison security by drone contraband smuggling around a forested upstate North Carolina prison site. Because UAV detection for prisons in this context encompasses complex analysis, collaborative tasking, and innovative design processes, the paper elaborates the project research process consistent with design based research (DBR) models (Brown). In broad strokes, this DBR project incorporates: a) landscape assessment for potential UAV launch and landing sites around prisons; b) UAV tracking and monitoring systems component development, and c) counter-measure development employing landscape camouflage.

Figure 1 NC Prison Surrounding Forest UAV Launch and Landing Site Analysis
More specifically, landscape assessment for potential UAV launch and landing sites around the prison evaluated: a) landscape cover characteristics within 1 mile of the prison; b) line of sight potential for drone pilots and prison security staff; and c) potential access/egress routes for contraband smugglers. Figure 1 illustrates the broader landscape context surrounding the Scotland Correctional Facility in North Carolina. The maximum-security prison is located in a forest clearing at the center of the illustration. A one-mile radius circle circumscribes the prison as an indicator of relative scale and distance. An airport lies partly within the one-mile radius, as does a small town, several water bodies, a stream, and several farms. There is relatively little topographic change across the illustrated landscape (approximately 200 across in gently rolling small hills). Relatively long sightlines extend from the prison’s surrounding forest edge to the fenced/walled prison yard, especially north and west of the prison yard. The entire landscape is crisscrossed with small roads surrounding the prison. There are numerous paths leading through the surrounding forest, which intersect with the surrounding network of small roads. In general, these environmental conditions provide numerous potential opportunities for drone contraband smuggling.

Landscape assessment also incorporated key prison personnel interviews to understand staff situational awareness (SA). For purposes of this DBR, SA describes human comprehension of temporal and spatial events within the prison and surrounding environments at three levels: 1) accurate perception of the relevant environment and its activities; 2) comprehensive understanding of those activities in the context of prison security; and 3) predictability of future situational changes (Pew). For purposes of the study, prison security personnel described their situational awareness of the surrounding landscape as a dynamic environment routinely probed in multiple locations by smugglers, who were suspected of communicating with people inside the prison.

Prison officials’ initial response to the perceived inadequacy of their security included a) the development of active measures around the prison property, with regular formal and informal patrols at varying times and locations to collect information and prevent potential smuggling; and b) the installation of battery operated motion-detection cameras with internal data storage mounted at hidden locations near suspected smuggling routes. After initial camera system installation, NC prison personnel recounted that they had discovered six drone-assisted contraband drops. They subsequently reexamined their security blind spots and identified several areas in the surrounding landscape that they believed might provide cover for future smuggling, offering good lines of sight for drone pilots or navigation spotters and potentially successful access/egress smuggling routes.

3 METHODS

3.1 Site Specific Landscape Architecture/UAV Issues and Conceptual Design

In further discussions with prison staff, design and research faculty proposed DBR in situ experiments to test an embedded Launch Warning Camera System (LWCS) that was capable of alerting prison officials of drone launch locations, to identify future drone operators, and predict drone flight paths. The proposed LWCS was intended to identify smugglers in real time and warn prison staff when contraband smugglers are present. It serves as the embedded landscape component of a more comprehensive detection system, named a Prison Reconnaissance Information System (PRIS), developed at the Duke University Humans and Autonomy Lab (HAL Website: http://hal.pratt.duke.edu/).

The embedded LWCS would incorporate solar energy collection elements, battery storage, thermal camera and microphone for image and acoustic data analysis, and motion detectors. It would operate within PRIS hardware infrastructure that includes: 1) a remote server that stores and transmits data, and 2) a mobile alerting interface (MAI) installed on secure prison personnel smartphones. The PRIS system is designed so that when HAL developed algorithms recognize intruders through LWCS real-time imagery analysis, a warning alert is transmitted to a mobile alerting interface (MAI). The PRIS then uploads data from the system server, displaying intruder location and drone directional movement sent to prison staff smartphones, enabling prison security response. For purposes of this project, PRIS hardware needed to be replicable and inexpensive, and in the case of the LWCS, needed to withstand operating conditions in the surrounding forest with little maintenance. Identification of the proposed
The LWCS site was critical to the DBR, not only as a site for experimentation, but as a locus for security design theory to include UAV drone countermeasures in existing landscape security design thinking.

**Embedded Landscape LWCS Placement as a Component of PRIS (Duke University)**

The diagram in Figure 2 illustrates Prison Reconnaissance Information System (PRIS) architecture with a schematic of potential LWCS embedded landscape components in the project landscape. Anticipating drone launch sites within 1 mile of the prison, research faculty analyzed potential experimental sites based on landscape cover, navigation lines-of-sight, and access/egress potential. A promising 16-acre area was identified approximately .4 miles from the prison. The site was surrounded by mixed mature and immature hardwoods and pines, contained a walkable path leading to nearby roads (.2 miles from a potential launch site). The site incorporated landscape elements capable of supplying cover for drone flight spotters. The experimental site is not identified here for security reasons.

Two small sites within the selected 16-acre area were field tested as candidates for LWCS experimental locations. One site exhibited more understory landscape cover, denser detritus with significant amounts of brush, trees tall enough for full solar exposure at their tops, and trees with foliage dense enough to discourage visibility from the ground. A path ran through the site with locations suitable for potential embedded LWCS testing. Initial in situ tests of the thermal camera, motion detector, and mobile alerting interface (MAI), verified motion detection reliability, thermal image legibility, and MAI operation.

Given this broader DBR context, the relevant DBR landscape architecture problem described in the remainder of the paper is: how can an in situ power supply system providing solar collection and battery storage for PRIS-related hardware be camouflaged in forested upstate North Carolina prison surroundings to evade detection by contraband smugglers attempting to launch and navigate drones?

Conceptually, this DPR landscape architecture problem is: nested in environmental contexts with differing situational awareness between two groups of people, using the same environment for conflicting security purposes (in this case one group using (UAVs) drones to counteract the security design of the other group). Heuristically, a designed landscape in this context advantages one group over the other. Pragmatically: a) the security group receives accurate perceptions and understanding from the shared designed environment, enabling an accurate prediction of future contextual change; b) the drone smuggling group receives less than full access to those perceptions and understanding - to the extent they are unable to fully predict future contextual change; c) the resulting difference in situational
awareness is proportional to the effective use of embedded landscape camouflage and technology; which
d) advantages the security group’s use of the shared environment. In terms of DBR processes, the
design of embedded landscape features in these contexts follow long-established camouflage principles
utilizing concealment, deception, misdirection, screening, mimicry and pattern, intended to maximize the
perceived integration of embedded landscape elements within surrounding landscapes (Hartcup, Root).

The design and camouflage principles elaborated in the DBR process complement existing basic
security design principles now largely focused to site hardening against blast damage delivered through
road systems with large vehicles. Existing security design principles relevant to the DBR process employ
in varying degrees: 1) unity (the repetition of a limited number of elements); 2) harmony (the elements
that are used to create unity must go together); 3) emphasis (giving added importance to certain
elements); 4) balance (the overall balance of weight and mass of site elements in a symmetrical,
asymmetrical, regular, or irregular arrangement); 5) scale (the relationship of the size of the site elements
and the pedestrian or user); and 6) rhythm (the sequencing of site elements).

3.2 Embedded Landscape DBR Utilizing Landscape Camouflage Principles

Employing camouflage principles to conceal and screen the solar collection and battery storage
components of the embedded landscape DBR considered: size and location of the solar panel and
battery with access open to sun all year, power generation, storage capacity, distance from thermal
camera, cable voltage capacity, gross size and weight of the embedded component. Solar panel
dimensions and battery size suggested a component with a minimum 20” x 14” x 16” interior camouflaged
space. Case study assessment of tree component deceptive camouflage for solar panels and microwave
towers, and case studies for potential mimicry of a variety of animal nest configurations common to local
forest trees recommended bird’s nests as initial embedded camouflage prototypes. Red tail hawk nests
were used as prototypes for the following reasons: a) they are typically found in large trees 13 to 69 ft off
the ground with good solar access like those in situ; b) their great variation in construction and vegetative
materials enabled ready prototyping with material found in situ; c) in situ tree species were common red
tail hawk nesting sites; and d) typical red tail hawk nest dimensions offered ample opportunity to conceal
and screen the embedded LWCS components (generally 28” to 38” in diameter and up to 38” tall).

<table>
<thead>
<tr>
<th>Embedded Landscape DBR Prototyping</th>
<th>Initial Nest Modelling Elevations and Plan Views</th>
<th>Red Tail Hawk Nest Case Study: small/large dimensions</th>
<th>Embedded Landscape Nest Prototypes: small/large dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Initial Nest Modelling" /></td>
<td><img src="image2" alt="Red Tail Hawk Nest" /></td>
<td><img src="image3" alt="Embedded Landscape Nest Prototypes" /></td>
<td><img src="image4" alt="Embedded Landscape Nest Prototypes" /></td>
</tr>
</tbody>
</table>

Figure 3 Red Tail Hawk Nest Prototypes
Construction and vegetative materials derived from shed twigs and branches, pine needles, and leaf detritus were gathered at the experimental site and transported to DBR assembly areas at Clemson University. The nest construction material was configured as two prototypes: one - 40"+ outside diameter, and one - 34"+ outside diameter. The larger nest was configured with thicker branches. Individual and small assemblies of branches and twigs were 3-D scanned to access the feasibility of 3-D printing for the nests or its various parts. Scanned branches were, in general, digitally incomplete or required too much digital reworking after initial scanning to efficiently and inexpensively utilize 3-D printing technology to completely or partially fabricate the nests. Instead, the two nests were modelled using construction adhesives and traditional “wood weaving” techniques.

Figure 3 above illustrates DBR iterative prototyping employed in the embedded landscape feature conceptual development. The DBR prototyping identified: 1) potential nest types by size, scale and configuration, 2) a model nest configuration capable of a range of suitable proportional dimensions, and 3) two nest configurations fabricated with woven wood branches and construction adhesives capable of enclosing the solar panel and battery storage components required by the LWCS and PRIS.

Figure 4 above illustrates digital 3-D modelling of the nests mounted in rendered trees similar to those on site. DBR evaluation of the 3-D models suggested the nests would be very difficult to see from ground level for several reasons: 1) the height of the tree and branch leaf cover; and 2) the restricted sight angles surrounding on site trees. The smaller of the two nests was evaluated as comparatively less visible and weighed less, potentially reducing the risk of the nest dislodging from its mountings in inclement weather. Evaluation of increased potential risk for personal injury/property damage resulting from the dislodgement of the heavier nest recommended a smaller and lighter prototype.

Because the woven wood and glued nest configurations occasionally lost structural integrity under routine transportation and handling, the nests proposed for field-testing were further prototyped as camouflaged superstructures. Two superstructure prototypes with examples of solar mounting plate and weaving pins, gridded elliptical trusses, and a solar orientation devise were modeled. One superstructure prototype was modelled with ¼” water-cut stainless sheet steel Type 304. Another superstructure prototype was modelled with ¼” CNC router-cut sheet Lexan polycarbonate resin thermoplastic. The steel prototype was estimated to weigh approximately 12 pounds, and require considerable effort to machine and weld. The Lexan prototype weighed approximately 4 pounds and was more easily machined and welded.

A smaller Lexan prototype for field testing was fabricated using split trusses assembled with Lexan adhesive and configured in a 3.5” on center interlocking grid. The gridded trusses interlocked through paired notches at intersection points. The initial prototype was fastened with additional ¼” plastic
4 DISCUSSION

The paper has presented descriptions of design-based research (DBR) addressing landscape contexts supporting the use of “drones” (UAVs) for criminal purposes at correctional facilities. Consistent with DBR models, this project is complex and iterative. The project specifically addresses a model for landscape architecture DBR that incorporates: a) the development of landscape assessment for potential “drone” launch and landing sites around prisons; b) the creation of “drone” tracking and monitoring systems; and c) the development of model countermeasures. Its methodology focuses on the placement and prototyping of embedded landscape components employing landscape camouflage principles to surreptitiously house “drone” detection systems located in forested upstate North Carolina. As a process, the methodology incorporates: 1) conceptual development of the design problems; 2) establishment of theoretical rationale for design problem resolution; 3) development of relevant design principles grounded in existing landscape security guidelines/camouflage design criteria; and 4) iteration intended to resolve complexity in human/machine/environmental design problems. In this case, the embedded landscape features are conceptualized and designed to: a) incorporate launch warning system technology to alert prison officials of drone launch locations; b) identify drone operators and pilots; c) predict “drone” flight paths; and d) accomplish these goals without detection by potential criminals at minimal expense. To illustrate DBR fabrication processes, the paper described model prototyping of camouflage and mimicked landscape features in two stages: 1) landscape superstructure, and 2) landscape camouflage. Fabricated models are now in preliminary field-testing prior to final testing at the prison site.

In broader context, the model landscape architecture DBR methodology presented here is consistent with general DBR methodologies structured in four iterative phases: 1) collaborative analysis of the practical problem; 2) development of solutions based on existing design principles and technological innovation; 3) iterative cycles of testing and refinement of solutions, and 4) researcher reflection to create design principles and enhance solution implementation (Reeves, T.C. 2006). From the standpoint of broader landscape architecture DBR applications, the paper suggests increasing potential for security design contexts across a broad spectrum of quasi-legal and clearly illegal conditions (Gregor). Extension of landscape architecture DBR akin to that presented here is immediately relevant to research currently underway through NSF sponsored grants related to the design of public space, given the rapidly increasing use of recreational and commercial “drones” (Cummings, M., Hala Nassar, Robert Hewitt). Similar NSF grants incorporate landscape architecture-based DBR to assess and redesign a wide range of urban transportation components, including street reconfigurations, street furniture design and placement, and detection warning systems to protect pedestrians, bicyclists, and UAV occupants. In anticipation of projected increasing automation and surveillance in the public realm across a wide range of contexts, DBR collaborations addressing the human/machine/environmental interface, akin to those presented here, suggest much more attention to landscape architecture DBR and its practical applications in this sector.

From a theoretical standpoint, extension of landscape architecture DBR akin to that presented here further supports foundations of landscape architecture design theory that contemplates increasingly insecure human/machine/environmental contexts. For example, while landscape architecture continues to contribute significantly to contemporary security design, contributions to date have focused more on design “hardening,” associated with a landscape’s ability to withstand physical attacks, especially the use of explosives delivered in large payloads. Increasing availability and advancing technology associated

snap ties to secure the woven wood camouflage. The Lexan superstructure was coated with a matt finish acrylic to reduce potential Lexan reflectivity, which might appear “unnatural” in a forest setting. The solar orientation devise was mounted for solar panel installation, and adjusted for appropriate solar exposure for the preliminary field testing site. The nest is currently mounted in a tree consistent with trees in the prison test site at a Clemson University field testing location. Initial tests will last 3 months through winter weather to assess construction weathering, fastening systems, solar panel function, and potential animal interference and damage. In response to anticipated field testing data, a final camouflaged nest will be field tested at the North Carolina prison test location. Following tests will assess the effectiveness of the camouflage and security design principles of the embedded landscape feature, and recommend final LWCS and PRIIS adaptations for final site design and system installation.
with “drones and like UAVs, however is widening the scope, range, size and intention of the security environment, To that point the above paper introduces model design considerations and concepts in line with “situational awareness theories” commonly associated with military and pilot navigation theory, as an important component of DBR. Further application of these theories in landscape architecture DBR, as well as other theories commonly in use among expanding collaborating disciplines offer important new ground for expanding definitions of contemporary landscape architecture theory in research and practice.

5 REFERENCES


Park, Ewing (2016), The usability of unmanned aerial vehicles (UAVs) for measuring park-based physical activity, www.elsevier.com/locate/landurbplan,


Figure 1. NC Prison Surrounding Forest UAV Launch and Landing Site Analysis 2018, Image by the authors.

Figure 2, LWCS Embedded Landscape Components 2018, Image by authors and Prof. Mary L. Cummings

Figure 3, Red Tail Hawk Nest Prototypes 2018, Image by authors

Figure 4. 3-D modelling of the embedded nest in a tree seen from tree top and ground levels. 2018, Image by authors
Creature Discomforts

Lipschitz, Forbes
The Ohio State University, lipschitz.4@osu.edu

1 ABSTRACT
We seldom think about where our meat comes from. This is no oversight—it is designed. The remote siting and placeless design of livestock production and processing allow society to avoid confronting the unsettling nature of slaughter. Hidden from public view, the ecologically and socially damaging nature of slaughter will remain unchallenged. Though design has facilitated the paradigm of industrial obscurity, it can also help to change it. If the realities of the system were rendered visible, society would be compelled to advocate for a more transparent, local, sustainable and humane model of meat production. This system need not be defined by society’s collective nostalgia for a pastoral past and historic barnyard vernacular. Rather, design could define new models for contemporary animal agriculture that acknowledge the industry’s importance in developing a sustainable and healthy food system that supports the world’s ever growing population. To this end, this paper explores the role of representation and design speculation in rethinking contemporary livestock production and processing systems.

1.1 Keywords
Livestock production and processing, critical representation, design as research
2 INTRODUCTION

Surprisingly, on the day it happens, I feel nothing. The weeks of anticipation turned out to be far worse than the actual event itself. It’s 6:30 in the morning and the outside air is cold. As the weighted doors of the abattoir push open, hot and humid air fills my lungs. A metallic smell hangs in the thick air. The room buzzes with activity. The rhythmic humming of various engines is punctuated by the staccato slapping of rubber boots on the wet concrete floor. A surprising stillness marks the adjacent holding area; a simple partition wall separates life from death. Plastic paddle in hand, a student ushers the first hog over the threshold. The black and white barrow ambles forward quietly, grunting softly. As Steve places a forked metal prod behind the hog’s ears, its entire body tenses. Steve removes the prod and the pig collapses, its body falling heavily onto the floor. As the prod touches its heart for the second time, its body tenses in one last spasm, vibrating eerily.

A heavy shackle slowly lowers to wrap around the pigs foot, before pulling the flaccid body upward. Steve effortlessly drives the knife deep into the pig’s chest. As he removes it, blood pours out in a steady stream. The pig’s free back leg kicks jerkily, reflexively pumping its life’s blood outward. As the outpouring slows, the hog is lifted upward yet again—its body slowly rotating. As the chain lowers the hog into the scalding tank, boiling water splashes onto the floor. Steam rises up toward the fluorescent lights. When the pig is transported to the dehairing machine, its body thunders as it tosses and turns behind the machine’s high steel walls. Bits of skin fly out and upward, hitting the ceiling and falling to the floor. The air immediately smells less of metal and more pungently of soil, manure and life as it meets death. As the hog tumbles out, it has lost all of its colored markings; its bristled black skin peeled off to reveal a soft and shiny pink undersurface. Is this the moment when animal becomes meat? Once it is stripped of its outer layers? Of its identity?

Before I can contemplate this transition, the animal is strung up yet again, this time not by shackles but by hooks. Its legs are spread outward, its head and ears hanging below its smooth and swollen belly. With another large knife in hand, a student slices behind the hog’s ears. Its head flops downward, held together momentarily by the soft tissue of its neck before being removed entirely. As the knife is drawn carefully through the hog’s abdomen, its skin and muscle slowly part and its deeply hued intestines spill downward into its chest. Once the entrails are removed, the student performs the final separation: a balanced circular saw slices the hog in two.

2.1 WHY MEAT MATTERS

Though Americans consume on average 200 pounds of meat each year, few stop to ponder the ways in which animals are bred, raised, and slaughtered. As anthropologist Noelle Vialles observes, animal slaughter “tends to be a somewhat ‘unpopular’ subject: no one wants to know about it” (1994, p. 125). Though the global livestock sector is arguably the most ecologically influential industry in the world, it remains largely hidden from public view. A paradigm of industrial obscurity allows us as a society to collectively avoid the unsettling realities of livestock production and slaughter. We are permitted to ignore its heavy footprint on the world’s land and water resources: the ongoing erosion of biodiversity and substantial contribution to climate change. It effectively allows us to ignore the form and functioning of some thirty percent of the ice-free surface of the earth, a total land mass equivalent to the American continents (Steinfield, 2006).

The United States slaughtered over 9 billion cattle, hogs, and chickens in 2018, at a rate of approximately 1 cow, 4 hogs, and 290 chickens per second (USDA, 2018). The consolidation and intensification of livestock farming has enabled this astonishing pace of meat processing. The industry increasingly produces livestock in much larger numbers on fewer farms known as Concentrated Animal Feeding Operations, or CAFOs. The US Environmental Protection Agency classifies an operation as a CAFO if it houses more than 1,000 cattle, 2,500 pigs, 10,000 piglets, 55,000 turkeys, 125,000 broiler chickens, or 82,000 laying hens (US EPA, 2008). With so many resident animals, it is not uncommon for a single CAFO to generate the same amount of waste as a city of 100,000 people (Imhoff, 2010). This waste often sits untreated in barns or large lagoons before being sprayed or spread on adjacent fields. Rain washes manure into some 35,000 miles of American waterways, while prevailing winds carry noxious odors to adjacent communities (Pew, 2013). Among the 200 compounds in hog manure include hydrogen sulfide, ammonia and the aptly named cadaverine, a substance reminiscent of rotting flesh (Zhu, 2000).
Though we might attribute our collective ignorance to the increasingly urban nature of our daily lives, the messy realities of meat production have not always been obscured from the urban environment. At the turn of the 20th century, slaughterhouses were common fixtures of American cities. Cattle and hogs were transported by rail to stockyards in Chicago, Cincinnati, St. Louis and Kansas City, where they could be processed and distributed to nearby markets (Pate 2005). Indeed, animal processing emerged as one of the first mass-production industries in the United States, from which Henry Ford is thought to have derived his mode of assembly line production. Slaughterhouses were not hidden from the public eye, but rather celebrated as icons of progress and innovation. During the World Columbian Exposition in 1893, more visitors explored the Chicago stockyards than any of the Exposition’s other novel attractions (Brantz 2001). The grand architecture of urban processing plants reflected the collective pride in the industry. Renowned architects Daniel Burnham and John Root designed the limestone gate that welcomed workers to Chicago’s Union Stockyard, carving a bust of the yard superintendent’s prize winning bull, “Sherman,” into its stone arch (Pacgya, 2018).

Following the publication of Upton Sinclair’s exposé, *The Jungle*, however, a collective distaste for the brutality of the meat processing industry began to outweigh our fascination with industrialized slaughter. As Richard Bulliet describes in his book *Hunters, Herders and Hamburgers: The Past and Future of Human-Animal Relationships*, contemporary American society “continues to consume animal products in abundance, but psychologically, its members experience feelings of guilt, shame and disgust when they think (as seldom as possible) about the industrial processes by which domestic animals are rendered into products” (2003, p 3). Our collective cultural guilt encouraged the relocation, rather than reformation, of the slaughterhouse. By the mid-1950s, advancements in refrigeration technology and the expansion of the interstate highway system enabled the construction of packinghouses in rural areas, closer to livestock producers.

Today, most urban livestock production and processing operations have been decommissioned. In stark contrast to the monumental architecture of the Union Stockyard Era, the architecture of the contemporary slaughterhouse is generic and placeless. The nondescript structures sit back from the street, often restricted from public access. The design of CAFO structures exhibits similarly generic qualities. Whether they are nestled in the mountains of North Carolina or the expansive plains of Oklahoma, the mass-produced, metal-skinned and mechanically ventilated structures look exactly the same. As anthropologist Timothy Pachirat notes “Although we literally ingest its products in our everyday lives, the contemporary slaughterhouse is ‘a place that is no-place,’ physically hidden from sight by walls and socially veiled by the delegation of dirty, dangerous, and demeaning work to others tasked with carrying out the killing, skinning and dismembering of living animals” (2011, p. 4). Such “designed indifference” has enabled the livestock industry to remain inconspicuous and largely unchallenged over the years. The remote siting and placeless design of livestock operations allow society to avoid confronting the unsettling nature of slaughter (Young Lee, 2008; Fitzgerald, 2010).

The environmental and social consequences of such designed indifference can be wide ranging. Historian Chris Otter warns that the willful ignorance of meat production “might create the conditions of possibility for cruelty of a new kind, on a greater, more deeply hidden scale (2008, p. 105). Indeed, just as consumers have become increasingly uneasy about the raising and slaughtering of animals for meat, the speed and scale of meat animal production has increased dramatically, while the quality of life for both the animals themselves and the workers responsible for their slaughter has arguably diminished (Fitzgerald, 2010). Hidden from public view, the ecologically and socially damaging nature of these industries will remain unchallenged.

Though design has facilitated the paradigm of industrial obscurity, it can also help to change it. I argue that landscape architects are well positioned to critically examine livestock industries and propose alternative scenarios. That we are economic, social, urban, and environmental generalists affords us a broad macro-level knowledge base with which to approach the cultural and ecological challenges of livestock production. Moreover, landscape architects have the capacity to think and communicate visually. We embrace the power and transcendence of visual images and their ability to communicate ideas across disciplines, cultures and even language barriers. By revealing underlying spatial patterns and relationships, and presenting them in a way that non-experts can observe and understand, we can critically represent the hidden realities of meat consumption. Finally, landscape architecture operates at multiple scales in both space and time, with an understanding that even discrete, site-scale projects are embedded in larger, dynamic social and ecological systems. This affords landscape architects the capacity to transform larger livestock systems through site scale interventions. This paper explores
opportunities for design to reframe and reimagine animal production and processing systems through critical representation and design speculation.

3      METHODS

3.1     (RE)REPRESENTING ANIMAL AGRICULTURE

As Americans increasingly live and work in cities, they have become further removed from the realities of the working landscape. Their understanding of the landscape is driven not by direct experience, but through representations. A study at the University of Southern Mississippi revealed that individuals who spend more time consuming media on television and online tend to consume more meat and are less likely to associate meat with its animal of origin (Lewis, 2018). The media is the primary communicator of the productive landscape, often relying on two contrasting aesthetic tropes: the pastoral and what might be referred to as the "agro-industrial sublime."

The pastoral is deeply rooted in a nostalgia for a quaint agricultural past that was never so simple. This aesthetic perpetuates the myth of rolling green pastures, lit by diffuse morning light, where the cows are happy and the dairy maids beguiling. This is a myth of “simpler” times, cleansed of the impure realities of slavery, exploitation and environmental degradation. In this way, the pastoral embodies purity politics: the pastoral countryside is a mythical counterpart to the urbanized center of economic and political power. Today pastoral imagery comprises the heart of food and agricultural marketing, used widely by corporate enterprises and small local operations alike. Take, for example, the advertising campaign produced by the California Milk Advisory Board that proclaims “Great Milk comes from happy cows. Happy cows come from California.” The myth of happy cows correlating to a higher quality product is hard to reconcile with the scale of contemporary dairy cow production in California, where the average size operation milks 1,250 cows (California, 2017). Claire Parkinson notes that “the notion of the happy farmed animal has been instrumental in realigning the animal-industrial complex with the notion of the caring farmer; the industrial scale of nonhuman animal suffering can thus sit, albeit precariously, behind compelling imagery and narratives of family farms, traditional practices, welfare standards and the corollary of bovine emotional contentment” (2019).

Within art and photo-journalism, a contrasting visual narrative has emerged. The works of George Steinmetz, Edward Burtensky, and Mishka Henner may be understood as forays into the “agro-industrial sublime.” In art history, the sublime is understood as the experiential aesthetic of a place or object that is so vast, magnificent and physically powerful that it defies comprehension (Burke, 1759). The sublime flirts with both terror and exhilaration. Unlike the romantic sensibilities of the picturesque and pastoral, the sublime experience is captivating because it is also unsettling. Just as 19th century paintings depicted the wilderness, so too do photographers like Steinmetz and Burtensky depict conventional working landscapes as awesome, but not personally unthreatening. The impressive scale and at times grandeur of feedlots, commodity fields and milking parlors is composed, framed and color balanced to our culturally calibrated aesthetic satisfaction. This trend is not new. National Geographic employed similar sublime imagery as early as the 1970 in the article “More food for our multiplying millions: The Revolution in American Agriculture” (Billard, 1970). Low aerial imagery reveals the expansive orthogonal axes of tidy wheat fields and feedlots, with tiny figures of combines and cattle conveying the immense scale of operations.

Both of these forms of representation oversimplify the cultural and ecological subtleties of contemporary livestock production. Looking at the expansive shots by Steinmetz, one might assume that the entire countryside is but an elegant cog in a giant corporate machine. And yet the majority of farms in the United States are owned and operated by families. This is not to say, however, that the family as represented in pastoral marketing materials is somehow more accurate. The farmer of today must be technologically savvy and well versed in global commodity trade. Even those productive landscapes that might appear pastoral on the surface are in reality “space- extensive industries dependent on the life of the urban market-place” (Cosgrove, 1998, p. 44). How might landscape architectural approaches to representation contribute to a more nuanced understanding of these systems?

This was a question posed to graduate and undergraduate landscape architecture students in a critical inquiry seminar exploring the history of livestock and poultry production in the United States. Lectures and discussions addressed the evolution of conventional and alternative paradigms of meat, dairy and fiber production, from colonization to present day. Students examined the typological spaces of animal agriculture, from field to slaughterhouse. Through independent research, site visits and selected
readings, students developed an atlas of meat production that graphically examined the livestock industry’s impact on the American landscape.

The following selected visualizations (Figure 1) explore the utility of different architectural drawing conventions, including plan, section, diagram and montage, in communicating the spatial and environmental implications of contemporary beef cattle production across multiple scales. Employing perspectival diagramming and anatomical drawing techniques, the upper left-hand image highlights how CAFOs alter animal health and behavior. Through annotated perspective, the upper right-hand image reveals the technological and physical dimensions of liquid waste lagoons and their accompanying environmental impacts. The lower left-hand utilizes plan and axon diagrams to communicate the relationship between state of the art livestock handling systems and cattle ocular anatomy and function. Finally, the lower right-hand employs plan drawing to explain the spatial and temporal organization of cattle slaughter.

![Figure 1. Graphic Strategies for Representing Livestock Systems (2018). Student work.](image1)

### 3.2 SPECULATIVE SLAUGHTER

Beyond representing livestock systems, could design speculation challenge the designed indifference of contemporary meat processing and, in so doing, suggest more transparent, local, sustainable and humane models of slaughter? In an interdisciplinary design studio, undergraduate landscape architecture and architecture students designed a masterplan for a multi-species slaughter facility on an urban, agricultural research station. Using a series of integrated conceptual, analytical and design methods, students developed innovative site strategies that engaged the design disciplines with livestock production and processing systems.

In addition to remote mapping exercises, students gained first-hand experience with the complex and at times unsettling spaces of meat production. Multiple field visits included an early morning hog-harvest, where they witnessed the sights and sounds of slaughter firsthand. Empowered by research and personal experience, students were asked to identify design opportunities that challenged stereotypes of meat production, processing, distribution and consumption. Using prompts provided by faculty, they explored how contradictions like attentive mechanization, personalized anonymity, controlled
transparency, and enlightened disgust could become catalysts for spatial intervention. Looking to each phase of production, they considered its spatial constraints, requirements, and opportunities for adaptation. Their designs considered the different scales at which these phases operated, as well as the social, political and cultural tensions that accompanied them. The final designs explored myriad spatial relationships including those between livestock, employees, consumers and their containers and contexts.

The project “Sublime Slaughter” acknowledges that the pastoral imagery that romanticizes the livelihood of livestock disconnects society from the sterile mass production of the meat industry (Figure 2). Exploring the relationships between humans and livestock through reflection and framing, the project juxtaposes the picturesque with the productivist spaces of feedlots and slaughterhouses. “Vantage Point” employs enclosure and sequenced views in order to mitigate cultural bias while reintroducing slaughter to the urban landscape. Inspired by cattle handling designs, circulation systems selectively hide and reveal productive programs on the site (Figure 3). “Herded Hydrologies” proposes experimental herding techniques that can support novel wetland ecosystems capable of storing and cleaning slaughterhouse and agricultural runoff (Figure 4). The hydrologic system is conceptualized as a test-plot for agricultural ecologies that can not only clean water, but utilize animals and landscape features to terraform these systems. “Double Standard” contrasts CAFO systems with free range husbandry practices. The slaughterhouse and a network of follies bring the visitors, inhabitants, and utilities of the site together. (Figure 5).

Figure 2. Sublime Slaughter (2017). Student work.
Figure 3. Vantage Point (2017). Student work.
Figure 5. Herded Hydrologies (2017). Student work.
3.3 CONCLUSION

Though the livestock sector represents one of the most environmentally impactful industries in the world, it has been largely absent from landscape architectural practice and education. As meat consumption grows worldwide, landscape architects can no longer afford to ignore one of the most economically and environmentally influential industries in the world. Architects and Landscape Architects are well positioned to examine the livestock industries and develop scenarios, typologies, and generative spatial principles that balance economy and ecology. The opportunities for such interventions are wide ranging. Strategically sited and designed composting facilities could be transform manure from an ecological liability into an economic asset. New truck back-hauling and barge routes could help affordably transport compost over long distances. Ecologically productive shelter belts could improve the interface between industry and growing urban communities. Expanded free range and sustainable husbandry methods, coupled with small scale processing and distribution networks, could improve the quality of life for both the animals and the people responsible for their slaughter. Such interventions could help define a new model for sustainable livestock production and peri-agricultural urbanization. The examples discussed herein represent preliminary attempts to engage the discipline with contemporary livestock systems and strive to be a springboard for further investigation.

4 REFERENCES


USING DESIGN-RESEARCH TO ADVANCE COASTAL ADAPTATION IN THE FRASER RIVER DELTA

LOKMAN, KEES
University of British Columbia, klokman@sala.ubc.ca

1. ABSTRACT

Coastal adaptation is a wicked problem. In order to bring divergent voices and disciplines together, we need to develop new forms of collaboration, alternative methods of visualization, and envision a range of adaptation approaches. The unique tools, methods and conceptual frameworks of landscape architects, positions them well to contribute significantly to the intellectual debate about climate adaptation. In this context, this paper discusses initial outcomes of an ongoing initiative entitled the Fraser River Delta Collaborative (FRDC), involving a collaboration of academics and student researchers from the University of British Columbia, alongside design professionals, local experts and decision-makers in the Fraser River Delta. With a rapidly growing population of nearly 3 million people, home the largest port on the west coast of North America, and situated along the Pacific Flyway, the region is exposed to a high degree of flood risk. The paper highlights outcomes of the first phase of work, which includes three distinct, yet interconnected studies: 1) the delta lexicon, 2) metabolic flows and critical infrastructures, and 3) the regulatory landscape. In conclusion, the paper addresses a need for design-research collaborations that enable knowledge sharing between academics, design professionals, municipal decision-makers and other stakeholders—fostering meaningful change while narrowing the academia-practice divide.

1.1. Keywords
Climate change adaptation; flood management; collaboration; landscape representation; visualization; multifunctional landscapes
2. INTRODUCTION

Coastal adaptation is a wicked problem (Jordan et al., 2010; Termeer et al., 2016). It involves many sectors and policy fields, including engineering, agriculture, infrastructure and transportation planning, industry, ecosystem management, and urban design to name just a few (Termeer et al., 2016). Rittel and Webber (1973) introduced the term 'wicked problems' to describe these complex and multi-faceted challenges that involve an array of stakeholders with differing values and perspectives. Incomplete knowledge, uncertainty, and divergent interests make it hard, if not impossible, for subject-matter experts, planners, and policy makers to agree on climate adaptation strategies that work for all stakeholders. Additionally, the multi-scalar, multi-jurisdictional and long decision-making timelines associated with climate adaptation often result in oversimplification and misrepresentation of interrelated social, environmental and economic issues (Everingham et al., 2016).

In order to bring divergent voices and disciplines together, we need to develop new forms of collaboration, alternative methods of visualization, and envision a range of adaptation approaches. This is where designers, including landscape architects, urban planners and architects can play an important role. The unique tools, methods, and conceptual frameworks used and developed by designers position them well to contribute significantly to the intellectual debate about climate adaptation. As Norderson et al. (2018: 8) argue: “working comprehensively and holistically across urban, ecological, and engineered systems,” designers can provide “a humanist impulse to a field typically dominated by technical expertise, bureaucratic regulation, and hard data.”

This is demonstrated by the recent success of competition-based initiatives such as Rebuild by Design (New York Region), Changing Course (Lower Mississippi River Delta), and Resilience by Design (San Francisco Bay Area). Transdisciplinary teams engaged in these initiatives are often led by landscape architects, architects and urban designer. The proposals developed by these teams often center around community engagement, and incorporate a wide range of adaptation strategies that combine flood safety with the creation of multifunctional landscapes, cultural activities and spatial quality. As such the proposals developed as part of these initiatives have helped to reframe discussions around coastal adaptation from one primarily seen as an engineering challenge, to one focused on the possibilities of design and spatial thinking in developing new social-ecological and spatial relationships.

At the same time, there has been a fair bit of criticism with respect to the compressed timeframes, unrealistic expectations, highly politicized results and ineffective management associated with these competition-based initiatives (Fleming, 2017; Trogrlic et al., 2018). These issues, in turn, have impacted the quality of the proposals in terms of their overall effectiveness, long-term adaptability, and responsiveness to local site/community needs (Fleming, 2017; Trogrlic et al., 2018). It has also been argued that these initiatives are difficult to replicate in regions that: 1) have not been subject to a recent flood-related disaster, and/or; 2) do not have access the amount of funding, resources, and investments available in major global centers like New York and San Francisco (Lentini, 2016). Nevertheless, what other regions can learn from these initiatives, and improve upon, are methods and principles centered around design-research innovation, multi-stakeholder engagement, and transdisciplinary coalitions.

In this context, this paper discusses initial outcomes of an ongoing initiative entitled the Fraser River Delta Collaborative (FRDC), involving a collaboration of academics and student researchers from the University of British Columbia, alongside design professionals, local experts and decision-makers in the Fraser River Delta. The overall aim of this the FRDC is explore how designers can: 1) support decision-makers in analyzing and visualizing current and future flood risks, and; 2) generate a range of potential adaptation strategies across multiple spatial and temporal scales.

2.1. Regional Collaboration in the Fraser River Delta

The FRDC seeks to fill a vacuum that has been created after 2004, when both the federal government of Canada and provincial government of British Columbia (BC) made decisions to download the responsibility for flood-risk management back to municipalities. As it turns out, municipalities have been reluctant to voluntarily pursue such a role, nor do they have sufficient capacity or access to funding to finance and implement flood control measures that meet new provincial guidelines (Stevens & Hanschka, 2014). This has not only resulted in unchecked urban development in flood prone areas, but it has also created a vacuum with respect to the advancement of collaborative, cross-jurisdictional planning and design approaches.
Currently, the Fraser Basin Council (FBC), a non-profit entity, is the only organization bringing together municipalities across the region to share data, to identify risks and vulnerabilities, and to develop a long-term regional flood strategy. A recent report published by the FBC states that the Delta “is presently exposed to a high degree of flood risk,” and concludes that there is a need for “the development of a comprehensive flood management strategy” (FBC, 2016: v). While the FBC is moving forward with consensus building, identifying regional priorities, developing potential shared solutions and pathways for implementation, as a non-profit entity they do not have any mandate or jurisdictional authority. As such, it is unclear as to how any policy recommendations and planning strategies will actually be implemented. Moreover, the FBC studies are highly technical, and mostly led by hydraulic engineers—leaving out the important perspectives of designers and planners.

For this reason, the design-research done by the FRDC seeks to foster processes and products that position designers, especially landscape architects, as leaders and meaningful contributors to debates and future visions concerning flood adaptation in the Fraser River Delta.

This first section of this paper will provide a brief background on some of the major flood management challenges in the Fraser River Delta. The subsequent section will discuss a number of design-research investigations by the FRBC that seek to visually communicate the spatial and temporal complexity of these issues. The last section discusses ongoing and future phases of work by the FRDC. In conclusion, the paper addresses a need for design-research collaborations that enable knowledge sharing between academics, design professionals, municipal decision-makers and other stakeholders—fostering meaningful change while narrowing the academia-practice divide.

3. FLOOD RISKS IN THE FRASER RIVER DELTA

Like many deltas in the world, the Fraser River Delta faces a range of socio-political, environmental and technical challenges with respect to flood management. The following section provides a high-level overview of various relevant issues in the region.

![Image of Metro Vancouver dikes upgrades to cost billions](image)

Figure 1. Recent headlines discussing Metro Vancouver’s vulnerability to sea level rise

3.1. Outdated Flood Control Infrastructure

The report estimated that it will require nearly $9.5 billion to update and reinforce the 250km of dikes in the Lower Mainland to protect the region against the implications of climate change and SLR. Most of these existing dikes have been built or upgraded to meet design guidelines set in 1969, but these standards did not take into consideration the implications of climate change, subsidence, seismic activity, and SLR (Shore, 2018). In the event of a “designed flood scenario,” which is similar to the record flood of 1894, over 70% of dikes would be overtopped (FBC, 2016). Similarly, with climate change and sea level rise, both the likelihood and intensity of storm surges is expected to drastically increase, which will lead to coastal dike breaches and overtopping.

3.2. Urban Development Pressures
Pressures to keep urban developments out of the floodplain have been an ongoing concern. The Lower Mainland Official Regional Plan, which was adopted in 1966, explicitly stated: “Floodplain [are] to be kept free of urban uses except where committed to urban development through early settlement, in which case further development for urban uses shall be contingent upon flood proofing.” Similar language can be found in successive regional planning documents. Yet, over the past several decades developments within the floodplain have proliferated across the region. As a result, over 250,000 people in the region now live within a meter of mean sea level (Lloyd, 2017). With the region expected to continue to grow by over 35,000 residents per year (Metro Vancouver 2011), pressure to develop in flood prone areas will continue to be a significant challenge in the future.

3.3. Agriculture and Food Supply
The Lower Mainland is an important agricultural and food producing region, generating more than 60% of the province's gross farm receipts (Crawford et al., 2012). This area is home to 68% of dairy operations and 80% of poultry operations in the province. The region is also known for its cranberry production, accounting for 92% of the cranberries in B.C. and 48% of all cranberries in Canada. Moreover, B.C. has become the largest producers of highbush blueberries in the world, with most of its production concentrated in the Fraser River Delta (Crawford et al., 2012). However, approximately 36% of the farmland in the Lower Mainland lies in the Fraser River floodplain and is potentially vulnerable to flooding during freshets and salination from rising sea levels (FBC, 2016).

3.4. Coastal Habitat Squeeze
Coastal habitat squeeze is another major challenge. The Fraser River Delta is the largest estuary along the Pacific Coast of North America. It is a critical crossroads along the Pacific Flyway where multiple paths of migratory birds converge. The Fraser River foreshore and selected provincial and federally owned lands were designated as a Hemisphere Reserve in 2004. The complex food chains found on the foreshore extend from tiny microorganisms to large mammals. The invertebrates, plants and small fish in the estuary provide a nursery for millions of out-migrating juvenile salmon. Moreover, the salt marshes and wetlands are key habitat for sturgeon and herring (Schaefer, 2004; Groulx, 2004). Yet, with most of the coastline fixed behind hard infrastructures (dikes and seawalls), key fish and migratory bird habitats including salt marshes, mudflats and coastal wetlands, are not able to migrate with rising sea levels. If nothing is done, these critical habitats might disappear in certain locations along the coast by the end of the century.

3.5. Legislation and Regional Coordination
Lack of leadership and funding on provincial and regional levels has resulted in a complex permitting landscapes as well as limited coordination between municipalities upstream and downstream from the Fraser, as well as communities along the coast. Key to this was the discontinuation of the Burrard Inlet Environmental Action Program and the Fraser River Estuary Management Program, often referred to as BIEAP-FREMP, in 2013. This intergovernmental program coordinated environmental management review and interagency communications for projects and shoreline developments in the Burrard Inlet and the Fraser River estuary. Beyond acting as a neutral body when it came to tensions between development and preservation, the BIEAP-FREMP streamlined environmental reviews by taking project applications (from municipalities or industries) and coordinating responses with all relevant agencies, such as Environment Canada, Fisheries and Oceans Canada, or the Port of Vancouver. Currently, municipalities have to navigate
this complex web of permitting agencies, zoning bylaws and other legislative hurdles themselves. This is not only very time consuming but also prevents innovation and risk-taking.

4. DESIGN-RESEARCH INVESTIGATIONS

As elaborated in the previous section, the social-ecological and spatial implications of climate change and sea level rise in the Fraser River Delta have yet to be fully understood. A lack of urgency and leadership combined with limited resources at all level of government—both from a financial and capacity perspective—have exposed the region to a high degree of present and future flood risk. At the same time, there have been few opportunities for design professionals and researchers to get involved with geospatial analysis or the generation of comprehensive adaptation strategies to address the abovementioned complex challenges. With few exceptions, projects and proposals awarded in the last decade were almost exclusively led by engineers, with landscape architects and planners taking on modest roles. This has perpetuated approaches to flood management based on a command-and-control attitude towards ecological systems.

In order to enable the exploration of alternative paradigms to coastal adaptation, the author, in collaboration with four Vancouver-based landscape architecture firms (HAPA Collaborative, PFS Studio, PWL Partnership, and Space2Place Landscape Architects) successfully applied for funding from MITACS, a non-profit organization designed to support research collaborations between industry and academia, to establish the Fraser River Delta Collaborative (FRDC).

At a most fundamental level the FRDC aims to collaborate with experts, municipal planners and engineers, decision-makers, and non-profits to connect knowledge, skills and resources. With an emphasis on design-research and the co-creation of knowledge, the ambition is to develop a range of human and non-human resources that become future drivers of policy discussions and decision-making. Key to this way of working is "the generation of a shared, usually visual, language that enables direct communication and mutual learning between different people (typically designers, researchers and stakeholders)" (Zamenopoulos and Alexiou, 2018: 19). As a multi-year project, the first phase of the FRDC focuses on visualization and provocation by developing ‘things’ (objects, visuals or situations) that promote critical thinking and behavioral/institutional change. From there, the emphasis shifts to visioning and developing adaptation approaches through co-design workshops with a range of stakeholders.

The following paragraphs will highlight outcomes of the first phase of work, which includes three distinct, yet interconnected studies: 1) the delta lexicon, 2) metabolic flows and critical infrastructures, and 3) the regulatory landscape. Key research questions included: Which communities and coastal landscapes in the Fraser River Delta are at risk as a result of projected sea level rise? What are the potential impacts of flooding on critical infrastructures? And, how can visualization help to change people's perceptions about current risks as well as their receptiveness to potential solutions? Outcomes of this first phase of work will be explained in the following paragraphs. Collectively, these investigations visualize the spatial implications of historical development and emerging regional trends (sea level rise, urban growth, transportation, ecosystem health, food security, etc.) on the form and functioning of the Fraser River Delta.

4.1. Delta Lexicon

The Fraser River Delta is vast and comprised of an incredible diversity in terms of spatial and social-ecological conditions. The Delta Lexicon seeks to document this wide range of land-water interfaces, which continue to evolve due as a result of human and non-human processes. As a means to systematically explore the region, the FRDC first developed a longlist of terms associated with geomorphology, flood control infrastructure, agricultural practices, and human settlement (i.e. dike, flood box, pump station, wetland, mudflat, etc.). The second step involved identifying where landscape conditions associated with these terms could be found in the region, and how they could be best documented.

As illustrated in Figure 2, each condition, whether unique or prototypical, was modelled at set scales (either 1:100, 1:200, 1:500, or 1:1000). By using a simple material palette (paper, newspaper, wire and chipboard in neutral tones) the models could be iterated quickly. The physical models are supported with a section drawing and key map highlighting the location(s) where this delta landscape condition could be found. In total 70 spatial conditions were documented in this way.
As a highly tactile and visual form of documentation, the *Delta Lexicon* serves as an educational tool through which the diversity of coastal landscapes in the region can be easily communicated with residents, planners, decision-makers and other stakeholders. By visualizing and making tangible the incredible diversity of spatial and socio-ecological conditions, it simultaneously communicates the complex human-nonhuman interactions in the region, and reveals there is no ‘one size fits all’ solution to address the multifaceted challenges of sea level rise. In doing so, the *Delta Lexicon* becomes a highly accessible tool to communicate which landscapes (including the people, plants and animals that rely on these landscapes) are implicated in the context of coastal adaptation.

4.2. **Metabolic Flows and Critical Infrastructures**

The Fraser River Delta, like any estuary, is incredibly dynamic and ever-changing. In other words, the landscapes documented in the *Delta Lexicon* are part of, and facilitate, a range of different social-ecological exchanges. In this context, the team adopted the conceptual framework of *urban metabolism*, which analyzes the flows of materials, resources and information within a region (Kennedy et al., 2007; Broto, 2012), to better understand the nature and spatial extents of these exchanges, as well as the potential implications of flooding on these exchanges.

The FRDC examined seven metabolic flows in the region: 1) *soil and sediments*, 2) *people*, 3) *cargo*, 4) *food*, 5) *energy*, 6) *water*, and 7) *biota*. For each topic, simple research questions were generated to guide documentation and visualization of the how relationships between metabolic exchanges, physical spaces, and flood management (Table 1). In order to communicate the spatial and temporal dynamics of these flows, animation was chosen as the desired way to communicate findings. This format not only has the benefit of being more accessible to multiple stakeholders, it also allows for the narration of a specific story by introducing information in a specific, sequential order (Figure 3).
### Table 1. Initial Research Questions to Help Identify the Spatial and Temporal Extents of Different Metabolic Flows in the Fraser River Delta

<table>
<thead>
<tr>
<th>Metabolic Flows</th>
<th>Research Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sediments + Soil</strong></td>
<td>What are the various soil characteristics in the region? Which areas in Vancouver are at risk of liquefaction? How much sediment is currently dredged? Is it contaminated? Can this be reused to nourish tidal wetlands or eroding beaches? What happens to clean construction rubble dug up as part of Metro Vancouver’s ongoing construction boom? Can this material be used to create coastal landforms to attenuate waves or reinforce existing dikes? How have people historically inhabited the delta? What are the trends of population growth and migration in the region? Which groups, communities and essential services are most at risk of potential flooding? How is tourism linked to water-based activities or landscapes? How can new plans for public transit, urban development, and services be incorporated with flood control?</td>
</tr>
<tr>
<td><strong>People</strong></td>
<td>Where are industries and associated logistics networks located and what is their importance historically, regionally, nationally and internationally? Which logistics-related infrastructures (airport, port, railway, highways, etc.) are vulnerable to flooding? Can any proposed logistics expansions double as flood management?</td>
</tr>
<tr>
<td><strong>Cargo</strong></td>
<td>What is the importance of agriculture in the region? What is being farmed and where? What are the implications of nutrient runoff? Which flood control infrastructures are key to agricultural operations? What are the implications of sea level rise / river flooding on agricultural production? Are there opportunities to introduce flood-resilient forms of agriculture and multi-functional land uses?</td>
</tr>
<tr>
<td><strong>Food</strong></td>
<td>Where are critical energy sources and sinks located in the region? Which parts of the energy infrastructure are at risk of a potential earthquake/flooding? Which essential services will potentially be impacted by flooding and associated power outage? What and where are opportunities to integrate energy generation into adaptation projects? How is our stormwater and sewage managed and treated? Where are CSO outflows, and how will climate change and SLR effect their functioning? Where are the sewage treatment plants in the region, and what happens to the sewage system in the event of flooding? How can stormwater management/sewer replacement/water treatment projects be coupled with flood adaptation?</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>What and where are different ecosystems located in the region? Which ones are sensitive, endangered, and/or at risk of sea level rise? What ecosystems are key to the Pacific Flyway? Which species are at risk and what are their habitat needs? Where are the lost streams? What is the relationship between tourism and ecology? How can stormwater management/flood adaptation become a driver to enhance biodiversity and access to nature?</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>In addition to showing which areas and flows are directly impacted by flooding, the animations also focused on illustrating cascading effects: secondary effects triggered as a result of a flood event (i.e. disruption to power and water supplies). The animation that focused on the topic water, for example, narrates how in the event of a major flood, sewage could back up into homes, businesses or essential services outside of the area directly affected by flooding. Due to the low-lying locations of the water treatment plants, flooding can also result in the release of untreated sewage directly into rivers or the ocean.</td>
</tr>
</tbody>
</table>
The animations also identify opportunities to structure new relationships between resource flows and flood management. The animation focusing on sand and sediment, for instance, reveals how considerable amounts of clean fill excavated during building construction, as well as dredged materials, can potentially be used for salt marsh restoration or beach nourishment. In doing so, the animations provide a starting point for approaching sea level rise adaptation not just as a risk, but also as an opportunity to think of new social-ecological and spatial relationships. As argued by Sijmons (2014: 2): “if we see the city as our natural ecology, analyze its structure and metabolism, and understand and use the process of its material flows, we can make the city more resilient and thus act to contribute to a more sustainable future world.” The animations are a first step in promoting new ways of seeing the Delta—not just as physical spaces but as a dynamic system of interrelated flows of water, waste, food, energy and living entities.

Figure 3. Stills of four of the seven animations mapping the metabolic flows in the region. Follow this link to sample the animations.

4.3. Regulatory Landscape
Flooding will have a visible impact on many aspects of the urban fabric: from (temporarily) inundating parks, buildings and roads to the potential contamination of drinking water, disruption of power supplies, and backing up of sewage lines. This means coordinating flood protection generally involves a wide range of actors, including private property owners, municipalities, asset owners, and provincial and federal agencies (Wang et al., 2018). In the case of the Fraser River Delta, explained earlier in this paper, this is perhaps even more challenging since there is no regional authority coordinating permitting applications. To illustrate this complexity, the team developed a series of animations illustrating the overlapping jurisdictions and complex permitting landscape local municipalities or First Nations have to engage when considering coastal adaptation approaches.

Figure 4 illustrates a section of the shoreline as part of the Musqueam Indian Reserve in Vancouver. Today, much of the reserve already resides in the floodplain. Flood risks will only increase in the future with rising sea levels. Depending on the location and type of flood adaptation measure proposed, the Musqueam
may have to engage a long list of local, provincial and federal bodies to get approval. Especially when this entails seeking approval for so-called ‘soft’ adaptation measures, which in contrast to a dike or seawall typically cannot be constructed on private or municipally owned land. Subsequently, this requires approval of many more permitting agencies, which is very time consuming and as such becomes a barrier to the implementation of resilient adaptation measures. As argued by Masoud (2017: 2), “in spite of the prevalence of contemporary discourse around resilient urban planning and design, traditional planning standards and codes continue to enable construction that shows little regard for the threats posed by climate change.” These animations instantly communicate that, if regional coastal resilience is to be achieved, better governance, policy and permitting mechanisms will have to be put in place to aid efficiency, innovation, and the implementation of no-regret adaptation measures.

Figure 4. Still from an animation illustrating the multiple, overlapping jurisdictions implied in projects involving the land-water interface (Drawings by FRDC). Follow this link to see the animation.

4.4. Future Phases

As part of future phases of work, the FRDC is currently planning a public exhibition at the University of British Columbia to display the work discussed above. The exhibition will be supported with a number of public events, including site visits, workshops and roundtable discussions to provide a platform for knowledge sharing between researchers, professionals, residents and planners from all levels of government. Additionally, the exhibition will also include a timeline, and scenarios visualizing potential futures for the region. The timeline documents interrelationships between key flood events, infrastructure developments, shoreline transformations, and legislation. The scenario planning exercise speculates on what the region may look like based on assumptions with respect to strategic planning foresight, level of regional coordination and whether adaptation measures are prioritizing protection or alternative ways to live with water (Figure 5).
In contrast to more conventional drawings prepared for real-world projects (i.e. for initiatives such as Rebuild by Design), which often illustrate desirable or attainable climate futures, these speculative scenarios foreground a spectrum of unknown, undesirable and potentially unattainable futures. They offer a space for explorations of utopian, dystopian or mixed-visions of conceivable futures. Drawn in a way that does not attempt to impose value judgments, audiences are provoked to question their own beliefs, feelings and attitudes towards the worlds presented in from of them (Figure 6). And by situating the scenarios in the future, they disclose the possibility of creating a different engagement with the present. In doing so, they can potentially have a significant impact on everyday politics of current debates surrounding climate change and adaptation.

Figure 6. Possible future scenarios for the Fraser River Delta (Drawings by FRDC).

The team is also actively developing connections with those communities and First Nations groups in the region that have limited capacity (staff, financial resources and/or expertise) to address issues of coastal adaptation. Using tools and methods similar to the Rebuild by Design initiative, but without the imposition of a set timeframe or set of deliverables, this work centers around collaborative engagements with municipal planners, engineers and other stakeholders to identify local assets, risk and vulnerabilities. Input from these engagements is used to develop potential adaptation strategies and design concepts.

5. CONCLUSION

Future flood risk due to climate change and sea level rise will disproportionately affect the world's major urban areas, many of which are situated along coastal areas (Wang et al., 2018). Designers have the ability to use unique tools and methods to visualize and represent potential climate impacts as well as to speculate on a range of futures for these coastal areas. In this context, this paper has highlighted a replicable way of working that uses design-research developed through academia-practice collaborations as a means to explore questions and approaches not constrained by a single jurisdictional client or anticipated set of deliverables. Especially for regions like the Fraser River Delta, which lack strong regional leadership, there
is a need to rise above single interests to think broadly about how to deal with the myriad of spatial and social-ecological implications of coastal adaptation.

The design-research investigations described in this paper are informed by research questions and methods of representation that are accessible and meaningful to diverse audiences. They aim at interconnecting the worlds of research, practice and regulation around pressing regional challenges. By adopting this proactive framework, the idea is to create a well-informed public, facilitate cross-jurisdictional collaboration, and inspire collective forms of action. As argued by Bishop (2015: 121): “changes in the environment are critical, but changes in the viewer can have a profound influence on attitudes to environmental change.” Situated in this context, the work by the Fraser River Delta Collaborative seeks to assists in the transmission of critical spatial knowledge in order to inform and strengthen coastal adaptation planning practices and policies in the region.

The main challenge of the FRDC, however, is that it lacks a directional path for change. In contrast to the Rebuild by Design methodology, which aimed at forging collaborations between authorities, private sectors, philanthropists and local communities (Trogrlic et al., 2018), the FRDC is building collaborations from the ground up. The processes and outcomes generated as part of future phases of work will determine whether this ‘grassroots’ model of academia-practice collaboration has indeed the potential to facilitate transformational change.

Figure 6. Sections showing different versions of the future. Top: evacuation and forced retreat if no coordinated action is undertaken. Bottom: planned retreat within the context of proactive coordination amongst all stakeholders. (Drawings by FRDC).
6. ACKNOWLEDGMENT
Part of this work was supported by MITACS through an Accelerate Grant, #IT09740. A special thank you to all members of the research team: Lee Patola, Sam McFaul, Chris Walker, Grace Morazzani, Nathan Ross, Kalli Niedoba and Candy Chen (University of British Columbia), Joe Fry and Allie Tweedie (HAPA Collaborative), Kelty McKinnon and Grant Fahlgren (PFS Studio), Derek Lee and Jenna Buchko (PWL Partnership), Jeff Cutler and Isabel Kunigk (Space2Place Landscape Architecture). The work is also partially an outcome of students that participated in the Cyborg Coast Studio, which was taught at the University of British Columbia in the Fall of 2017. A special thank you to students in this course: Brit Naylor, Lisa Ng, Rebbecca Anderson, Ru Jia, Alicia Kingdon, Zhou Li Chen, Niko Aliasut, Jessica Hoang, Celia Winters, Pauline Moskal, Jiauhi Huang, and Liping Dong.

7. REFERENCES


SURPASSING RESEARCH: INFORMED PRACTICE

TREIB, MARC

University of California, Berkeley  
mtreib@berkeley.edu

Abstract
In recent years, a growing coterie of landscape architects has asserted that design constitutes a legitimate form of research. They might argue that practice should not only share equal validity with academic "research," but in fact, that design is more comprehensive, more engaged with people and places, and more involved with real life than those studies left only in the laboratory or as publications. Realized designs bring research into the real world, take it further, and thus render it more viable. Not all design constitutes research, however. Common practice often repeats tried processes and produces conventional results. Thus, we need distinguish habitual from involved design practice: the latter contributes knowledge and to experience in a new way.

When does design represent research? Each involved design responds to a host of constraints normally left unaddressed, or addresses them in an innovative way; that is to say, because every design project is unique, the thinking and development behind it represent experimenting in a manner parallel to the normal sciences. The method or trajectory of designing is rarely as pure and precise as that of scientific inquiry, however. Unlike the laboratory, design must address an enormous number of factors that span those social, environmental, aesthetic, and material—quite unlike the laboratory where factors can be limited and controlled. When let out into the world, however, the bombardment of the hundreds or thousands of new issues left unaddressed in the laboratory may seriously modify or even nullify these findings.

The most significant contribution made by the landscape architect should be an overarching vision, an idea, a concept that enfolds many disciplines, at times rejecting the grand gesture, at times using it to shape a coherent work that surpasses functional criteria—and innovates. How to educate the involved designer, one might ask? With a curriculum that balances the qualitative and quantitative aspects of landscape architecture, and examines the life experience that results from both.

Key Words:  
informed/humanistic practice; Georges Descombes; Robert Royston; Michel Corajoud; Sigurd Lewerentz; Gilles Clément
In recent years, a growing coterie of landscape academics and landscape architects has asserted that design practice in itself constitutes a valid form of research. They argue that practice should not only share equal legitimacy with publication in the eyes of the academic institution, but that design, at times, may be a form of research more comprehensive, more engaged with people and places, and more involved with real life than studies left in print. Any reader who peruses journals such as Landscape Research and encounters a study based on as few as eleven “semi-structured interviews” (i.e., conversations) might honestly question why efforts of this type have been so privileged in academic programs, purportedly centered on design. Design brings detached research into the world, takes it beyond the printed page or digital screen, and renders it palpable and viable.

As one anonymous reviewer of my initial abstract rightly noted, however, one must distinguish between the act of design and the design as artifact, that is to say design as a verb or a noun. The thought comes first, but the act renders the thought concrete and yields the tangible artifact. Within those divisions of noun and verb we might also distinguish among background research performed before generating a preliminary solution, research undertaken during the design process, and research after the landscape is realized: the post-occupancy evaluation or case study, whether made by the designer or some other party. Responsible design depends on study—research, if you will—that strives to understand the context and predicted effects of the new design, the study of prior solutions to similar problems, and the lessons in space and form gleaned from historical and contemporary works. The resulting physical design may itself stimulate research into its address of programmatic issues, the performance of its forms and materials, and even the beauty of the landscape. All of these may constitute research. But only may.

While I believe that the act of design can produce valid research I would not argue that all design does so. Ordinary practice accepts what is known and most often yields only conventional results. In these practices the what—the specifics of the program and site—may be addressed, but not necessarily the why: those larger issues that surround the project. Although every design project is necessarily unique, the method by which the design is determined may be restricted to established paths. Therefore we need to distinguish ordinary or habitual design from what might be termed involved design practice that contributes to knowledge and/or experience in a new way.

When does design represent research? Each involved design responds to a host of constraints often left unaddressed, or addresses them in a fresh way: because every design project is unique, the thinking and study behind its development and realization represent a manner that in many instances parallels the experimentation of normal science. The method or trajectory of design is rarely as pure and precise as that of scientific inquiry, however. Unlike the laboratory, design must address a plethora of factors that span those social, environmental, aesthetic, and material—quite unlike the laboratory where factors can be limited and controlled. Sadly, when let out into the world, the bombardment of the hundreds or thousands of the factors left unaddressed in the laboratory may nullify the findings determined within its walls. As noted above, not all design is research. A wild, poetic, idiosyncratic proposal, for example, may be more or only about the designer, while neglecting the dicta of the program and the qualities of the site or any effort to produce findings more broadly applicable.

Initiating the design process usually involves some degree of self-education through the study of parameters and issues deemed critical to the work at hand. Although one attempts to be objective, at times the efforts may become more personal or poetic, like making collages from the materials of the site during the initial stages of design. Then comes analysis, which in its most objective form suggests work in the
laboratory. The initial design is then formulated and tested against the set of original goals and constraints. These constraints may be modified by the initial design, however; for example, when it becomes obvious that the client’s desires are far greater than what their budget allows. The process moves forward, with gives and takes, modifications to the design—and at times the program as well—until the most fitting solution is achieved, or time simply runs out. Then the design may be evaluated through simple observation or more serious post-occupancy study. Or perhaps just using “semi-structured interviews.” This admittedly over-generalized description of a design “process” that is far more complicated and rarely as straightforward, neglects the intangible aspects of the result, which may extend far beyond the idea of a “solution to a problem.”

I question why post-occupancy evaluation is regarded as research while the design of the landscape or building is not. Where would researchers be without the designer, and for that matter, where would society? Most researchers present only findings, which are in reality only propositions; they do not act upon or realize their findings to test them. And again I would stress that laboratory conditions, whether we regard the term literally or more metaphorically, are not those of the world.viii

Practice as Research
Landscape architecture is rooted in botany and the organization of living species. While the act of planting comprises an inherently optimistic exercise that yearns for triumph, learning may result as much failure as from success. In planting the Jardin en movement at the Parc André Citroën in Paris (1993) Gilles Clément purposefully enacted a proposition that allowed the inaugural species to thrive or wither in an almost Darwinian manner.ix Here the proposition took form as a garden realized within the context of a large park. Interestingly, within very few years the wildflowers of the garden’s initial year had disappeared and the site had become a garden of grass and shrubs alone. In one part of the Parc Henri Matisse in Lille (2003), however, Clément sequestered a grove of trees and shrubs behind a tall concrete wall with access denied to all but the specialists who track its evolution [figure 1]. Today the trees within have grown to heights far above that of the circumferential wall, although the research garnered from the project remains privy only to Clément and the team of naturalists that monitors the site. In effect, the project was conceived by its designer as become a living laboratory, its vegetation the subjects of an experiment studying the effects of an urban environment on plant growth.
In designing the playground for the Parc de Lancy (1980–86) outside Geneva, Georges Descombes attacked the issue of territoriality that often colors the actions of children at play. During a series of visits to local playgrounds, Descombes observed periodic conflict among the small children who use them. To mitigate these issues of personal territory, Descombes divided the sand box into five zones separated by low walls of concrete block [figure 2]. Yes, a love of geometry is evident in the play of circle and square. And yes, there is the potential issue of play by numbers of children greater than five. Nonetheless, a proposition about children’s play and territoriality directed the playground’s design—in all, a theorem enacted in sand, concrete block, and mortar. Research into children’s play was furthered by observation both before and after construction. In designing the play space Descombes used observation—which we may fairly regard as at least equal to those enacted by PhDs candidates—to produce a landscape that itself can serve as a test site studying play, which contributes to the viability of the design. If a sociologist or psychologist had made the proposal perhaps there would be no question of its constituting research. But if a landscape architect proposes a functional—and beautiful—solution… Is this not research as well? The results of the observations were beneficial not only to the designer for application in his projects that followed and to those may have had through observation reached their own conclusions, but also—yes, it must be admitted—for those who learned about the design and subsequent behavior through publication.
Don Schön has written of the “reflective practitioner,” the designer who engages in design at a depth beyond the superficial reading of the brief and course of ordinary practice. In *The Reflective Practitioner*, Schön distinguished between reflection-on-action and reflection-in-action: that is to say, considering what one will do, is doing, and has done. Perhaps, as a reviewer of this paper suggested, it is “reflection-on-action” that better constitutes research. This reflective thinking is critical to the making of an informed design. Robert Royston’s design of Mitchell Park in Palo Alto, California, accompanied the expansion of suburbia on the San Francisco Peninsula in the postwar period. A wading pool for tots was shaped with biomorphic curves in an idiom near and dear to the landscape architects of the time. More insightful perhaps was the pool’s section, whose depth was reduced at its center. After studying the design of related playground Royston concluded that risk should diminish as the child played further from parental supervision. This was followed by a period observation to test the design for its success. Perhaps this type of implementation followed by evaluation is typical; I can not say with accuracy one way or the other. My point is that the observation, the idea, and the implementation were done by Royston and his assistants: there was no playground or pool consultant, no sociologist arguing for “evidence-based design.” Royston had been educated as a humanist with a broad view of what constituted landscape architecture; understanding social behavior as well as art were formative in his approach to landscape design. Can the same be said of landscape education today? How does one educate the informed landscape architect?

I would like to believe that a curriculum of study embracing a broader humanistic view is critical to the development of informed designers. I do not mean to imply that specialists and consultants are never needed; given the complexity of contemporary practice it would be foolish to believe we can operate without them. However, I would welcome curricula which provide a greater balance between the sciences and the humanities so that we can balance the qualitative aspects of landscape study and practice with those more quantitative. One case study: In the early 1960s Jørn Utzon

Figure 2. Georges Descombes, Parc de Lancy, Geneva, Switzerland, 1981–1989 [Marc Treib]
was commissioned to design private houses for Danes who had served abroad, primarily in diplomatic positions. The housing market on Sjaelland had become so tight that recruitment for service had become difficult, as potential staff feared the difficulty in finding a place to live when they returned. Utzon’s scheme for the mix of attached and terrace houses is incredibly clever, planned to retain maximum open space while gaining economy from linking the units in swaths. That in itself was a rather clever idea. But Utzon chose also to operate at the psychological level as well. To dispel any sense of confinement, he created an inventive section for the houses on the greens. Most units were configured as Ls in plan, with the remaining outdoor area assigned to private use [figure 3]. The walls of tan brick, with tile caps that recall Danish vernacular building, were made only about three-feet high. Grading the common areas to at least four feet below the units’ floor levels, insured both privacy and long views. This increased livability was not the product of the researcher, but the informed practitioner who looked beyond the dicta of the program, beyond the science.

Figure 3. Jørn Utzon, Fredenborg Houses, Fredenborg, Denmark, 1964 [Marc Treib]

Some years ago we witnessed the arrival of what was termed evidenced-based design. To my mind all design should be evidenced-based. Evidence may produce the reasons for a design, but it will not produce the design. Over the years there have been numerous attempts to rationalize the design process, among them the so-called “pattern language”—although it is not really a language as much as a lexicon, since it offers no “grammar” by which to interrelate its elements. Analysis is only one aspect of design. The computer has provided us with enhanced power for managing everything from site and regional factors to determining the floor-area ratios of high-rise buildings. It even may produce form, that is if we can accept the products it generates. Despite any rationalized process, however, there are still qualitative decisions to be made. Which factors prevail? How do these factors interrelate? What form can or should they take? An informed design is more than a simple response to a functional program. It is more than its individual parts, just as a great work of fiction is more than a bunch of words and
sentences. Could a computer have created Michel Corajaud’s *Miroir d’eau* in Bordeaux, France? Deflecting a program that called for a standard plaza, Corajoud instead proposed a great sheet of water that mutates through cycles as mist, as a grid of small bubblers, and as a placid sheet. In all, the *Miroir* at times becomes a beach, a lake, a plaza, a wading pool, a hang-out, and a social event [figure 4].

![Figure 4. Michel Corajoud, Miroir d’eau, Bordeaux, France, 2007 [Marc Treib]](image)

Admittedly, the breadth and amount of information facing today’s student can be overwhelming; many curricula try to cover it all, or given constraints of time and resources stress only the sciences. I would like to argue instead for a more humanistic education with design, involved design, returning to a more central position in the program. Read literature; see the world of the everyday as well as the world away; look; note your subjective reactions to a place; consider; project. Caution: becoming an informed designer may severely constrain your life. No aspect of experience remains as just a meal or a room or a garden; instead they serve as a locus for the critical observation of space, materials, and behavior. In that sense, we might say that yes, design at its best does encompass research, but through the design surpasses it. Conversely design regarded only as research may lack poetry and a soul [figure 5].
Engineers calculate structure and flows; botanists know more about plant systems; geomorphologists are probably better informed about topography, and sociologists are said to know more about people and behavior. If all this is true, just what is the landscape architect’s contribution in the world? For one: an overarching vision, an idea, a concept that draws upon and enfolds all these factors, at times rejecting the grand gesture, at times celebrating it. At the Saint Peter’s church in Klippan, Sweden, the architect Sigurd Lewerentz installed a giant clamshell as the baptismal font. Fed from a simple copper tube, water drips constantly into the shell, with a consequent overflow that drips over its edge into a basin on the floor below. Within a nave constructed entirely of brick, the sound of that drip is amplified, condensing architectural experience into a single drop of water. Admittedly, not every building or landscape warrants or achieves this level of profundity; I imagine that few landscape architects ever try.

My call then is not for more research removed from design, more PhDs, more consultants—all are needed and all will take care of themselves. Instead my call is for landscape architecture curricula that educate informed or humanistic landscape architects. At times it has been achieved in the past; can it not be possible in the future?
Notes

i This group obviously includes those who have organized these sessions on Research by Design at this annual meeting of CELA.

ii The reference here it to universities who rank publications over constructed work and may only accept as valid publications in reviewed journals such as those lincluded on the SCOBUS list in Europe. While “research by design” is one way of establishing the meirt of design work, it should not be the only way. I feel that each discipline should establish its own standards of evaluation rather than having to jump through the same hoop with a one-size-fits-all attitude imposed upon it.

iii In all fairness, the article is more theoretical than empirical, and I have no reason to doubt the ideas advanced by its authors. Andrew Butler, Ingrid Sarlöv-Herlin, Igor Knez, Elin Ångman, Åsa Ode Sang and Ann Åkerskog, “Landscape identity, before and after a forest fire,” Landscape Research, August 2018, pp. 878–887. Note that the eleven “semi-structured interviews” seem to have required six researcher/authors.

iv I do not mean to imply, however, that publication is of only limited value. We know a single mathematical formula can be earth-shaking, as can innovative theories and discoveries in all fields broadcast through publication, whether through print or electronically disseminated.

v The disparity between the selective address of variables, and their full range may instigate substantial doubts about many so-called “scientific findings,” for example, those of environmental psychologists. One might even question whether the pairing of “social” and “science” produces a term that is inherently oxymoronic.

vi Artists may possess this license to stress personal expression, but there are certainly instances where that license should be revoked, for example when a poorly designed bench—in terms, say of its comfort or durability—is nonetheless regarded highly as sculpture.

vii Without dismissing the value of such exercises for students, I feel it is important to distinguish what distinguishes true communication from mere personal expression. For communication, both the transmitting and receiving parties must share a common language, which is often not the case with the collage.

viii My polemic and hyperbole aside, we know that the laboratory is a part of the world and of course has a vital part to play in our lives. Where would we be without science? But here I am referring specifically to those who would dismiss design of little consequence as research.

ix The efforts and effects of the gardener necessarily entered into the equation of course.


Rather than the current stress given to STEM subjects, could we not broaden the disciplines and the acronym to STEAM, adding a place for arts in the mix?

Anne Dahl, Ulrika Stigsdottir, Bettina Lamm, and Kristin Thorleifsdottir, “Evidence Based Playground Design: Lessons Learned from Theory to Practice,” Landscape Research, February 2015, pp. 226–247. As noted in the text, I accept that “evidence” gathering—research—should be the first phase of all design.

The book, despite what I see as its many theoretical faults, was an influential text during the 1990s, especially at the University of Oregon. Christopher Alexander, Sara Ishikawa and Murray Silverstein, A Pattern Language: Towns, Buildings, Construction, New York: Oxford University Press, 1977.
APPENDIX
The Landscape Research Record publishes top quality articles selected from manuscripts submitted to the Council of Educators in Landscape Architecture (CELA) annual conference each year. The Record serves the mission of the CELA, that is, to encourage, support and further education in the field of landscape architecture specifically related to teaching, research, scholarship, and public service. The Record contains recent research and scholarship in all aspects of landscape architecture, distributed in the following tracks:

- Communication and Visualization
- Design Education and Pedagogy
- Design Implementation
- Engaged Scholarship
- Film
- History, Theory and Culture
- Landscape Performance
- Landscape Planning & Ecology
- People-Environment Relationships
- Research & Methods
- Sustainability
- Urban Design
- Film

The steps and typical timeline of the peer review are described below.

**Abstract Submittal: September**
Peer-reviewed article publication on the Record starts from the abstract submittal to the CELA annual conference. The CELA executive office sends out Call for Abstracts around August each year.

**Abstract Review: September-October**
The Vice President for Research leads the track chairs in the abstract review. Double blind review is used. Each abstract is reviewed by at least two reviewers.

**Paper Submittal: January 20-25**
Authors of accepted abstracts receive the invitation to submit a full paper in November. The deadline is in January of the following year. The papers submitted at this time are not peer reviewed but only edited to satisfy the conference standard. Papers that do not follow the template of the conference are rejected.

**The CELA Annual Conference: March-April**

**Paper Review: May-June**
Papers that are submitted in time in January and stratify the conference standard become eligible to enter the peer review for the publication in the Record. The track chairs manage the review for their tracks and select high quality papers based on the score of abstract review, grammar, completion of study, contribution of new knowledge, format quality, etc. The track chairs then send out selected papers to at least two reviewers.

**Review Result and Revision: July**
Track chairs collect review results and make recommendations on the manuscripts. Papers that are accepted with revision requirement will be sent back to the authors in July.

**Final Manuscript Submittal: August**
Authors submit final manuscripts by August 31st. All papers are published by December 31st.

**The Outstanding Paper Award: December-March**
The CELA Executive Committee has authorized The Outstanding Paper Award for published papers in the Record. The Vice President for Research and track chairs collectively select the winning paper. CELA notifies the winner(s) of the award, which is presented at the following CELA Annual Conference.