MATERIAL FAILURE AND ENTROPY IN THE SALTON SINK

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1 ABSTRACT

The Salton Sea is a saline lake and the largest inland body of water in southern California, formed by a geologic depression below sea level at the bottom of an isolated basin similarly titled the Salton Sink. Once an outlet for the Colorado River to the Gulf of California, the depression was isolated over time through the deposition of sediments. The current volume of the Salton Sea originated in the first decade of the 20th century with the failure of infrastructures built to redirect the Colorado River for irrigation. The Salton Sea now functions both as an agricultural infrastructure, albeit one increasingly degraded by nutrients and contaminants present in the agricultural run-off irrigating the Imperial and Coachella Valleys, and as an ecological resource. This paper argues that the example of the Salton Sea demonstrates the capacity of material failure and entropy to generate novel landscape conditions that have properties which are valued.

The theoretical work of this paper ties together three distinct but related strands of contemporary theory impacting the field of landscape architecture: emergence and indeterminacy, new materialist thinking in philosophy, and discourse related to the concept of the Anthropocene. Theoretical arguments that engage these strands and a selective environmental history of the Salton Sea work together to advance our case for the generative capacity of failure and entropy. This case develops concepts for understanding how failure and entropy operate, applying a discourse that, within landscape architectural theory, has primarily focused on ecological phenomena and discrete sites to the behavior of geological, hydrological, sedimentary, and infrastructural assemblages at very large scales. Ultimately, the paper argues that there will be an important role for landscape architectural design that understands how to operate within the context of very large scale landscapes experiencing failure and entropy.

1.1 Keywords

Salton sink, Salton Sea, Colorado River, indeterminacy, emergence, fecundity

2 INTRODUCTION

The contemporary landscape history of the Salton Sink (Figure 01) is punctuated by a moment of failure which initiated a period of entropy. Together, these landscape processes have generated novel landscapes in the Sink at very large scales.

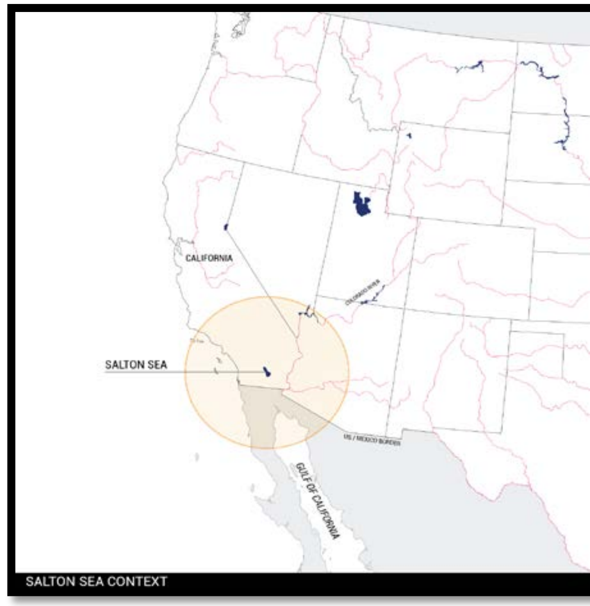

Figure 1. The shore of the Salton Sea & the Salton Sea in context. Photos: author

The contention of this paper is that this example, the history of the Salton Sink, can be understood by considering it in light of a series of related discourses — new materialism in philosophy, the nascent concept of the Anthropocene, and new positions emerging from contact between landscape architecture and contemporary ecological thought — and, in turn, that these discourses can be extended in new directions by considering them in light of the history of the Salton Sink. In order to bring this landscape into dialogue with that body of theory, this paper provides an overview of the state of the discourses it engages, an abbreviated environmental history of the Salton Sink, and a series of lessons related to understanding the operation of failure and entropy as landscape processes at very large scales. Given the significance of those discourses for contemporary landscape architectural theory and practice, this work ultimately speaks to the value that might be obtained through the engagement of landscape architecture with these processes and the landscapes that they make.

Before beginning to speak about the Sink itself, though, it will be valuable to carefully define two key terms for this paper — failure and entropy — and to explain, briefly, why this study is significant to landscape architectural theory.

2.1 Failure and Entropy

Failure and entropy are clearly linked, both conceptually and in the history of the Salton Sink. Both relate to disintegration, breakdown, and disorder, carrying negative connotations. Both would appear initially to be hostile to design, insofar as design intends to make, structure, and order. Yet, recent scientific discourse has altered understandings of these phenomena, suggesting that processes of growth and decay may be better understood as interwoven and interdependent, rather than mutually exclusive or necessarily opposed (Cook 2000, 125-126). Moreover, in both cases we are using these terms to describe critical processes operating within very large scale landscapes.

For the purposes of this paper, distinctions between failure and entropy begin with timespan: we speak specifically of moments of failure and periods of entropy, even though there are slow failures and fast entropies that might be discussed under other circumstances. It is important to note that we are not concerned with all kinds of failures, but rather with a very specific set of failures: failures of the material structures or properties of landscapes. The breaching of a dam is this kind of failure; so is a landslide, or the saturation of a soil with toxins following an industrial accident.

This focus on failure as a physical process shares characteristics with two concepts which are significant to contemporary ecology; one, disturbance, has had significant impact on landscape architectural theory, while another, bifurcation, has not yet. Disturbance has largely been of interest to landscape architects for its potential to indeterminately generate new landscapes, primarily through shifts in plant assemblages. While this paper shares interest in the generation of novel landscapes through phenomena that appear to increase disorder, it attempts to move away from exclusive focus on biological systems, which we believe obscures similar behaviors in other kinds of landscape assemblages — infrastructural, geological, or chemical, for instance.

By contrast, despite its significance in complex systems theory, bifurcation has infiltrated landscape architectural discourse in a much more marginal manner. It is nonetheless more closely related to the way in which we are discussing failure here, because, in addition to emphasizing suddenness, catastrophe, and the generation of novelty, bifurcation attends to generative behaviors within any assemblage describable by complex systems theory, not just biological systems. (This differing connotation is partly a matter of origin: the scientific concept of disturbance originates with the study of ecosystems, while bifurcation originates with the work of a chemist, Ilya Prigogine, on thermodynamics.)

Bifurcation refers to a moment of transition, describing the states of systems as wholes: "...ecosystems may flip into a new state relatively suddenly. Such flips [are] properly called bifurcations." (Lister 2007, 43) "non-equilibrium potential theory implies that ecological systems which can exhibit complex dynamics or multiple outcomes will typically not have leading indicators of regime shifts… drastic changes can appear in nature without warning" (Hastings and Wysham 2010, 471). We are using failure in a similar temporal sense — also a moment — but a narrower spatial sense, describing the point of catastrophe. Spatially, our use of failure is more similar to disturbance, as the spatial scope of both is initially restricted to the extent of the phenomena that is failing or disturbing. (The infranatural dam collapse that formed the Salton Sea is both a failure and a disturbance, and the Sink as a whole experienced sudden bifurcation.) Similarly, bifurcation and disturbance are not somewhat different terms for the same phenomena; rather, disturbance is a precipitating cause for change in the described system, while bifurcation refers to the fact of that change. It is very possible for a disturbance (or a failure) to be the precipitating cause of a bifurcation. (The Sink experienced bifurcation because of that failure.)
Like failure, entropy is a broad term, having expanded from its scientific origins as a specialized descriptor used as a measure of energy in the field of thermodynamics to refer more widely to states of loss, decay, and increasing disorder, "a turning towards" chaos . We are using entropy in this latter fashion, as a descriptor for the kinds of processes operating in leaky landscapes, landscapes which are decaying following some moment of failure.

2.2 Significance

At this point, it seems appropriate to ask: why should landscape architects be concerned with these two particular concepts of failure and entropy? What is their significance to the theory and practice of our discipline?

One answer is that we believe these concepts, considered in light of this example of the Salton Sink, shed new light on important on-going conversations within landscape architecture, particularly conversations that have begun by considering what landscape architecture might learn from ecology. We focus below on discussions of the importance of landscape processes to landscape architecture that draw on indeterminacy and emergence, concepts which are tightly linked to landscape architecture's investigation of the shift in ecology toward a "nonequilibrium paradigm" (Hill 2005, 132).

The significance of those conversations goes to the core of landscape architecture's historic and on-going responsibility for configuring physical interfaces between human cultures and our environments. These interfaces require alteration in light of contemporary recognition that environments are dynamic, characterized more often by flux than stability. Historical paradigms for urbanization were founded on the assumption of environmental stability, and have often failed when confronted by landscape dynamism. This flux is now being accelerated by planetary-scale human impacts, exacerbating and intensifying the mismatch between static, inflexible forms of urbanization and the landscapes they are embedded in.

The landscape architecture required by these conditions will be facile with indeterminacy, which leads to a second answer: the development of this facility opens new territory for the discipline. Specifically, we see opportunities for landscape architecture to operate alongside other disciplines engaged in a range of ecological restoration practices, particularly in anthropogenic wildernesses that emerge from “operational landscapes” (Brenner 2013, 20). Discourses of new materialism and the Anthropocene, summarized below, shed significant light on how landscape architecture might behave in these landscapes.

More generally, both failure and entropy share an important potential, which is the capacity to generate new landscapes and new characteristics within existing landscapes. Together, those propensities may be summarized as the generation of novelty. Landscape architecture is concerned, in large part, with making landscapes; and this role requires the ability to generate novelty, as defined above in terms of both new landscapes and new characteristics within landscapes. (Of course, novelty-as-newness is in particular demand when historical paradigms are failing, as mentioned above.) Thus, landscape architecture is properly concerned with understanding the various processes by which novelty is generated.

3 A BRIEF SUMMARY OF RELEVANT DISCOURSES

There is significant precedent for this stance on novelty, failure, and entropy. We ground our discussion in three distinct discourses: indeterminacy and emergence in landscape architecture, new materialism in philosophy, and the Anthropocene, a new epoch defined by human geologic agency.

3.1 Indeterminacy and Emergence in Landscape Architecture

The first of these is a set of on-going conversations within landscape architecture concerning the significance of new scientific paradigms, particularly but not exclusively in ecology, for landscape design. These new scientific paradigms are broadly related to one another, but engaged in varying measures by different theorists. The paradigms include complexity (emerging first from studies in thermodynamics as complex systems theory, but heavily applied to ecological phenomena through systems ecology), emergence (often described as a characteristic of complex systems), indeterminacy, and nonlinearity. These discussions also have non-scientific impetuses, gaining momentum from parallel developments in philosophy, particularly Continental philosophy as it has been adapted and understood by architects.

Towards the latter half of the 1990s, general interest in the design potential of engagement with natural processes took this specific turn toward insights from complex systems theory, propelled by things like the 1996 Landscape Urbanism conference at the University of Illinois-Chicago, the writings of James Corner (“Ecology and Landscape as Agents of Creativity” in the 1997 book *Ecological Design and Planning*, the 1999 book *Recovering Landscape*, edited by Corner), and the Environmentalism in Landscape Architecture symposium at Dumbarton Oaks (reflected in the book of the same name, published in 2000). Reflection on built and speculative works, such as the Tschumi and OMA schemes for Parc de la Villette, also played a significant role in this turn. While much of this interest was associated explicitly with “landscape urbanism”, significant components of it were not, such as *Environmentalism in Landscape Architecture* and the slightly later *Ecology and Design: Frameworks for Learning*. Where landscape urbanism took many cues from Continental philosophy via architecture — Waldheim was trained and originally teaching as an architect; architects Stan Allen, Alex Wall, and Mohsen Mostafavi wrote key texts in early landscape urbanist discourse — these other components were generally more closely associated with sciences, particularly ecology. Kristina Hill, who co-edited *Ecology and Design* in addition to contributing significant essays to *Shifting Sites* and *CASE: Downsview Park*, was trained as both an ecologist and a designer; Robert Cook, who wrote “Do Landscapes Learn?” for *Environmentalism in Landscape Architecture*, is a plant population biologist.

Both of these strands are linked by their interest in reconsidering design operations in light of ecological theories of balance, stability, and climax giving way to theories of dynamism, change, and flux. Our interest in this paper is focused in particular on a few recent texts that have reflected on this discourse, critiqued it, and extended it, paying particular attention to their treatment of *emergence* and *indeterminacy*. These texts are Rod Barnett’s *Emergence in Landscape Architecture* (2013), Julian Raxworthy’s dissertation “Novelty in the Entropic Landscape”, and *Projective Ecologies*, a volume edited by Nina-Marie Lister and Chris Reed that looks both backward on the history of this discourse and forward to its future.

"Novelty in the Entropic Landscape" centers around the question of how entropic processes generate novelty in landscape, defining novelty as "emergent newness" (Raxworthy 2013, 31). Sharing the theme of emergence, *Emergence in Landscape Architecture* is also concerned with how processes generate new landscapes, notably pointing to the concept of bifurcation as an appropriate concept for understanding the "switch[ing of] a physical system such as a landscape from one state to another" (Barnett 2013, 44). Earlier, James Corner's essay "Ecology and Landscape as Agents of Creativity" (reprinted in *Projective Ecologies*) asserted the importance of developing "an alternative kind of landscape architecture" of "the design of 'processes', 'strategies', 'agencies', and 'scaffoldings' — catalytic frameworks", "in which calcified conventions about how people live and relate to land, nature, and place are challenged" (Corner 1997/2014, 58-59). Each of these texts asserts that the creative orchestration the generation of novelty is central to the role of landscape architecture, not only as it copes with performative questions related to landscape dynamism, but also as it serves as cultural imagination for societies developing new awareness of their roles as a planetary change agents (Corner 1997/2014, 56). As we trace the history of the Salton Sink, three particular ways in which emergent novelty might be valued will emerge, adding specificity to this assertion.

Beyond this shared agreement on the value of novelty for landscape architecture, a pair of critiques, one by Raxworthy and one by Barnett, are worth noting. Raxworthy develops an extended critique of what he terms "the process discourse", in which he includes figures such as Corner, Waldheim, and other landscape urbanists, linked by their shared interest in deploying processes as agents of design. Focusing in particular on how the "process discourse" has reflected on the Parc de la Villette competition, Raxworthy argues that this discourse has often mistakenly conflated representations and representational strategies ("layering", "algorithms") with the dynamic reality of actual landscapes, leading to design operations that "produce simulations [of dynamic landscapes] that nonetheless become static themselves when built, because they do not produce novelty" (Raxworthy 69). In response, he proposes that landscape architecture return to and learn from gardening, "combin[ing] the use of 'tendencies' in the design stage with an 'ongoing feedback' relationship with the developing landscape" (Raxworthy 188). In the sections that follow, we ask the question: how might a response to this tendency to simulate rather than engage novelty be different if the response is developed through reflection on very large scale landscapes, rather than gardens?

Barnett offers a different critique, noting that "emergence in landscape architecture has been too closely tied to ecology", ignoring other domains that "emergence theory might enrich": "includ[ing] the historical, the cultural, the political" (Barnett 1-2). This critique is explicitly less central to *Emergence in Landscape Architecture* than Raxworthy's critique is to his dissertation, but it is central to this essay. As with Raxworthy, we ask a question instigated by Barnett: where might novelty emerge from assemblages which are not biotic — and thus overlooked by emphasis on ecology — but which are material and nonhuman?

In North America, the greatest impact of the ideas of indeterminacy and emergence within landscape architecture has been geographically concentrated in a broad northern swathe of the United States and Canada, sweeping west from the heavily urbanized coastal Northeast to the Rust Belt on and near the Great Lakes. Seminal projects such as Fresh Kills and Downsview Park were sited in this swathe; the schools of landscape architecture that have advanced it, including Penn, Harvard, and Toronto, are situated within it; and the speculative design research, such *Stalking Detroit*, that has propelled the discourse has been focused in it. Extending Jane Amidon's arguments in "Big Nature", we postulate that this may be no coincidence, but actually a result of the co-incidence of the seemingly tabula rasa conditions of post-industrial sites and shrinking cities with a design philosophy that may be more aimed at generating novelty in controlled conditions than in operating within unruly landscapes that already exhibit failure, entropy, and novelty (Amidon 2010). Such landscapes — the Salton Sink is one — call for additional concepts.

3.2 New Materialism

In parallel to these discussions within landscape architecture, there has been a significant shift in many fields including philosophy, political ecology, history, art, towards a new appreciation of the agency of materials, underwritten by the metaphysics of "new materialism". This shift has been relatively unappreciated by landscape architecture, yet has the potential to infuse the discipline with a new vibrancy, emphasizing not only vegetation as an agent of growth, but also the generative capacity of many other natural and subnatural actors: schists, salts, dams, lichen, molds, power lines, beetles, and so on.

New materialism emphasizes the agency of all things, objects, and forms of matter. In *Vibrant Matter*, Jane Bennett describes this agency as a “vitality”, “the capacity of things—edibles, commodities, storms, metals—not only to impede or block the will and designs of humans but also to act as quasi agents or forces with trajectories, propensities, or tendencies of their own” (Bennett 2010, viii). Emergence might be understood as one of the primary ways in which abiotic assemblages express this vitality.

Bennett, like new materialism generally, employs an ontologically flat approach to both human and nonhuman entities, in which “materiality is a rubric that tends to horizontalize the relations between humans, biota and abiota” (Bennett 2010, 112). This has significant political consequences; Bennett suggests, for instance, that “the figure of an intrinsically inanimate matter may be one of the impediments to the emergence of more ecological and more materially sustainable modes of production and consumption” (Bennett 2010, ix). Thus new materialism offers a broader philosophical framework from which we might begin to understand the *significance* of the question posed above regarding novelty and abiotic phenomena, particularly as landscape architects struggle with planetary-scale impacts of human activity.

3.3 The Anthropocene

There is much recent energy surrounding the notion — initially proposed in geology — of the Anthropocene, a new geologic age defined by the capacity of humans to behave as geologic change agents. Geologic change in the Anthropocene is intensely accelerated by human activity, and Anthropocene events are characterized by their speed relative to natural analogs. Triggering developments in a broad array of seemingly-unrelated disciplines, including arts, sciences, and the design disciplines, this notion of geologic agency has brought to the forefront both the scale of human agency and the degree to which human outcomes are linked to planetary forces, on scales which are geologic in both time and space.

There is also an ecological aspect to the Anthropocene. If most of the terrestrial biosphere has been shaped by anthropogenic influences, existing descriptions of “biomes” oversimplify human impacts and do not account for the complexity of interrelated ecological conditions that arise from human land use patterns (Ellis & Ramankutty 2008, 449). Using the neologism “anthromes”, environmental scientist Erle Ellis has identified an alternative category, defined as “mosaic landscapes composed of agriculture, settlements, and infrastructure in which remnant, recovering, and more lightly used novel ecosystems are embedded” (Ellis 2014, 176).

These anthromes and their affiliated novel ecosystems are, like biomes, characterized by landscape-scale processes of emergence and indeterminacy, but the failures and entropic processes found in them are differentiated by their hybrid quality, as they are triggered and sustained by mixtures of human and nonhuman inputs. These synthetic ecologies are prompting radical new forms of experimentation in practices of ecological preservation, conservation, and restoration, such as assisted migration, the design of novel ecosystems, and rewilding — landscape practices which are necessitated by Anthropocene conditions (Marris 2011). While these practices are outside the scope of most traditional landscape architectural practice, new paradigms of complexity imply the blurring of the standard disciplinary distinctions through the disappearance of discrete site boundaries and the consideration of multiple scales of influence (Hill 2005, 150-152).

Emma Marris’s *Rambunctious Garden* is an accessible but informed account of some of these practices. Like many of the landscape architects under discussion here, Marris critiques binary conceptions of nature and culture. She offers an expanded view of nature which is more inclusive of managed, disturbed, or novel ecologies, and which shifts away from the use of ‘baselines’ as a primary goal for landscape practices. Instead, she suggests that a more achievable and beneficial goal for ecological management practices would be to establish and define characteristics to assess ecological fitness that are specific to local conditions and site-specific histories in landscapes. For example, a disturbed landscape colonized by non-native species might nonetheless exhibit high biodiversity, and therefore be valued (Marris 2011). The Salton Sea is one such landscape.

4 THE SALTON SINK

How did the Salton Sea come to be so heavily influenced by anthropogenic factors? What is the history of failure, entropy, and novelty in the Sink that it lies within? Answering these questions requires an environmental history that shifts across radically different temporal and spatial scales, recognizing that forces as disparate as geology and infrastructure have combined, over time, to form current conditions.

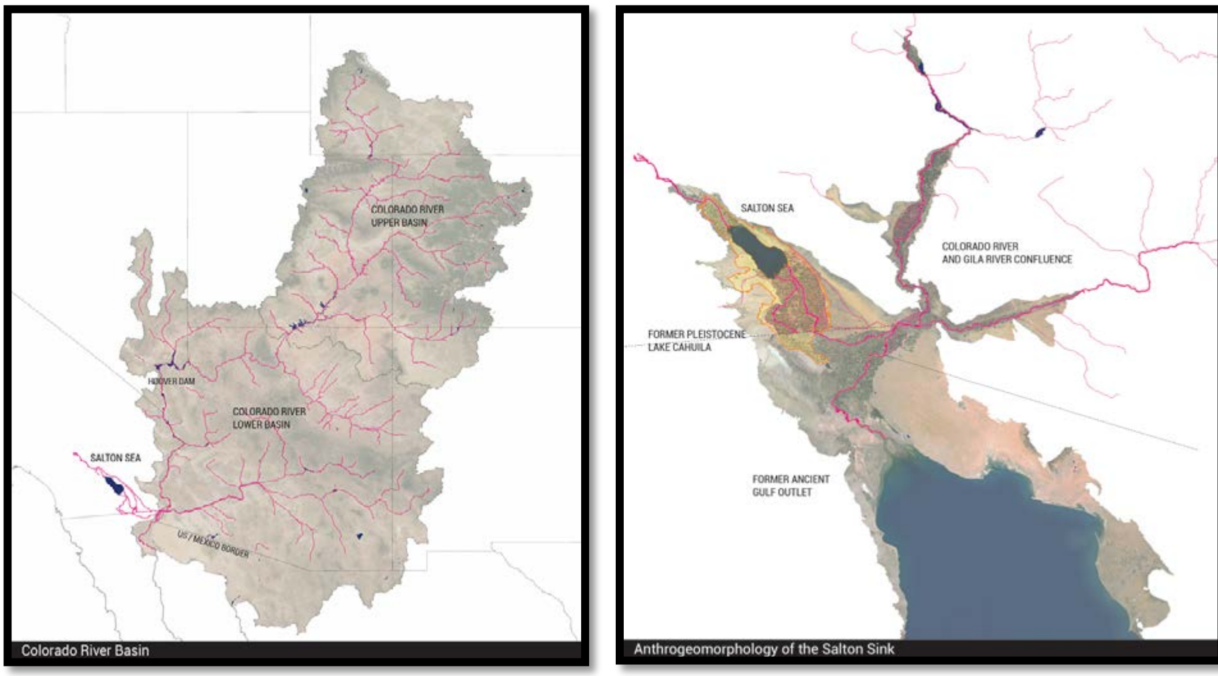

Figure 2. Colorado Rivers basin and its geologic origin: author.

4.1 Cahuilla

The Salton Sink is a deep topographic depression in Southern California, east of San Diego and close to the Mexico-United States border. Several million years ago, it was the outlet of the Colorado River (Figure 2). During a pluvial period in the Pleistocene, the depression slowly became isolated through the deposition of vast quantities of sediments, forming a low, flat ridge that produced two potential trajectories for the Colorado River: one eastern, into the Gulf of California, and one western, into the Sink. The river oscillated between the two; when it swung west, it filled the Sink with freshwater, forming a freshwater precursor to the Salton Sea, Lake Cahuilla. This lake existed and disappeared multiple times over the millenium (roughly, 700-1750) preceding the arrival of Europeans and Americans in the vicinity.

When those explorers and settlers arrived, they found the Sink in a dry period, a vast desert filled with salt deposits. Observing floods from the Colorado into the basin in 1891, they realized it might be possible to irrigate the sink by gravity using water from the river. By 1900, “California promoter and engineer” George Chaffey and engineer Charles Rockwood incorporated the California Development Company (CDC), which “ran a diversion canal from bedrock near Pilot Knob, a mile into the United States, through Mexico, and into the channel of the Alamo River” (McGuire 2003, 384). In 1901, “within eight months of its construction, the CDC's irrigation project spawned two towns and by the end of 1904, two thousand settlers were farming the desert—now productive land” (Reisner 123).

4.2 Infranatural Disaster

The current Salton Sea (Figure 2) owes its existence to an infrastructural failure of geologic proportion. After a couple years of low flow from 1902-1903, the CDC made the “hazardous move… to cut into the bank of the river" to create the "Mexican Cut" and channel the water "down a short quick descent" into the Alamo Channel, an old delta channel (Crane 1914, 217). Disastrously, though, the volume of flow in the Colorado oscillated upward in following years. In 1905, the newly engineered Mexican Cut was overwhelmed. The Alamo River became the main path of the Colorado River, diverting the Colorado's entire flow into the Salton Sink — as in the bygone era of Lake Cahuilla. "During the Great Flood onlookers described a raging torrent of huge waterfalls—as high as twenty, forty, even eighty feet high and 1,000 feet wide were recorded as the river gushed unrestrained." (deBuys and Myers 2001, 112). During the nine months of flooding, the volume of sediments deposited into the Salton Sink were equivalent to 4 times the amount of material moved for the Panama Canal (deBuys and Meyers 2001, 114).

In 1906 while the breach was still open, an account by Edmund Mitchell in the *North American Review* described the "surprise" of the emergence of a "new geologic feature" termed the "Salton Sea". The account begins with a footnote outlining the failed attempts to close the breach, which despaired at the "remote" possibility of "regaining control" (Mitchell 1906, 224). Even at this early stage in the emergence of the Sea, Mitchell identifies qualities that identify humans as geologic agents: the speed of change, the unfathomable scale of that change, and the similarity of this failure to "catastrophes" such as "earthquakes" or "volcanic eruption". Mitchell recognized that "we are witnessing a reversion to an order of things that had a prior existence in some remote period of the earth's history" (Mitchell 1906, 225).

Following multiple failed attempts to close the breach, on February 10th, 1907, a headgate was installed at original canal intake on the US-Mexico border at Pilot Knob. Closing the breach required "a workforce of nearly 2,000 men recruited from six local tribes, area settlers and Mexican laborers" and the help of the Southern Pacific Railroad to relocate "the equivalent of more than 3,000 railroad cars of timber, rock, gravel, and clay" (Boyle 2002).

4.3 Fecundity

The Salton Sink entered into a period of fecund growth following this failure. Agriculture, urbanization, and ecology all flourish on varying temporal spans, and were supported by or contributing to emergent novelty within the Sink. After the breach, investigations were undertaken by various disciplines to understand the physical characteristics, geology, systems, species, and abnormalities. Without a consistent flow of water, the level of the water slowly dropped from -195 ft below sea level to -250 ft, increasing in salinity as the water evaporated. In 1935, with the completion of the Hoover Dam and increased control over flows in the Colorado, the sea's water level began to rise again, reaching -240 ft by 1948. With this new stable source of water, agricultural lands expanded, particularly after World War II land reclamation (Carpelan 1958, 375-376). This period of infrastructure-building offered stability for agriculture in the Imperial, Coachella and Mexicali Valleys (Figure 3).

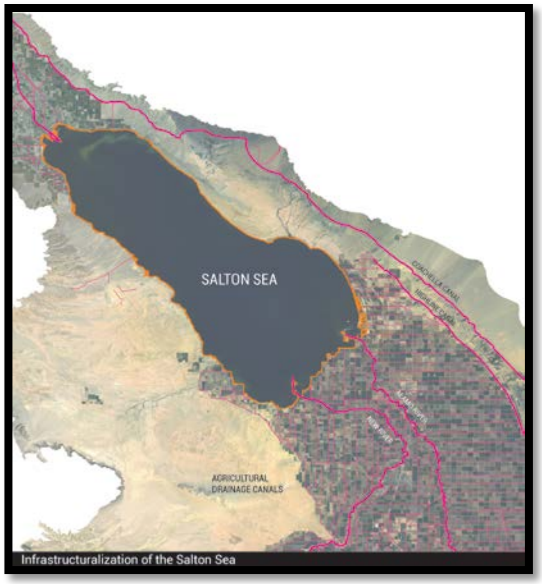

Figure 3. The Salton Sea as infrastructure: author

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Today, the Imperial Valley is allotted "20 percent of the Colorado River's water" for a productive return that includes, among other things, roughly "80 percent of the nation's winter crops" (Than 2014). The Salton Sea plays a vital infrastructural role in supporting this agricultural irrigation system as a catchment basin for agricultural run-off, which carries an array of contaminants that cannot be permitted to build up in agricultural soils, most importantly salt. Through subsurface tile drainage systems, the Imperial County Farm Bureau estimates the equivalent of 5,200 trucks of salt per year is deposited into the Salton Sea instead of leaching into the soil.

Figure 4. Novel ecologies; author.

4.4 Entropy and Novelty

Consequently, the Salton Sea now functions both as a hybrid agricultural-ecological system (Figure 4), collecting nutrients and contaminants while also functioning as a vital component of various ecosystems, including the Pacific Flyway. These two functions have entered a peculiarly tense relationship, which illustrates well the capacity of entropy to both generate novelty and threaten the landscapes it generates.

Because the sea has no outlet, dissolved materials that enter the sea tend to build up to extreme concentrations. An early account of high dissolved oxygen levels, algal blooms, anoxia, and fish kills was associated with concentrations of ammonia, nitrate, and phosphate. A field note from July of 1958 reads:

"Fish 'kill' general throughout the north end of the Sea. A few dead *Biardiella* floating at surface about a mile offshore from Fish Springs. Many dead on beaches" (Carpelan 1958, 380).

Although the concentrations of ammonia, nitrate, and phosphate were correlated to irrigation practices and agricultural run-off, the sea was considered, "highly productive and there seems to be an effective use and re-use of the nutrients that enter" (Carpelan 1958, 384). The algal blooms were mildly described as "conspicuous at times" (Carpelan 1958, 385). These conditions have only intensified over time, to the degree that the Sea is regularly described as being in crisis.

This state of crisis has led to an enormous 'ecological restoration' effort. These efforts recognize the sea as an important ecological landscape for maintaining infrastructural functions while providing habitat and protecting species. Estimates suggests that its current trajectory of decline could cost $29 billion and $70 billion in reduced ecological services over the next 30 years (Cohen 2014). In addition to ethical decisions surrounding the future of emergent novel ecosystems within the sink, the selection of maintenance protocols is further complicated by this economic calculus.

In order to establish future trajectories to mitigate negative ecological and economic impacts, there are several scales of ecological demands to consider. At the scale of the sink, there are recurring issues of fish kills and avian disease tied to agricultural run-off from the Imperial Valley. Ecological restoration proposals for nutrient removal include diked wetlands at the mouth of inflow channels. The sea as a marine habitat is threatened by over-salinization and nutrient pollution. Restoration proposals include pumping alternatives that would replace the saltier water of the sink with ocean water; solar evaporation ponds; and enhanced evaporation systems, a mechanized and aggressive form of salt removal by evaporation.

At the related scale of the nearby Colorado River Delta, conflicting agendas for appropriate restoration strategies stem from ecology boundaries being obscured by differing international policies for environmental policy, water management, and monitoring requirements. Restoration groups and agencies have recognized the benefits of reconnecting the Colorado River to its delta, to re-establish estuarine conditions benefitting ecological functions above and below the international boundary. However, for the Salton Sea, which depends on maintaining the current diversion of flows, this option poses serious risks. Thus not only entropy itself, but also management imperatives that interact with it at multiple scales have this dual capacity to both generate novelty and accelerate entropic processes.

5 LESSONS

We see three significant lessons emerging from this study of the Salton Sink in relationship to the discourses outlined in the second section: indeterminacy and emergence must be applied beyond ecology alone, scalar differences are central to understanding the operation of these processes, and the ways that novelty is utilized in the Sink help us understand why landscape architecture should value emergent novelty.

All three lessons relate directly to the third discourse we discussed concerning indeterminacy and emergence. Two of these lessons concern the scope of the application of the concepts discussed above, critiquing it. The first lesson's critique is informed by the discourse of new materialism, while the second lesson's critique is informed by the scalar concerns of the Anthropocene discourse. In contrast, the third lesson offers specific ways in which novel landscapes emerging from failure and entropy have been valued in the past and — significantly for landscape architecture — might be valued in the future, adding specificity to the general assertion that this discourse of indeterminacy and emergence is valuable.

5.1 Beyond Ecology

First, the history of the Sink shows that indeterminacy and emergence can and should be applied to understanding not only how landscape architecture might operate with regard to ecology, but also to other aspects of landscapes, particularly the infrastructural, geological, and chemical. Most discussion of indeterminacy and emergence within landscape architecture has focused on drawing from examples in ecology and, in turn, on landscape architectural methods which might cultivate indeterminacy and emergence within ecological systems. (To a lesser extent, though particularly where landscape architecture has drawn from architecture, there has also been a concern for social and programmatic indeterminacy and emergence (Berrizbeitia 2007, 177).) For instance, Corner's critique of ecology as source material for landscape architecture in "Ecology and Landscape as Agents of Creativity" focuses primarily on 'radical ecologies', which serve primarily to suggest the inadequacies of "conservation" and "ecological restoration" as inspirations for landscape praxis, inadequacies which are defined in terms of the absence of cultural imagination (Corner 1997/2014, 47-60). While it mentions "philosophical critiques of anthropocentrism [and] biocentrism", it does not explore the potential implications of those critiques for considering non-biological landscape assemblages on equal footing with biological landscape assemblages (Corner 1997/2014, 52). Later, Corner quotes Henry Bergson's contention that "the role of life is to inject some *indetermination* into matter", with Corner elaborating that "Bergson speaks of the infinite creativity of biological and imaginative life" (Corner 1997/2014, 59). This is wrong; it does no violence to the vibrancy of life to admit the vibrancy of all matter.

Beginning with ecology imposes a filter on the consideration of landscape, a filter that distorts and obscures other potential organizations, agents, and values beyond the behaviors of organisms. In the Sink, echoing new materialism, we see how vibrant and alive other forms of matter are: a dam collapsing, a sea evaporating, tiles draining.

5.2 Scalar Difference

Second, we contend that scalar differences are significant to novelty as it emerges indeterminately from failure and entropy. Raxworthy and Barnett both largely develop their insights in relationship to relatively small-scale landscapes: gardens, groves, parks, plazas, and so on. The Salton Sink, by contrast, is a *very large scale* landscape. The operations of these processes certainly have similarities at small and large scales, but there are differences, and these differences are important to both the development of adequate theory and the potential role of landscape architectural design.

Some of these differences relate to sheer volume of matter. While both a garden and a basin share the characteristic of being intentionally productive, the volume of matter produced by the application of nutrients and water to the soils of the Imperial Valley is exponentially greater than the volume of matter produced by watering a grove of fruit trees in a garden. The novelty which emerges from processes of failure and entropy at very large scales is radically more productive than novelty at smaller scales. This is true as a material of volume, but also in other ways. For instance, biodiversity is not tied linearly to size, because some species require very large ranges, and thus, when measuring plots of increasingly large scale, biodiversity increases more rapidly than mere area itself does. Moreover, fecundity at the scale of Sink necessarily produces great volumes of waste, in the form of agricultural wastewater contaminated with excess nutrients and chemical-laden runoff. This waste is too great in volume to be feasibly exported, and so the Sea is now managed in part as a landscape machine for the disposal of these wastes.

These two differences point to a broader, more fundamental difference: at relatively small scales, issues are relatively easily resolved through recourse to external resources. For instance, if the soil of a garden is contaminated, it can be removed wholesale, trucked off-site, and replaced by new, soil. At very large scales, such as within the Sink, interventions must depend more wholly on the manipulation of processes within the landscape in question and existing interactions with outside systems. Very large landscapes cannot be reconstructed in totality. If the soil of the Sink is contaminated, it can be remediated by restructuring waste flows so that they no longer bring contaminants into the soil, waiting as background processes such as microbial metabolism break down contaminants, and perhaps accelerating microbial metabolism through various artificial triggers (temperature, nutrients, etc.). But it will not be removed wholesale; the sheer volume of material makes that impractical.

As a result of these differences, attitudes and practices for management are different in large landscapes than in small landscapes, such as the gardens that are the focus of Raxworthy's dissertation. Lister makes this point in the context of discussion of "large parks": "'Large-ness' is a singularly important criterion that demands a different approach to design, planning, management, and maintenance—one that explicitly provides the capacity for resilience in the face of long-term adaptation to change, and thus for ecological, cultural, and economic viability." (Lister 2007, 35)

"Adaptation to change" becomes even more significant in landscapes of very large temporal and spatial scale that are affected by failure and entropy, like the Sink. In these landscapes, the "short-term disturbance and long-term, cyclic… change" that Lister describes as characteristic of park-sized landscapes is readily apparent and on-going (Lister 2007, 43). Indeterminacy and emergence do not need to be instigated; they exist by default (Figure 11). At very large scales, the role of the landscape designer may often be less to directly orchestrate novelty and more to react to failure, to channel entropy, and to identify specific emergent potentials that ought to be encouraged or discouraged. It is particularly important for designers to engage processes at this scale given the increasingly large (geologic) scales that humans are making landscapes at.

Figure 5. Non-Irrigated Industrial Landscape in the Imperial Valley; photo: author

5.3 Valuing Novelty

The third lesson returns to a question raised near the beginning of this essay: why is the novelty that emerges from failure and entropy significant? The case of the Salton Sink describes three specific ways in which that current landscape, emerging as it has from failure and entropy, *is* valued. These ways, in turn, suggests important categories of value which might be looked to by landscape architects designing for and with failure and entropy. Each of these ways might be understood in terms of utilization.The Sink is utilized for agricultural production. It teems with sheep and catfish, with fields of kleingrass (*Panicum coloratum*) and alfalfa, with rows of beets and carrots. This role has resulted in the infrastructuralization of the Sea itself, the assimilation of artificial nature as infrastructure, as the Sea absorbs irrigation drainage contaminated by salts, fertilizers, animal wastes, and agricultural chemicals. As ecosystems, environments, infrastructures, and urbanization grow increasingly entangled, the design and construction of such landscape machines is an urgent task for landscape architecture to participate in (Roncken, Stremke & Paulissen 2011).

The Sink is utilized by subcultures — bikers, “snowbirds”, skateboarders, outsider art like “Salvation Mountain”, and so on — which find space in the relative dereliction of the sink. This is one of the differentiating aspects of growth that emerges from entropy: it has the potential to be characterized by creative fecundity rather than more utilitarian economic vitality, and so it leaves space for practices, populations, and phenomena that are marginalized in areas of greater order. This fecundity may be ecological. This ecological fecundity is often performative, in that the ecologies that utilize disvalued landscapes undergoing entropic change often perform significant roles in both human and environmental systems (Del Tredici 2014). At the same time, it has the potential to be culturally and aesthetically significant, to “evoke ‘wonder and enchantment’” (Gandy 2013, 7). It may also be the fecundity of “terrain vague”, space defined by “the absence of use, of activity” and a corresponding (or resultant) “sense of freedom, of expectancy”: “void… as absence, and yet also as promise, as encounter, as the space of the possible” (De Sola Morales 1995).

It is often asserted that there is a potential conflict between design (which requires intent and organization) and the flourishing of subcultures (which thrive on neglect and disengagement) (De Sola Morales 1995). Learning to design with entropic processes offers one promising avenue to circumvent this potential contradiction, where design might prepare substrates for subcultural futures.

The Sink is utilized as a wilderness, even though its most visited and used wild place — the Sea — is anthropogenic in origin. Displaced from other potential stopping points, such as California’s Central Valley, by agricultural development, migratory birds come to the shores of the Sea in vast numbers, making the Sea “one of the most heavily used bird habitats in the country” (Than 2014). Features like these birds, the ancient rock formations surrounding the sea (on some of which the high-water mark of ancient Lake Cahuilla is still visible), and the desert itself fit immediately with one of the four primary characteristics of wilderness described in the Wilderness Act of 1964: “contain[ing] ecological, geological, or other features of scientific, educational, scenic, or historical value”. The people drawn to the Sink by these features often engage in the human uses that also form another of those characteristics, “outstanding opportunities for solitude or a primitive and unconfined type of recreation”. The Sink certainly meets the scalar requirements of the Act (“at least five thousand acres”). The only characteristic that it does not meet is being “untrammeled by man”, or “generally appear[ing] to have been affected primarily by the forces of nature, with the imprint of man’s work substantially unnoticeable” — but this characteristic may very well be obsolete in the face of Anthropocene conditions.

Each of these values, these modes of use, relate to contemporary goals and values within landscape architecture: the design of landscape machines, productive landscapes, and landscape infrastructures; designing for and with informal and spontaneous (sub)cultural practices; and designing new American wildernesses. When combined with movement beyond ecology and consideration of the significance of scalar difference, they point forward toward potential engagement between landscape architecture and the novel landscapes that emerge from entropy and failure at very large scales. This engagement has the potential not only to advance the body of landscape architectural theory concerned with indeterminacy and emergence, but also to illuminate avenues for landscape architecture to practically and productively participate in the design of large-scale landscapes shaped by human action, including restoration efforts like the one now underway in the Salton Sink.

5.4 Endnotes

1. For instance, Kristina Hill’s essay “Shifting Sites” (in *Site Matters*) and Robert Cook’s essay “Do Landscape Learn?” (in *Environmentalism in Landscape Architecture*) both discuss disturbance in some detail. Generally, landscape architecture has tended to be interested in an ontologically flat approach to disturbance, which recognizes that ecosystems do not distinguish between disturbances of anthropogenic and non-anthropogenic origin.

2. Nina-Marie Lister and Rod Barnett, both of whose work is discussed in more detail later in this text, are exceptions to this general inattention. Lister discusses bifurcation in “Ecological Design or Designer Ecologies?” (*Large Parks*), while Barnett discusses the concept in some detail in *Emergence in Landscape Architecture*.

3. The design potential of bifurcation is discussed in some detail in Casey Lance Brown and Rob Holmes’s article “Landscape Switching”, found in *Kerb* 22. The formation of the Salton Sea fits their definition of a “switch”: “switching landscapes progressively accelerate in temporal units and narrow in geographic scope along three defined tracks: switches, glitches, and twitches. Switches are serious, infrastructural-scale plans or disasters. They reach into the largest, geologic-scale events and armatures humanity has constructed.”

4. The Ancient Greek word that entropy descends from literally meant “a turning towards”.

5. See, for example, Waldheim’s discussion of Parc de la Villette in “Landscape as Urbanism”, in *The Landscape Urbanism Reader*.

6. Projective Ecologies brings together these two strands both in the backgrounds of the co-authors and in the content of the book itself.

7. The term “subnature” originates with David Gissen.

8. While this is true as a description of the overall propensities of this discourse, there are certainly exceptions, in both theory and practice, ranging from Sanford Kwinter’s discussion of wildness in

Far From Equilibrium to Elizabeth Meyer's reading of the toxic sublimity of Gasworks Park in the collection *Richard Haag: Bloedel Reserve and Gas Works Park* (ed. William Saunders).

9. In contrast to Corner, Raxworthy is explicit in allowing this vibrancy: "Inorganic materials are subject to environmental processes and undergo significant changes that result in important chemical and physical changes, at both the architectural form and the mineral level... while growth provides a model for change processes, I co-opt this sense of process to discuss inorganic materials too" (Raxworthy 2013, 29-31). He goes on to use specific examples of soil and erosive processes which demonstrate the agency of abiotic matter. However, this broadened lens on indeterminacy and emergence is not central to Raxworthy's project in his dissertation. It deserves to be addressed more directly, in more detail, and at other scales.

10. Ashley Carse treats this concept — the assimilation of nature as infrastructure — at length in "Nature as Infrastructure: Making and managing the Panama Canal Watershed".

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