OBSERVATIONS FROM THE LANDSCAPE PERFORMANCE SERIES CASE STUDY DATA

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ABSTRACT
As of 2023, over 200 Landscape Performance Case Studies have been published on the Landscape Architecture Foundation's (LAF) Landscape Performance Series (LPS) website, documenting sustainable sites. Downloadable case study data includes quantified performance benefits, which are indexed to one or more environmental, social, or economic benefit categories. Such data is valuable for extended research purposes (Yang, B. 2020; Wang et al., 2016; Luo & Li, 2015; and Modi & Ozdil, 2014). However, a lack of standardized metrics and methods within the data limits comparative analysis and broader research applications. To address this, we manually reviewed all benefit statements and methods documents to build a comprehensive database of project attributes, benefit categories, and associated metrics, coded using LAF's Evaluating Landscape Performance: A Guidebook for Metrics and Methods Selection (Canfield et al., 2018), with additional metrics added. Our analysis reveals 822 environmental, 640 social, and 330 economic benefit/metric instances. The most frequently cited metrics include 'amount of atmospheric CO_2 sequestered' and 'site visitation and use.' Environmental metrics clustered around stormwater, potable water, and habitat/species richness; social metrics focused on visitation, engagement, and health; economic metrics were cited less frequently and showed less thematic clustering. Patterns emerged by climate zone and project type, with stormwater management consistently the most cited benefit. Frequently cited metrics tend to be those easiest to assess. Our findings also reveal several new metrics developed post-2018, reflecting evolving priorities such as climate adaptation and equity. This research provides a foundational dataset to support evidence-based design and future landscape performance assessments, beneficial for practitioners, academics, and students. It also suggests updates to the LAF Guidebook and improvements to LPS data reporting standards.

Keywords
Landscape Performance Data, Benefits, Metrics, Methods, Landscape Performance Case Studies

1 INTRODUCTION

Designed landscapes provide various environmental, social, and economic benefits. However, measuring and documenting such benefits can be challenging, in part because there is no standardized way to evaluate a landscape's performance (Barnes, 2024a). Yet, increasingly, landscape architects must justify the measured value of their built work (Canfield et al., 2024; Egan & Dalke, 2024; Whitlow et al., 2021; McCoy, 2018; Kapper & Chenoweth, 2000). By utilizing performance metrics, the benefits landscapes provide to society and the environment can be quantified. Quantified benefits help promote the beneficial impacts of sustainable design and are useful for students and practitioners engaging in evidence-based design practices (Newman et al., 2025; Barnes et al., 2024b).

To support landscape performance assessments, the Landscape Architecture Foundation (LAF) published its first comprehensive resource in 2018, *Evaluating Landscape Performance: A Guidebook for Metrics and Methods Selection* (Canfield et al., 2018). The Guidebook is structured into three primary realms: environmental benefits, which include 16 benefit categories; social benefits, with 10 benefit categories; and economic benefits, with 7 benefit categories. Each category includes a description, assessment considerations, and a list of potential metrics and methods that can be used to measure benefits within the category. The suggested metrics and methods are primarily adapted from other disciplines, such as hydrology, biology, and sociology, and are intended for use by non-experts.

LAF's Guidebook is part of a comprehensive collection of resources for professionals, clients, and educators to evaluate performance and communicate the value of built works, known as the Landscape Performance Series (LPS). Central to the LPS are the Landscape Performance (LP) Case Studies. The first set of LP Case Studies was published on the LPS website in 2010, and by the end of 2023, the collection had grown to 200 (LAF, 2024). These case studies are developed through LAF's annual Case Study Investigation (CSI) program, a funded collaboration among academics, students, and design firms. LAF's substantial investment in CSI reflects its strong commitment to advancing landscape performance through academic-professional partnerships (Canfield et al., 2024). Each CSI team produces comprehensive documentation for their project, including a project overview, descriptions of its sustainable features, design challenges and solutions, lessons learned from the design team, and a list of quantitative environmental, social, and economic benefits. A corresponding methods document details how each performance benefit was measured.

While the Guidebook provides valuable guidance for structuring a landscape performance assessment, it does not prescribe specific sets of metrics or methods. Evaluators must determine what to measure and how, based on factors such as project type, context, goals, design features, age, and the timing of the assessment. Additional considerations may include data availability, cost, timeframe, and the evaluators' expertise. This flexibility allows for customized assessments that reflect each project's unique goals and conditions, but it also creates inconsistencies in how benefits and metrics are selected, measured, and reported. For example, to demonstrate benefits of water conservation, some case studies use the metric 'reduction in potable water consumption,' whereas others use 'amount of water supplied by non-potable sources.' Though both demonstrate the same benefit, they use different metrics. In some cases, benefit statements use multiple metrics to more comprehensively convey a benefit. For instance, Blue Hole Regional Park, "Saves an estimated 600,000 gallons of potable water per month by using drought-tolerant turf and on-site well water for recreation field irrigation. This results in an estimated annual cost savings of $25,500," demonstrates two distinct but related benefits, water conservation and cost savings (Canfield & Fagan, 2013).

Such variability in metric use highlights the broader challenge of inconsistent reporting, which limits comparing performance across case studies or aggregating findings in a meaningful way. Addressing this limitation could significantly enhance the utility of the LPS dataset. Establishing standardized procedures, such as a recommended set of metrics for specific project types or features, could help guide evaluators toward more consistent and potentially comparable outcomes.

In addition to variation in metric selection, inconsistent terminology further complicates the interpretation and comparison of performance data. In many cases, benefit statements conflate the benefit with the metric, even though the metric and the benefit are distinct. A performance metric is a single measurable unit used to assess how well a specific design feature or system is functioning, allowing evaluators to

quantify its performance. A benefit, by contrast, is the outcome that results from a particular design feature or system, allowing audiences to understand its impact or value resulting from the feature or system. For example, within the “Water Conservation” section of the 2018 Guidebook, the *reduction in potable water consumption* is the performance benefit, while the ‘*amount of potable water’* is the metric. Despite this distinction, many LP benefit statements often describe the benefit and metric in parallel. For clarity, this paper uses the term ‘benefit/metric’ to reflect how the data is currently reported. However, parsing these data points is essential to distinguish between what is being achieved (benefit) from how it is being measured (metric).

Before publishing a completed case study on the LPS website, LAF staff digitally tag each performance benefit statement, indexing it to one or more landscape performance benefit categories, as established by the 2018 Guidebook. Additional tags include project features, type, location, climate zone, size, and budget, which help filter project searches. For example, filtering by “Water Conservation” will return all case studies tagged with that benefit category, including Blue Hole Regional Park. However, while filtering directs users to relevant case studies, it does not link to specific benefit statements or reveal the metrics and methods used, which are not included in the tagged metadata. All tagged data is compiled into a downloadable spreadsheet available on the LPS website. As of December 2023, 200 Case Study Briefs were published with a total of 723 environmental, 502 social, and 295 economic performance benefit statements.

Though the LPS metadata is valuable for expanded research studies, including Yang (2020), Wang et al. (2016), Luo & Li (2015), and Modi & Ozdil (2014), and for teaching purposes (Canfield and Hahn, 2023), it is limited in that it does not include information on specific metrics and methods used in the landscape performance analyses. Yet, such information reveals how research teams are actually measuring performance, offering valuable insights to guide future metric and method selection. Without this information, opportunities for comparative analysis and data aggregation remain limited.

1.1 Research Objective

This study aims to parse individual benefit/metrics from performance benefit statements within Landscape Performance (LP) Case Studies published between 2010 and 2023 (n=200). By identifying the most frequently cited benefit/metrics, the research seeks to uncover patterns, trends, and correlations across projects. These findings will inform future landscape performance assessments and support the development of expanded research studies.

2 METHOD

Currently, the LAF database does not separate metrics into discrete fields, which limits the potential for advanced quantitative analysis. Instead, benefits and metrics are combined within text fields displayed on the Landscape Performance Series website. This presents a significant challenge for researchers. For this study, we manually reformatted and tabulated benefit/metric counts using enhanced spreadsheet versions of the downloaded data. Our recommendations for improving the database to support more robust numeric analysis are provided in the Conclusion section.

To understand which benefits/metrics have been used in the landscape performance benefit statements from the 200 LPS Case Studies, we first constructed a comprehensive Excel spreadsheet using an internal coding system that we created to organize our data capture and tabulation (see partial example in Figure 1). The structure included 34 benefit categories and 104 benefit/metric sub-categories, derived from the LAF Guidebook. Additionally, an ‘other’ category was added to each benefit category to capture unique instances of other benefits/metrics not found in the Guidebook. Next, we downloaded the LP Case Study data and all the methods documents. Then, our team manually reviewed each landscape performance benefit statement to parse and tabulate all specific benefits/metrics instances. From there, we began populating our spreadsheet. In total, we indexed a total of 1,792 benefit/metric instances.

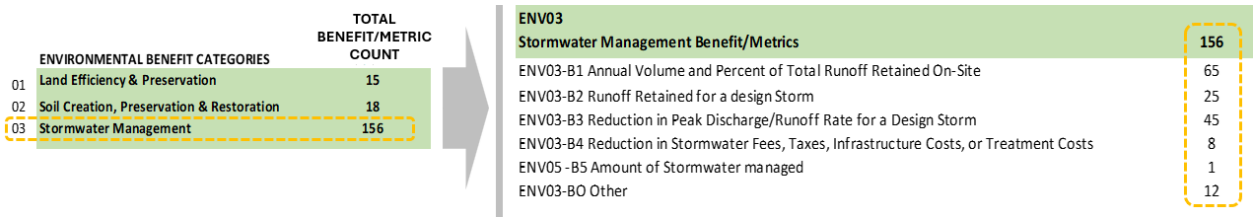

Figure 1: Benefit/metric coding used to tabulate and parse LP Case Study benefit statements
Diagram by the authors.

3 RESULTS

For the first time, specific benefits/metrics have been parsed and tabulated from the original LP Case Study benefit statements. We report and analyze findings by benefit category, rank-ordered by individual benefit/metric frequency, project designer, climate zone, project size, and project type.

3.1 Benefit/Metric Counts by Benefit Category

The summary begins by reporting the total benefit/metric counts tabulated by benefit category for the Environmental, Social, and Economic performance realms (Figure 2). Within the 17 environmental benefit categories, 822 total benefit/metric instances were tabulated within 68 unique benefit/metric sub-categories. Within the 10 social benefit categories, 640 total benefit/metric instances were tabulated within 45 unique benefit/metric sub-categories. Within the seven economic benefit categories, 330 total benefit/metric instances were tabulated within 29 unique benefit/metric sub-categories. Note that the benefit/metric totals reported in Figure 2 are higher than the total number of benefit statements mentioned in the Introduction because some benefit statements included multiple benefits/metrics, which were split and tabulated under different categories.

Environmental benefit categories	Total benefits	Social benefit categories	Total benefits	Economic benefit categories	Total benefits
Stormwater management	156	Recreational and social Value	213	Operations and maintenance	76
Water conservation	117	Health and well-being	99	Economic development	50
Carbon sequestration & avoidance	97	Educational value	95	Property value	45
Water quality	67	Safety	41	Job creation	43
Populations & species richness	64	Access & equity	41	Visitor spending & earned	42
Temperature & heat island	57	Other	38	Construction cost savings	30
Energy use	53	Scenic quality & views	35	Other	29
Habitat creation, preservation, &restoration	39	Transportation	27	Tax revenue	15
Reused & recycled materials	38	Food production	20		330
Habitat quality	34	Cultural preservation	18		
Flood protection	28	Noise mitigation	13		
Waste reduction	23		640		
Soil creation, preservation & restoration	18				
Land efficiency & preservation	15				
Air quality	6				
Shoreline protection	6				
Water body/groundwater recharge	3				
Other	1				
	822				

Figure 2: Total benefit/metric count per benefit category (rank-order) (LPS case studies 2010-2023) Benefit/Metrics by Rank-ordered Listing Diagram by the authors.

Total instances are ranked within the Environmental, Social, and Economic performance realms (Figure 3). Across all benefit categories, the two most frequently cited benefits/metrics are the 'amount of atmospheric CO2 sequestered,' with 82 instances, and 'site visitation and use' with 80. The environmental realm had the largest number of individual benefits/metrics. The first three benefit/metric counts are substantially higher than the rest, ranging from 44-82% higher. Beyond the top environmental benefit/metric, we observe that the most frequently cited benefits/metrics are clustered into two topic groups: stormwater and potable water, and habitat and species richness. After these top rankings, the remaining benefits/metrics are mixed across categories.

Similarly, the top three social benefits/metrics had substantially higher counts than the rest, by a 38-100% increase (Figure 3a). The top six social benefits/metrics cluster around topics of site visitation, engagement, and health. Rank-ordered economic benefit/metrics are also shown in Figure 3b. The top five economic benefits/metrics are cited most often by a 56-125% margin. No clustering of similar benefits/metrics is apparent compared to the environmental and social categories.

Figure 3a: Rank-ordered count of top benefits/metrics from LP Case Studies 2010-2023 Diagram by the authors.

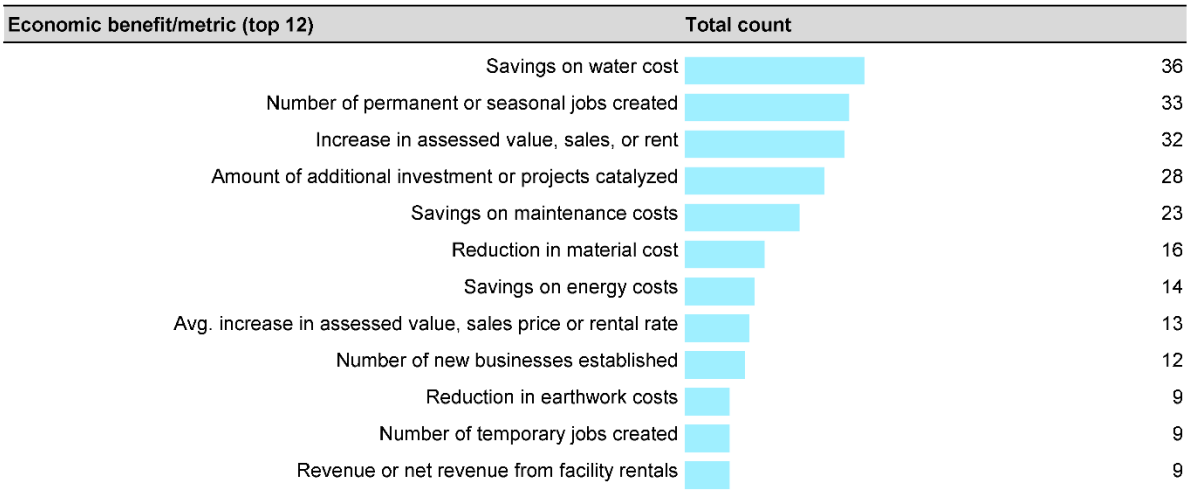

Figure 3b: Rank-ordered count of top benefits/metrics from LP Case Studies 2010-2023 Diagram by the authors.

3.2 Benefits/Metrics by Project Designer

Of the 200 LP Case Studies we analyzed, there were 26 Project Designers with two or more case studies. The top was Design Workshop, which had 15 case studies (Figure 4). We sorted the benefit/metric data by Project Designer to see if notable patterns emerged. Overall, the top benefits/metrics were similar to the top benefits/metrics from LP Case Studies overall (shown in Figure 3). As Yang & Li (2019) discussed, firms with the most case studies typically integrate landscape performance with their regular project work when possible. For Design Workshop, landscape performance is part of their Legacy Design® process, which guides their approach to projects.

Project designer	Project types	# of Projects	Top benefit categories		Benefit citations within category	Top cited benefits	Benefit count
Design Workshop	Nature preserve, Park/Open space, Stream restoration, Garden/Arboretum, Waterfront redevelopment, Courtyard/Plaza, Single-family residence, Retail, Streetscape, Transportation, Community	15	ENV	Stormwater management	11	Annual volume and percent of total runoff retained on-site	4
						Reduction in peak discharge/runoff rate for a design storm	4
				Carbon sequestration & avoidance	12	Amount of atmospheric C02 sequestered	9
			SOC	Scenic quality & views	8	Percent of unwanted views screened or desirable views retained	3
						Perception of aesthetic value	4
			ECN	Operation & maintenance services	7	Savings on water cost	7

Smith Group - 10 projects
Andropogen - 7 projects
Sasaki - 7 projects
SWA Group - 6 projects
Michael Van Valkenburgh Associates - 5 projects
PWP Landscqape Architecture - 5 projects
Conservation Design Forum - 4 projects
THUPD - 4 projects
EDSA - 3 projects
HGA Architects & Engineers - 3 projects
Olin - 3 projects
Hoerr-Schaudt Landscape Architects - 2 projects
MIG - 3 projects
Mithun - 3 projects
TBG Partners - 3 projects
Turenscape - 3 projects
AECOM - 2 projects
BNIM - 2 projects
HDR - 2 projects
Perkins+Will - 2 projects
Michael Vergason Landscape Architects - 2 projects
Reed Hilderbrandt LLC - 2 projects
Ten Eyck Landscape Architects - 2 projects
Terry Guen Design Associates - 2 projects
Wenk Associates - 2 projects

Figure 4: Benefits/metrics cited by project designer (example from Design Workshop) from LP Case Studies 2010-2023 Diagram by the authors.

3.3 Benefits/Metrics by Climate Zone and Project Size

When the benefit/metrics were analyzed by Climate Zone, results followed the rank-ordered trends reported in Figure 3. Most of the case studies were conducted in the ‘Humid Subtropical’ and ‘Humid Continental’ climate zones, and Stormwater Management was the top cited benefit category. This was

also the case when the benefit/metrics were analyzed by Project Size. Likewise, no apparent trends were evident when benefits/metrics were correlated to project size.

3.4 Benefits/Metrics by Project Type

An analysis of landscape benefit/metrics by Project Type was done for 15 of the current 32 Project Type categories listed on the LPS website (Figures 5a-5c). These 15 project types represent the majority of the LP Case Studies. The remaining project types represent fewer than six case studies per project type. Note that the 303 case studies reported in Figure 5 exceed the actual 200 case studies published by 2023, as individual case studies are often tagged to multiple project types. Consequently, the same benefits/metrics are cited under multiple project type categories. To make our summarization more succinct, only the top 4-6 benefit/metric categories are shown across the Environmental, Social, and Economic realms. Within the total tabulated benefits/metrics for each project type, the benefits/metrics are broken down by percentage and represented by a bar graph to reveal relative citation frequency per benefit category. For each top benefit category, the corresponding top benefits/metrics and total count(s) are also provided.

Relative to Environmental benefits, the Stormwater Management and/or Water Conservation benefit categories were among the top cited for all 15 reported project types. Parsing the data down one more level, the corresponding top benefits/metrics relate to retaining water on-site, reducing peak runoff discharge rates, and reducing potable water consumption. Other high-count tabulations relate to the benefit categories of Carbon Sequestration & Avoidance, Water Quality, Temperature & Heat Island Effect, Populations & Species Richness, and Health & Well-Being.

Relative to Social benefits, the top benefit category was Recreational & Social, which appeared in 13 out of 15 project types. The most cited benefits/metrics corresponding to this benefit category were *'site visitation or use'* and *'visitors engaged in recreational or social activities.*' Other top benefit categories were Educational Value, Health and Well-being, Safety, and Transportation.

Comparatively, benefits/metrics relating to economics were cited far less than those relating to environmental or social considerations. The top benefit categories within the Economic realm are related to Property Value ('*increase in assessed value, sales, or rent'*), Job Creation (*'number of permanent or seasonal jobs created*'), and Operations & Maintenance Services ('*savings on water cost'*).

Project type	# of case studies		Top cited benefit categories per project type	Total cited benefits	Benefits % breakdown	Top cited benefits per benefit category	Benefit count
Park/open space	85	ENV	Stormwater management	53	15%	Annual volume and percent of total runoff retained on-site	26
		ENV	Water conservation	52	15%	Reduction in potable water consumption	27
		ENV	Carbon sequestration & avoidance	44	13%	Amount of atmospheric C02 sequestered	39
		SOC	Recreational & social	113	33%	Site visitation or use	50
						Visitors engaged in recreational or social activities	32
		SOC	Health & well-being	53	15%	Improvement in mood, level of satisfaction, or quality of life	28
						Improvement in physical health or activity	21
		ECN	Property value	31	9%	Increase in assessed value, sales, or rent	20
					100%		
School/ university	30	ENV	Stormwater management	32	33%	Annual volume and percent of total runoff retained on-site	11
		ENV	Water conservation	22	23%	Reduction in peak discharge/runoff rate for a design storm	11
		SOC	Recreational & social	22	23%	Reduction in potable water consumption	13
						Site visitation or use	7
						Visitors engaged in recreational or social activities	10
		SOC	Educational value	21	22%	Number of attendances at educational events	7
						Number of people accessing educational materials	4
						Increase in knowledge	4
					100%		
Waterfront	28	ENV	Stormwater management	12	12%	Annual volume and percent of total runoff retained on-site	7
		ENV	Water conservation	14	13%	Reduction in potable water consumption	8
		ENV	Carbon sequestration & avoidance	11	11%	Amount of atmospheric C02 sequestered	11
		SOC	Recreational & social	37	36%	Site visitation or use	19
						Visitors engaged in recreational or social activities	9
		SOC	Health and well-being	16	15%	Improvement in mood, level of satisfaction, or quality of life	8
						Improvement in physical health or activity	6
		ECN	Job creation	14	13%	Number of permanent or seasonal jobs created	10
					100%		

Figure 5a: Top benefits/metrics by 15 project types from LP Case Studies 2010-2023. Diagram by the authors.

Project type	# of case studies		Top cited benefit categories per project type	Total cited benefits	Benefits % breakdown	Top cited benefits per benefit category	Benefit count
Courtyard/ plaza	26	ENV	Stormwater management	29	26%	Annual volume and percent of total runoff retained on-site	9
						Reduction in peak discharge/runoff rate for a design storm	10
		ENV	Water conservation	18	16%	Reduction in potable water consumption	10
		ENV	Temperature & heat island	17	15%	Reduction in Surface Temperature	9
		ENV	Carbon sequestration & avoidance	13	12%	Amount of atmospheric C02 sequestered	12
		SOC	Recreational & social	33	30%	Visitors engaged in recreational or social activities	12
					100%		
Stormwater management facility	21	ENV	Stormwater management	15	20%	Annual volume and percent of total runoff retained on-site	7
		ENV	Water conservation	14	18%	Reduction in potable water consumption	8
						Annual cost savings from reduced potable water consumption	5
		ENV	Carbon sequestration & avoidance	10	13%	Amount of atmospheric C02 sequestered	7
		SOC	Recreational and social	20	26%	Site visitation or use	6
						Visitors engaged in recreational or social activities	7
		SOC	Educational value	17	22%	Number of attendances at educational events	6
					100%		
Streetscape	20	ENV	Stormwater management	22	27%	Annual volume and percent of total runoff retained on-site	7
						Reduction in peak discharge/runoff rate for a design storm	7
		ENV	Carbon sequestration & avoidance	14	17%	Amount of atmospheric C02 sequestered	14
		SOC	Recreational & social	22	27%	Visitors engaged in recreational or social activities	9
						Quality of the visitor experience	6
		SOC	Safety	13	16%	Perception of safety	7
		ECN	Property value	11	13%	Increase in assessed value, sales, or rent	9
					100%		
Nature preserve	18	ENV	Stormwater management	10	14%	Annual volume and percent of total runoff retained on-site	4
						Runoff retained for a design storm	4
		ENV	Water conservation	11	16%	Reduction in potable water consumption	6
		ENV	Populations & species richness	12	17%	Increase in species richness for a taxon of interest	6
						Increase in abundance of a species of interest	5
		SOC	Recreational & social	23	33%	Site visitation or use	10
						Visitors engaged in recreational or social activities	7
		SOC	Educational value	14	20%	Number of attendances at educational events	8
					100%		
Stream restoration	15	ENV	Stormwater management	8	16%	Annual volume and percent of total runoff retained on-site	3
		ENV	Water quality	9	18%	Reduction in sediment load	4
						Change in chemical or physical properties of interest	4
		ENV	Flood protection	10	20%	Increase on flood storage capacity	4
						Reduction in peak discharge at an outlet point	3
		SOC	Recreational & social	16	31%	Site visitation or use	6
						Visitors engaged in recreational or social activities	6
		SOC	Transportation	8	16%	Increase in walking, biking, or mass transit use	4
						Increase in key connections	4
					100%		
Garden/ arboretum	11	ENV	Stormwater management	13	24%	Annual volume and percent of total runoff retained on-site	5
						Reduct. in peak discharge/runoff rate for a design storm	6
		ENV	Water conservation	8	15%	Reduction in potable water consumption	4
		ENV	Water quality	8	15%	Change in chemical or physical properties of interest	5
		SOC	Recreational & social	11	20%	Site visitation or use	5
		SOC	Educational value	9	16%	Number of attendances at educational events	4
						Increase in knowledge	3
		ENV	Operations and maintenance services	6	11%	Savings on water cost	4
					100%		
Residence	9	ENV	Stormwater management	6	23%	Runoff retained for a design storm	3
		ENV	Water conservation	4	15%	Reduction in potable water consumption	4
		ENV	Carbon sequestration & avoidance	6	23%	Amount of atmospheric C02 sequestered	5
		SOC	Recreational & social	4	15%	Visitors engaged in recreational or social activities	4
		SOC	Educational value	6	23%	Number of attendances at educational events	3
					100%		
Civic/ government facility	8	ENV	Stormwater management	11	33%	Annual volume and percent of total runoff retained on-site	4
						Reduction in peak discharge/runoff rate for a design storm	4
		ENV	Water conservation	7	21%	Reduction in potable water consumption	4
		SOC	Recreational & social	7	21%	Visitors engaged in recreational or social activities	4
		ECN	Operations and maintenance services	8	24%	Savings on water cost	4
					100%		
Office	7	ENV	Stormwater management	9	30%	Annual volume and percent of total runoff retained on-site	4
		ENV	Temperature & heat island	4	13%	Reduction in air temperature	2
						Reduction in surface temperature	2
		SOC	Recreational & social	8	27%	Visitors engaged in recreational or social activities	3
		SOC	Educational value	9	30%	Number of attendances at educational events	4
					100%		

Figure 5b: Top benefits/metrics by 15 project types from LP Case Studies 2010-2023 Diagram by the authors.

Playground	6	ENV	Stormwater management	5	25%	Annual volume and percent of total runoff retained on-site	2
			Water conservation	4	20%	Reduction in peak discharge/runoff rate for a design storm	2
		SOC	Health and well-being	6	30%	Reduction in potable water consumption	3
			Educational value	5	25%	Improvement in mood, level of satisfaction, or quality of life	3
					100%	Increase in knowledge	3
Museum/ cultural center	6	ENV	Stormwater management	4	16%	Annual volume and percent of total runoff retained on-site	3
			Water conservation	5	20%	Reduction in potable water consumption	3
			Water quality	5	20%	Change in chemical or physical properties of interest	3
		SOC	Recreational & social	6	24%	Site visitation or use	4
		ECN	Operations and maintenance services	5	20%	Savings on maintenance costs	3
					100%		
Retail	6	ENV	Stormwater management	3	20%	No Significant Metric Used	3
			Water conservation	4	27%	Reduction in potable water consumption	3
			Temperature & heat island	4	27%	Reduction in air temperature	2
		SOC	Safety	4	27%	No significant metric used	4
					100%		

Figure 5c: Top benefits/metrics by 15 project types from LP Case Studies 2010-2023 Diagram by the authors.

4 DISCUSSION

Our dataset has enabled us to conduct preliminary analysis of the benefits/metrics documented in the 200 LP Case Studies published between 2010 and 2023. When examining the frequency of the benefit/metric data overall, the top cited benefits/metrics are from benefit categories generally applicable across project types, including Stormwater Management, Carbon Sequestration & Avoidance, Recreational & Social Value, and Operations and Maintenance Savings. Note that the highest benefit/metric counts do not necessarily denote higher relative performance benefits; instead, project teams most often assess those specific benefits, likely due to ease of data collection and assessment. Additionally, there are more environmental benefit/metric instances overall because there are more environmental benefit categories than social and economic categories. Additionally, many of the LP environmental benefits/metrics align well with categories from the USGBC Sustainable Sites Initiative (SITES™). Thus, projects designed or certified with SITES™ are well-positioned for a post-occupancy LP assessment.

Certain patterns in benefit/metric use emerge when examining the data by project type. However, the total number of case studies within each project type category remains somewhat limited, with only 9 of the 15 project types we examined having 10 or more case studies. Within the 15 project type categories, all but two had a high frequency of the benefit/metric' *annual volume and percent of total runoff retained on-site*' from the Stormwater Management category. Similarly, 12 of the 15 project types exhibited a high frequency of the benefits/metrics' *site visitation or use'* and/or *'visitors engage in recreational or social activities'* from the Recreational & Social Value benefit category. Additionally, a few project types had unique benefits/metrics, like *'perception of safety*' found within the Streetscape category.

Across all case studies, the most frequently cited benefit/metric was the *'amount of atmospheric carbon sequestered,'* likely due to the importance of demonstrating carbon drawdown. This benefit/metric is also relatively easy to measure using tree species data and tools from iTree®. The next four most frequently cited benefits/metrics relate to the Stormwater Management and Water Conservation categories, which makes sense given that most sites must manage stormwater and comply with local runoff regulations. Many of these benefits/metrics are also relatively easy to measure with tools like the EPA National Stormwater Calculator. The third-highest tier of environmental benefits/metrics falls within habitat categories. This could be attributable to designers using sustainable site design practices, which seek to utilize native vegetation and support biodiversity, which in turn can be measured through benefits/metrics from habitat and species richness categories.

In the Social realm, the top six benefits/metrics cluster around site visitation, engagement, and health. This clustering is likely due to landscape architects' concerns with placemaking, community building through increased interactions, and personal health when designing public spaces. Methods used to assess these benefits/metrics typically involve first-hand observations, tally counts, and user surveys, which can be conducted relatively easily with minimal training. However, many benefits/metrics in the social categories present a snapshot of performance at a moment in time rather than a true measure of

before-and-after conditions, likely because social data before design may not exist or be valid for a post-occupancy comparison.

In the Economic realm, the top two benefits/metrics are *'savings on water cost'* and the *'number of permanent or seasonal jobs created.'* These two benefits/metrics are site-specific, and data for these measures are likely easily collected or sourced. The third most frequently cited benefit/metric is *'increase in assessed value, sales, or rent.'* Many of the economic benefits/metrics relate to site construction or operations and the site's impact in a broader context, which may require data that is hard to access or collect. Additionally, coordination with market analysts or real estate developers is beneficial when assessing several economic benefits/metrics. Overall, economic benefit/metrics are cited least among the three major performance realms, likely because they are more challenging to assess.

Although our initial findings focus on the top-cited benefits/metrics, those less frequently cited are also important and warrant scrutiny. We suspect some benefits/metrics citations do not reach the top tiers for two reasons: 1) some benefits/metrics apply to fewer types of projects (i.e. they are more niche but not necessarily less relevant), and 2) the least cited benefits/metrics may be more difficult to assess or rely on data that is more difficult to obtain. Our analysis also revealed several additional benefits/metrics that were not part of the LAF Guidebook and originated from the CSI teams since 2018. This expanded set is likely because, in some years, the CSI program selected projects that explicitly addressed topics such as climate adaptation or diversity, equity, and inclusion (LAF, 2021). This topical focus challenged research teams to develop an expanded set of metrics and methods to measure a broader range of performance benefits. Our data shows that the LAF Guidebook has been influential in informing LP assessments. However, seven years after its release, updates are needed to incorporate insights from the LP Case Studies published after 2018, including a broader range of potential benefits, metrics, and methods.

5 CONCLUSION

We conducted a thorough manual tabulation of the benefits/metrics cited within the benefit statements of the LAF's LPS Case Studies, revealing how CSI teams have assessed various environmental, social, and economic benefits. This data can be informative for others interested in designing for performance or conducting landscape performance assessments. However, the choice of what to measure and how largely depends on the purpose of the findings and the intended audience. Different stakeholders, such as clients and design teams, may have distinct priorities regarding the information they want to glean from an LP assessment, which can affect the benefits measured. Metrics are used to depict part of a site's story, but other intangible benefits may go undocumented because they cannot be easily quantified. For a more comprehensive picture of performance, combining metrics with narratives can lead to a richer story of a site's benefits and broader environmental, social, and economic value.

While our data is useful for illustrating benefit/metric frequency and trends, it does not facilitate direct numerical comparisons of specific measures across different cases. There is considerable variation in how benefit statements are written, and the lack of standardization in data reporting poses challenges. Some benefit statements provide clear metric units, whereas others do not. Additionally, while some express performance changes as percentage values, others do not. Presenting metrics as percentages alongside relative quantities can aid in making comparisons since percentages are independent of project scale. Standardization of metrics will be necessary for performance benefit statements to be directly compared. However, even with standardized metrics, the diversity of project types, contexts, sizes, and design features will remain significant. It may be worth questioning whether the pursuit of true cross-case comparisons will ever be viable or useful, and what will be lost if such comparisons cannot be made.

Performance should ideally be assessed over time, but significant barriers such as cost and resource availability often limit longitudinal studies. A common critique of the LP case studies is that they typically provide a one-time measure or snapshot of performance. Yet, perhaps all that is needed is a snapshot to see how well a design fulfilled its initial goals. Moreover, a performance snapshot can highlight areas where a site is underperforming, providing valuable insights for designers or maintenance teams. While it's important to highlight what is not performing as expected and identify areas of failure, such information may not be published in a case study because clients, municipalities, or designers may not want a project's shortcomings to be made public. Again, the purpose of the assessment data and the end-user

should be considered when determining if multiple measures over time are necessary. Additionally, post-occupancy performance measures may not accurately or meaningfully demonstrate whether specific intentions were achieved if the design team did not establish performance benchmarks and collect applicable baseline data during the project's design phase. Future studies should critically examine the applicability and validity of the metrics and methods used in the case studies to date.

The most immediate application of this research, and the LP case study benefit statements overall, is to help practitioners inform their work and substantiate their designs to clients and stakeholders. Understanding the benefits and metrics used in the LP case studies allows practitioners to identify relevant precedents, which can guide performance goal setting and baseline data collection. These precedents also enable practitioners to advocate for specific design practices to wary clients, especially when those practices have demonstrated tangible benefits. Several larger firms have integrated landscape performance into their design processes and projects, even developing internal guides for data collection and assessment. However, for firms looking to incorporate landscape performance and evidence-based design into their practices, this research suggests some benefits and metrics that may be relevant to begin with.

Expanded research should include parsing the metrics from the benefits and build a more robust relational database structure. Data fields can include parsed metrics, quantities, and units, as well as information about the methods and whether a benefit has been measured or modeled. All of this information will enable continued analysis and a deeper understanding of the data, which in turn is crucial for advancing landscape performance knowledge and practice on a broader scale. Additionally, to make future LP Case Study data more useful, we suggest expanding the LPS website database and the data reporting requirements for CSI teams to include discrete fields for capturing benefits, metrics, and methods.

Our analysis identified several new social and economic benefit categories that can be added to the next edition of the LAF Guidebook. Under social benefits, these additions relate to topical themes of Social Media Attention, Housing Choice, Nature Interactions, and Perception of areas beyond the project site. Under economic benefits, additions relate to topical themes of Agriculture, Education, Fundraising, and Housing Impact. For environmental benefits, no new benefit categories were identified; however, 14 new metrics were cited by research teams that can be incorporated into future metric methods. Additional suggestions for updating the LAF Guidebook include refining "benefit" and "metric" terminology and creating suggested metric lists by project type or by project feature.

In summary, landscape performance assessments are a critical aspect of landscape architecture practice. Performance data can reveal the benefits of designed sites and help to inform and strengthen evidence-based design. The 200 LP Case Studies compiled over the last 15 years represent a significant collection of landscape performance data to draw upon. The ongoing challenge is to make deeper levels of data more accessible so practitioners and researchers can efficiently extract, analyze, and apply landscape performance benefits, metrics, and methods to their projects and research.

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