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Artificial Intelligence in Landscape Architecture: A Survey of Theory, Culture, and Practice

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ARTIFICIAL INTELLIGENCE IN LANDSCAPE ARCHITECTURE: A SURVEY OF THEORY, CULTURE, AND PRACTICE

by

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ABSTRACT

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This dissertation investigates the intersection of artificial intelligence (AI) in landscape architecture (LA). It examines AI's growth in the field over time, its current pervasion of the industry zeitgeist, and its potential to transform research, practice, and pedagogy. The work involves a systematic literature review, which uncovers trends and themes in AI applications for landscape architecture and identified knowledge gaps. It serves as a cultural exploration of how landscape architects perceive AI and its impact on their profession using the Cultural Topography Analysis (CTops) method, which found LA culture accepting of the potential benefits from AI but unaware and unprepared for the potential disruptions to their creative identity and design processes. It then offers a proposition of new mental models and frameworks for landscape practice in the AI era, arguing for a multifaceted understanding of AI adoption. It also addresses the limitations and potential future directions for landscape architects in an AI-driven world. The work is a unique contribution to the discipline and offers valuable insights for future AI-LA research and practice.

(175 pages)

PUBLIC ABSTRACT

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This dissertation explores the role of artificial intelligence (AI) in shaping the landscape architecture profession. It looks at how AI has evolved in the field, its current influence, and its potential to change research, teaching, and professional practice. The research includes a detailed review of existing literature to identify trends in AI applications and gaps in knowledge. It also examines landscape architects' attitudes towards AI, revealing a mix of enthusiasm for its benefits and concerns about its impact on creativity and design processes, and proposes new ways of thinking about and working with AI. The work brings a unique perspective on AI in the field and gives valuable insights for future research and practice.

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Phillip J. Fernberg

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INTRODUCTION

If you were to thumb through old issues of *Science* magazine, once you hit 1967 you would come across an obscure article by esteemed professor and researcher, Allen Newell, arguing for the validity of an emerging discipline called computer science. In the article, Newell and colleagues address some fundamental objections within academia to the idea that the study of computers was, in fact, a science or even a worthwhile pursuit. The questions are simple but fundamental: Is there such a thing as computer science? If so, what is it? Is it not just a branch of some other discipline like engineering, mathematics, electronics, etc.? Isn't it just the study of algorithms rather than computers? As you read the objections and their respective responses, you might begin to think as we did about the similar line of questioning that has been employed in landscape architecture. Substitute the computer speak with landscape jargon, and you have near carbon copies of themes from licensure advocacy meetings, ASLA conferences, or academic treatises (Kullmann, 2016) on the state of the discipline. Computer science and landscape architecture have a surprising amount in common. They are both relatively new—at least in the official sense—they have both evolved in significant ways over the past century, and they both have been in an ongoing existential discussion about their position amidst peer disciplines. This is nice to know but not revelatory. Yet the intersection gets more interesting. Objective 2 of the article states: "The term 'computer' is not well defined, and its meaning will change with new developments, hence computer science does not have a well-defined subject matter." The authors' reply is astute and resonant: "The phenomena of all sciences change over time; the process of *understanding* assures that this will be the case. Astronomy did not originally include the study of interstellar gases; physics did not include radioactivity; psychology did not include the study of animal behavior. Mathematics was once defined as the 'science of quantity'"

(Newell et al., 1967). So too is the phenomenon of landscape architecture, it just happens to work on an accelerated timeline. The field is ever shifting, retooling, and reassessing our place as our understanding of our medium and our instruments evolves. Before Olmsted, landscapes were gardens rather than systems (Olmsted, 1893); before *Design with Nature,* those systems were not intertwined with ecology (McHarg, 1969); before CAD, GIS, or Adobe, our tools were pen and paper.

Landscape architecture is in one of those shifts now. Alongside the social and ecological issues changing paradigms of practice, the field is in another great technological leap. But it's not happening in the way you might think. Most readers of design-centric news can probably guess the usual suspects of our perceived landscape tech revolution. New computational approaches like BIM and parametricism are gaining traction, drones are becoming a go-to office tool for collecting site data, VR and AR walkthroughs are starting to show up on RFPs, and adoption of still-multiplying design software programs or plugins is rising precipitously. These innovations are all fascinating but maybe not the new sliced bread for anyone who experienced the pivot to CAD or the algorithmic designs trickling over from architecture in the 90s and early 2000s. To me, these are pieces of a larger techno-progressivist puzzle now being assembled by a more profound technology: artificial intelligence (AI).[1]

Computational Design Lays the Groundwork

It is no secret that AI has reached the architecture, engineering, and construction (AEC) industry. But before the Age of AI, there were a series of monumental shifts that laid the groundwork for its adoption. The introduction of Information Technology (IT) systems in the 60s and 70s, and the personal computer soon after, led to the emergence of Computer-Aided Design

[1] This section is partially excerpted from an article written by the author along with Dr. Brent Chamberlain for *Landscape Architecture Magazine,* August 2021 issue, entitled "i, Designer?"

(CAD), a practice that has become ubiquitous across fields ranging from engineering and architecture to manufacturing and industrial design (Sarcar et al., 2008). The precipitous adoption of CAD software in the design disciplines was initially a practical matter—the scaling up of production outputs while cutting down time to produce increased efficiency in a way not seen since the industrial revolution. It also revolutionized the relationships between designer, builder, and client (Andia, 2002). As design software and computational ability improved, their use would extend beyond the practical into a new period where previously impossible geometrical investigations drove new design theory, particularly in architecture. Combining robust computational modeling with contemporary philosophical approaches, groups of Avant Garde designers led the formation of deconstructionist then organic and minimalist theories of form finding to push back against post-modernist ideals and disrupt public design discourse in the 1990s and even today (Picon, 2010).

The introduction of parametric design techniques from animation software workflows into architecture in the early 2000s has pushed this dialogue even further and even sparked some architects and critics to dub our era with a new style called parametricism (Schumacher, 2009). This new style is one where design is driven by algorithmic, rules-based thinking that defines the relationships between design intent and design procedures rather than the form itself (Jabi, 2013). As concerns mount over the unintended consequences of economic, technological, and societal advancement in a globalized world, the ability of parametric design systems to quantitatively define all the relationships between design elements has given way to new ways of thinking about addressing problems like waste, climate change, emissions reduction, equity, and cost overruns (Schumacher, 2016). It has also inspired other more direct applications of CAD software, such as Building Information Modeling (BIM) where every element in a design model is given measurable properties, actions, and functions that can produce highly accurate visualizations, shop drawings, cost estimates, and predictions of design performance over time (Azhar, 2011); or the integration of statistical modeling methods with design software allowing designers to add more empirical soundness to their projects without necessarily needing deep knowledge of statistics (Abdulmawla, 2018).

Recognizing the possible applications beyond the building, landscape architecture has begun readily adopting algorithmic, information model, and other computational systems into its curriculum and professional workflows, experimenting with design processes, such as terrain modeling (Hermansdorfer et al., 2020; Hurkxkens et al., 2017), monitoring public spaces for design assumptions (Zeiger, 2019a), modeling uncertainty in a "synthetic" ecology (B. Cantrell & Holzman, 2014), or reflecting temporality in CAD workflows (Tebyanian, 2016), to name a few. The use of computation in landscape design is burgeoning, and according to a professional survey by George and Summerlin (2019), shows signs of sustained growth in the future. Yet in recognizing this, the authors also note that the growth has thus far been, and will most likely continue to be, gradual and mostly focused on software that increases production efficiency rather than heuristic design exercises. Some landscape architectural researchers and practitioners have begun imagining the potential for a greater disciplinary discourse on computational design and parametricism (B. Cantrell & Mekies, 2018), proposing that landscape is a profoundly more complex system than that of a building or singular piece of infrastructure and thus needs to construct a system more responsive to the many factors and contexts in which it is embedded (B. E. Cantrell & Holzman, 2015). Yet because landscape is such a fundamentally expansive medium, it means the array of possible computational tools to apply to its design is also far vaster than the more manageable scope of something like architecture and can thus lead to digital overload (Fricker et al., 2013).

Just as the parametricism movement has expressed ambitions to address the wicked problems of the 21st century, so too have some of the thought leaders of landscape architecture declared the need for designers to be at the helm addressing issues such as climate change, advocacy, and environmental equity (*Landscape Architecture: A Solution to the Climate Crisis*, 2022; *New Landscape Declaration*, 2016) These issues are broad encompassing subjects themselves with many facets that transcend the abilities of any single landscape architect or firm. For all the diverse ways designers engage with other disciplines, most simply do not have the time, knowledge, or cognitive capacity to account for all the intersectional aspects of today's design problems.

What is AI?

The Oxford Dictionary defines Artificial Intelligence as "…computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." The term *machine learning* is also used in common speak, often interchangeably with AI, though it technically represents only a subset of the AI field. The scope of AI is extremely vast, which has led to the derivation of several subfields or branches (Chiabai et al., 2018; Mata et al., 2018; Zhu & Yan, 2015). Some of the more common subfields seen in the literature include: 1) *Machine Learning*, 2) *Knowledge-based Systems*, 3) *Computer Vision*, 4) *Robotics*, 5) *Natural Language Processing, and 6) Optimization* (Abioye et al., 2021; Public Health Agency Canada, 2020).

Though the concept has been in development for centuries (B. G. Buchanan, 2005; Poole & Mackworth, 2010), the beginnings of modern AI computing are often understood to have spawned in 1950 when Alan Turing posited: “Can machines think?” While he soon discovered that they could indeed, the bigger question he came away with was whether or not machines are capable of thinking like humans (Turing, 2009). This highlights an important distinction often overlooked by the AI layperson - AI capability is different from AI functionality. Before AI attains human capabilities like abstract thought, empathy, and understanding meaning, it has to master the basic functions that build those capabilities. Functions include effective use of limited memory, reaction to stimuli, and real-time decision-making (“Types of Artificial Intelligence,” 2020). Some of the latest inquiries into the state of the field claim there are still many barriers to crashing before reaching that milestone (M. Mitchell, 2020). While ruminations on machines surpassing, or even supplanting, humanity are certainly part of AI discourse—a variety of thinkers have wrestled with the concepts of artificial general intelligence (AGI) and artificial super intelligence (ASI) (Bostrom, 2014; Christian, 2020; Goertzel & Pennachin, 2007; Russell et al., 2021)—the vast majority of technical and even theoretical work focuses on much more discrete and self-contained problems in computation, also known as artificial narrow intelligence or ANI (Wooldridge, 2021).

However, when the term *artificial intelligence* is presented to a general audience, it is still more likely to elicit troubling images from sci-fi movies than a basic understanding of AI research (Fast & Horvitz, 2016). Despite the understanding that there is yet much progress to be had in the realm of AI capability, the recent public releases of generative AI applications such as ChatGPT, Dall-E 2, Midjourney, or Stable Diffusion have unleashed a near unprecedented zeitgeist of techno-existentialism where just about every knowledge work industry is questioning their future occupational outlook.

AI Emergence in Landscape Architecture

Landscape architecture is included in this frenzy. World Landscape Architecture (WLA) identified artificial intelligence as one of the top trends and possible disruptors to the industry in 2023 (Holmes, 2023a). At around the same time, the Chief Editor of Landscape Architecture Magazine (LAM) opened one of their recent issues with a ChatGPT-inspired thought experiment, signaling to the profession that we need to “pay attention” to what things like large language models can do to affect practice. In short, the industry is now aware of AI and some of its capabilities, and they are *nervous.*

The AI-Landscape Architecture (AI-LA) literature is nascent but growing. It includes work such as historical reflections on cybernetics and landscape architecture (Z. Zhang, 2020), machine learning primers and ontologies for landscape design (Alina et al., 2016; Fernberg et al., 2021; Tebyanian, 2020), proof of concept for AI in coastal adaptation design (Z. Zhang & Bowes, 2019), and even envisaging an automated, post-human ecology (B. Cantrell, Martin, et al., 2017). While most work of this sort has historically come from outside of the discipline, there is an increasing trend of AI-related publications in venues central to landscape architecture, with an especially notable surge in the past three years. For instance, in the 2022 and 2023 issues of the *Journal of Digital Landscape Architecture* alone, several new publications apply artificial intelligence techniques, with some of those being direct applications and others referencing the significance of the techniques (Barbarash et al., 2022; Fengjing et al., 2022; Khalilnezhad, 2022; X. Liu & Tian, 2022; J. Yang et al., 2022).

Motivation and Research Questions

Still, AI-LA literature remains underdeveloped, leaving knowledge seekers to turn to adjacent disciplines where the research is less nascent. Even though current explorations evoke broad observations about AI in landscape design, a lack of compilation presents key unanswered questions: What exactly is meant by the term AI in the context of landscape architecture? Is it a thing, field, discipline, or theory? How has AI been used in research, pedagogy, or practice, if at all? Where are our current knowledge gaps regarding it? How do landscape architects perceive AI advancement in terms of their practice? What are the implications of AI for landscape practice, and how should landscape architecture practice be adapted to an AI-permeated economy?

Most of the current research in AI systems for landscape design focuses on either conceptual exercises or singular tools for specific applications. There is a growing body of case studies in algorithmic site-scale design, but these have not harnessed the potential of AI in their workflow. Furthermore, these scattered case studies have yet to be systematically compiled and organized to illustrate the "bigger picture" of AI's pervasion of practice. This dissertation seeks to:

1. **Provide a review of AI's presence in landscape architecture research and practice.** This is done through a systematic literature review of existing research and use cases of AI in landscape architecture.
2. **Illustrate the cultural context of AI in landscape architecture.** To know how AI might enhance, disrupt, or transform practice, we must understand the *culture* of practice as it relates to technology. This is done using a social sciences method called Cultural Topography Analysis.
3. **Introduce new mental modes and frameworks for landscape practice in the Age of AI.** With a clearer understanding of the one-dimensional perceptions of AI acceleration, I

introduce more multifaceted mental modes for AI adoption, model their interactions using dynamic systems theory, and then argue where elements of posthumanism might complement those interactions.

Underlying Assumptions

The work will be driven by the following assumptions:

Assumption #1: Artificial Intelligence is the theory and development of machine capabilities to model and eventually match or surpass the analytical and decision-making capabilities of human beings, including creative thinking. As such, it is unique from other technological innovations in human history. AI can also be understood as a complex system of tools, technologies, and methods with both self-contained and interconnected influences on each other.

Assumption #2: Landscape architecture is a profession, a process, and a way of perceiving the world. Those who practice landscape architecture—whether in the public, private, or academic sectors—are agents in a complex system often referred to as “the industry.” This industry has highly networked components, both material and immaterial, which are embedded in, and influenced by, the greater superstructures of social-ecological systems.

From these assumptions flows a logical need for understanding the foundations of artificial intelligence as both a theory and a technological system; assessing the current knowledge base of AI amongst landscape researchers and practitioners; reframing landscape architecture as not only a process but a system of labor, knowledge, and products and that produces a unique *culture and subcultures* amongst its practitioners; and formalizing what interactions between these two systems may yield for the future of the spaces and places designed by landscape architects—or others who may be assisted by landscape architecture-based, AI-mediated knowledge.

Research Questions

The dissertation is organized around three chapters, each one addressing 1-3 research questions. The questions are:

Chapter 1

- What theories, subfields, and applications of artificial intelligence field are relevant to the practice of landscape architecture?
- How specifically have the subfields and applications of AI been used in research, pedagogy, or practice, if at all?
- Where are our current knowledge gaps regarding AI in the discipline?

Chapter 2

- How do landscape architects perceive rapid AI advancement?
- How do group identity, values, and behavioral norms accelerate or impede AI adoption in the profession?

Chapter 3

- What mental models do landscape architects use to make judgments about AI acceleration?
- How can landscape architecture practice expand those modes of thinking to adapt to a fast-moving, AI-permeated economy?

A Brief Summary of Dissertation Chapters

The ensuing chapters will address all of these components using a multi-paper format where each chapter represents a manuscript that directly investigates a group of research questions. Their structure and methods are as follows:

Chapter 1 Artificial Intelligence in Landscape Architecture: A Literature Review

This chapter is about the state of AI in the profession—i.e. what is happening with AI and what landscape architects currently do with it.

The use of artificial intelligence (AI) is becoming more common in landscape architecture. New methods and applications are proliferating yearly and are being touted as viable tools for research and practice. While researchers have conducted assessments of the state of AI-driven research and practice in allied disciplines, there is a knowledge gap for the same in landscape architecture. Chapter 1 begins to fill the gap by conducting a systematic literature review, searching and evaluating studies specifically focused on AI and disciplinary umbrella terms (landscape architecture, landscape planning, and landscape design). It includes searches of academic databases and industry publications that combine these umbrella terms with the main subfields of artificial intelligence as a discipline (machine learning, knowledge-based systems, computer vision, robotics, natural language processing, optimization). Initial searches returned over 600 articles, which were then filtered for relevance, resulting in about 100 articles that were reviewed in depth. The work highlights trends in dissemination, synthesizes emergent AI-Landscape (AI-LA) themes, and argues for unifying dissemination and compilation in research and practice so as not to lose relevant AI-LA knowledge and be caught off guard in the built environment profession's next technological leap.

Chapter 2 Landscape Architects and AI Transformation: A Cultural Mapping Exercise

This chapter is about cultural identity—i.e. who we are as landscape architects, how we perceive the world, and why that matters for AI development in the profession.

The review from Chapter 1 reveals that AI has increasingly pervaded the landscape industry, with capabilities to carry out project management tasks, perform analysis and optimization, and even autonomously engage in creative acts endemic to the design process. However, it points out that existing applications and attempts at AI integration remain scattered and singular, with little understanding of what AI is on a broader scale and to what extent it might influence the future of landscape architecture practice, if not redefine practice itself. This first requires landscape practitioners to understand their industry as a functioning, perceptible culture and then discern how the groups within that culture would respond to AI developments in a specific way at a specific point in time. Chapter 2 attempts to do so using the Cultural Topography (CTops) methodology—an established research approach within strategic culture and security studies that enables scholars and practitioners to better understand cultural factors influencing decision-making in specific groups. The study offers insights into landscape architects as a cultural group by facilitating an inductive discovery of unique patterns, values, norms, and behaviors that define their professional identity. Doing so helps to uncover the underlying principles, motivations, and challenges that shape their work and influence their decision-making processes when it comes to the adoption or evasion of AI. The hope is that this analysis can contribute to a richer understanding of the landscape architecture profession's culture for those who are not immersed in it, fostering better collaboration among interdisciplinary teams that include landscape architects in their ranks.

Chapter 3: Problematizing AI Omnipresence in Landscape Architecture (and Offering some Antidotes)

This chapter is about how to adapt—i.e. how we as landscape architects currently discuss the implications of widespread AI adoption and how we can discuss them better.

This chapter takes the form of a position paper that argues for and offers a critical lens through which to examine the current AI frenzy in the landscape architecture profession. In it, we argue that the current discourse on AI is at once too simplistic, too focused on a one-dimensional spectrum of AI acceleration, and too fixated on judging the merits of the technology rather than critiquing the way humans think about and use it. To address this impasse, we propose four caricatures, or mental modes, that landscape architects might inhabit when thinking about AI. Rather than limiting judgments of AI use to a good/bad, either/or binary, these archetypes and corresponding narratives exist along a spectrum and are permeable, allowing LAs to take on and switch between them according to context. We then utilize these caricatures to speculate how more nuanced ways of approaching AI might also open new modes of practice in the new digital economy.

To those outside of my contractually obligated doctoral committee who venture to read this dissertation, I hope you find it insightful. Moreover, I hope you use its inadequacies as a springboard for further exploration and to elevate landscape architects' place in the new world being brought about by rapid AI diffusion.

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ARTIFICIAL INTELLIGENCE IN LANDSCAPE ARCHITECTURE: A LITERATURE REVIEW[2]

Abstract

The use of artificial intelligence (AI) is becoming more common in landscape architecture. New methods and applications are proliferating yearly and are being touted as viable tools for research and practice. While researchers have conducted assessments of the state of AI-driven research and practice in allied disciplines, there is a knowledge gap for the same in landscape architecture. This literature review begins to fill the gap by searching and evaluating studies specifically focused on AI and disciplinary umbrella terms (landscape architecture, landscape planning, and landscape design). It includes searches of academic databases and industry publications that combine these umbrella terms with the main subfields of artificial intelligence as a discipline (machine learning, knowledge-based systems, computer vision, robotics, natural language processing, optimization). Initial searches returned over 600 articles, which were then filtered for relevance, resulting in about one hundred articles that were reviewed in depth. The work highlights trends in dissemination, synthesizes emergent AI-Landscape (AI-LA) themes, and argues for unifying dissemination and compilation in research and practice so as not to lose relevant AI-LA knowledge and be caught off guard in the built environment profession's next technological leap.

Keywords

landscape architecture, landscape design, landscape planning, machine learning, optimization, computational design

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[2] Fernberg, P., & Chamberlain, B. (2023). Artificial Intelligence in Landscape Architecture: A Literature Review. *Landscape Journal*, *42*(1), 13-35.

Introduction

Leaders in landscape architecture have declared the need to consolidate data and expertise from disciplines such as engineering, land planning, agriculture, and ecological sciences to give "artistic physical form to modern ideals of equity, sustainability, resilience, and democracy" (*ASLA Is Committed to Climate Action*, n.d.; *New Landscape Declaration*, 2016). Such an assertion is fitting since landscape architects see their profession as an intersection among all others dealing with spatial issues (Kullmann, 2016). As designers of all types of exterior spaces, landscape architects' work involves near-constant coordination with experts in allied fields. This is especially evident in the current state of practice, where projects are increasingly scaling up in scope to meet open-ended, territorial scale challenges (Bryant, 2021; Polk, 2015). Yet, for all the diverse ways designers engage across disciplines, most simply lack the time, knowledge, or background to account for the sheer number of 'design problem' permutations arising from multifaceted issues such as climate change resilience, large-scale ecological degradation, and social equity. To this end, there is an emerging discussion around the potential of artificial intelligence (AI) to address such limitations. The discussion includes topics like laying a historical groundwork for AI (Z. Zhang, 2020), current and potential AI applications to landscape architecture (B. Cantrell et al., 2021), proposing machine learning primers and ontologies (Alina et al., 2016; Fernberg et al., 2021; Tebyanian, 2020), gauging the potential for AI in coastal adaptation (Z. Zhang & Bowes, 2019), and conceptualizing an autonomous post-human ecological infrastructure (B. Cantrell, Martin, et al., 2017).

Still, AI-focused literature remains underdeveloped in landscape architecture, leaving knowledge seekers to turn to adjacent disciplines where the research is less nascent. The majority of current research in AI systems for landscape design or planning focuses on either conceptual exercises or somewhat singular tools for specific applications. Even if current explorations evoke broad observations about AI in landscape, a lack of compilation presents key unanswered questions:

1) What exactly do we mean when we say AI in the context of landscape architecture?
2) How has AI been used in landscape architecture research/practice, if at all? And
3) Where are our current knowledge gaps with regard to AI?

This literature review seeks to lay a foundation to begin answering these questions. In it, we: 1) establish a scope of review for landscape architecture and its subfields, 2) identify a framework for artificial intelligence as a research area within which to embed the landscape disciplines (i.e. the definition of AI as a discipline along with its sub-fields), 3) combine those terms to perform a literature search using online databases, and 4) after refining results, we provide a summary of trends, highlight emergent themes, and present the need for a future AI-Landscape (AI-LA) research framework.

Defining Review Parameters

"Terms" of Landscape Architecture

Landscape architecture practice is interdisciplinary, so it can often be difficult to delineate what falls under its purview. Grading, for instance, is a design exercise that can reasonably be claimed by both engineers and landscape architects but is often taught, talked about, and executed quite differently by each discipline. The same holds for many activities landscape architects carry out (e.g. stormwater management, construction documentation, landscape history, etc.). We recognize defining the scope of practice within landscape architecture is integral for a comprehensive and systematic review of AI's pervasion into the entire discipline—and that such an undertaking could be enhanced by using established frameworks such as the Landscape Architecture Body of Knowledge (LABOK) survey findings (2004) or Langley et al.'s knowledge domains of landscape architecture (2018). However, the combination of these multi-level conceptual frameworks with the scope of artificial intelligence is extremely vast. There have indeed been efforts to frame the context of the AI-LA knowledge base (B. Cantrell et al., 2021; Tebyanian, 2020; Z. Zhang, 2020), but these works did not intend to comprehensively review and formalize an AI-LA framework. Thus, for this review, we first needed to establish a simple but encompassing disciplinary scope as the foundation for this framework. We chose to adopt Ogrin's definition of landscape architecture as a discipline which comprises design and planning as two distinct subfields of creative work (1994). Hence our scope uses the three disciplinary terms from Ogrin: landscape architecture, landscape design, and landscape planning. These are often used interchangeably, and though sometimes seen as distinct in detailed discussions of practice, they can confidently be lumped into a representative set that represents the same discipline for the purposes of this review (von Haaren et al., 2014).

Artificial Intelligence and Applicable Subfields

The *Oxford English Dictionary* defines the term artificial intelligence (or AI) as "the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." In the context of the AEC industry, the is often used colloquially as a catch-all for highly technical or computational approaches toward design and automation. The term machine learning is also used in common speak, often interchangeably with AI, even though it technically represents only a subset of the AI field. The scope of AI is extremely vast, which has led to the derivation of several subfields or branches. Here we outline some of the more common subfields seen in literature to provide a framework for how we conceptualize the contributions and application of AI within landscape architecture. The primary subfields we explore in this paper include: 1) *Machine Learning*, 2) *Knowledge-based Systems*, 3) *Computer Vision*, 4) *Robotics*, 5) *Natural Language Processing and 6) Optimization* (Abioye et al., 2021; Public Health Agency Canada, 2020). We acknowledge there is a range of other proposed subfields (Chiabai et al., 2018; Mata et al., 2018; Zhu & Yan, 2015), but for this review we chose these six as they are the most applicable to landscape architecture.

Machine learning. Machine Learning is one branch of AI, but the techniques often underpin a range of different subfields. The term itself may often be used as a synonym for artificial intelligence, perhaps because it is not well understood by non-experts, or the diversity of AI subfields is not well understood (and ever changing). In simple terms, machine learning focuses on using statistical methods and models that can redefine and refine themselves to "learn." Learning is done through supervised, unsupervised or reinforcement learning. Supervised learning necessitates a system to observe data, conduct analyses, and output to improve its understanding of the analyzed phenomenon (Bzdok et al., 2018; Kotsiantis et al., 2007). Unsupervised also uses statistical techniques which are suited to discovering patterns without outputs or interaction with another agent such as a human or other computer system (Hastie et al., 2009; Tarca et al., 2007). Reinforcement learning includes techniques where the computer agent is intended to explore a set of actions or situations and then learn or anticipate outcomes from different choice options (Sutton, 1992); the system learns the relationship between consequence and action (Chandak et al., 2019; Huang, 2021). A simple example of machine learning is an online application that learns purchasing habits and begins to make recommendations based on your own patterns and those of individuals like you.

Knowledge-based Systems (KBS). Knowledge-based systems are focused on using existing knowledge to enable computational decision-making. This subfield aims to develop inferences about knowledge and enable user interaction to support, supplement or engage complex systems (Akerkar & Sajja, 2009). These systems may require constructed representations of knowledge (e.g. that use an ontology) with a particular focus on the relationship of the meaning of elements within the set of knowledge. A KBS is an agent that adapts or creates inferences (Bergmann et al., 2005) based on existing knowledge. While these systems have existed for some time, they are not as popular given newer development in AI (Abdullah et al., 2006).

Computer Vision. Computer vision may be one of the more popular known AI techniques within landscape architecture because of the subfield's pursuits of simulating human perception of visual elements (Szeliski, 2010). There are a range of approaches used in this subfield, with some of the more recent oriented toward machine learning approaches. Computer Vision focuses on pattern recognition (Chen, 2015) and object extraction (Prince, 2012). A popular tool landscape architects use is Google Lens, which can identify a whole host of plants using computer vision techniques.

Robotics. Robotics is centered on the use of sensors, often coupled with machine learning (often reinforcement) and computer vision, to automate tasks. Robotics can encompass technology such as autonomous vehicles (Faisal et al., 2019) and lawnmowers (Wasif, 2011), as well as systems to irrigate and weed agricultural lands (Talaviya et al., 2020). Robotics can serve to replace human actions but can also offer new forms of collaboration (Vrontis et al., 2022).

Natural Language Processing (NLP). Natural language processing is another subfield that focuses on learning language and then recreating it to generate meaningful responses or outputs. NLP uses a range of techniques to form an understanding of language, including grammar and lexicon, learning and language processing (statistical techniques), constructs and representation (meaning and action), and techniques to manipulate language and learn the appropriateness of those manipulations (Chowdhary, 2020).

Optimization. Optimization is another subfield within AI, that may often be misrepresented within landscape architecture. While designers often attempt to optimize a given space, or develop parametric models to aid in design, AI approaches necessitate some kind of learning or algorithm to support the optimization. An important lesson here is that AI approaches usually require a specific delineation of the problem in some quantifiable means. The techniques often associated with optimization in AI are usually associated with search algorithms (Mirjalili & Dong, 2020), such as genetic algorithms (Chamberlain & Meitner, 2009; X. Li et al., 2013), simulated annealing (Rutenbar, 1989).

Importantly for all the subfields identified, the quantitative expression of constraints, goals, inputs and outputs (when applicable) must be well defined. Fernberg and Chamberlain (Fernberg et al., 2021) state that nearly every application of AI requires creating ontologies, methods, data mining or expert-based learning and developing statistical approaches to facilitate reasoning and may be done explicitly or implicitly. While humans play a range of defining roles in AI, the key is that the machine is the learning agent. Learning happens, typically, with abundant data, a clear language, and a reliable set of rules to follow.

Methodology

This section lays out a protocol for implementing our systematic review. In it, we describe the process for searching, screening, and selecting literature that is sufficiently relevant to the research objectives. Landscape Architecture encompasses activities and processes from a range of disciplines. Many LA-related fields already have extensive AI-related literature reviews, such as urban forestry (César de Lima Araújo et al., 2021), urban design and planning (Abusaada & Elshater, 2021; L. Yang et al., 2022), transportation (Abduljabbar et al., 2019), land use planning (Chaturvedi & de Vries, 2021), horticulture (B. Yang & Xu, 2021), construction (Abioye et al., 2021) and a range of others. For this review, we narrowed articles to specific disciplinary keywords of Landscape Architecture, Design and Planning.

To be included in our review, articles must exist within a searchable English-based literature database. All years of publication were included, though the recency of AI in literature is relatively new (post 2000s). The initial literature search utilized three databases: Scopus, IEEE, and JSTOR. Each of these was chosen to provide expansive interdisciplinary coverage across the arts, humanities, and sciences—all of which are integral in some way to the landscape and AI fields. JSTOR and a digital humanities affiliate called Constellate were used to find landscape architecture industry insights, as JSTOR currently houses every issue of the official periodical for the American Society of Landscape Architects (ASLA)—currently operating with the moniker Landscape Architecture Magazine or LAM—from its first publication in 1910 up until 2015. The most recent issues of LAM, from 2016 to the present, were searched and screened using keyword searches on the publication website, URL https://landscapearchitecturemagazine.org/. Hence, SCOPUS was chosen as the main data source, while the others were used for full article download and data validation.

Search Strategy

The search terms comprised two lists, one encompassing all relevant AI techniques and methods (and spelling modifiers) and one representing what we deem to be core landscape discipline terms, organized into two single-line text strings then combined with the Boolean operator AND. These terms were adapted from previous literature reviews of AI (Abioye et al., 2021; Emaminejad & Akhavian, 2022; Tebyanian, 2020; Wu & Silva, 2010; Yigitcanlar et al., 2020) with some additional terms we added in order to be more exhaustive. We did not limit applications of AI. The combination is as follows:

Line 1 (AI Search Terms): “Robotics” OR “Computer vision”, OR “Machine learning” OR “Expert System” OR “Knowledge-based Systems” OR “Optimisation” OR “Optimization” OR “Natural Language Processing” OR “Artificial Intelligence” OR “K-Means Clustering” OR “Hierarchical Clustering” OR “Fuzzy Clustering” OR “Model-based Clustering” OR “Linear Discriminant Analysis” OR “Monte Carlo” OR “Deep Belief” OR “Deep Boltzmann” OR “Deep Learning” OR “Convolutional Neural Network” OR “Stacked Autoencoders” OR “Recurrent Neural Network” OR “Deep Neural Network” OR “Speech processing” OR “Evolutionary computing” OR “Evolutionary Algorithms” OR “Swarm Intelligence” OR “Discrete Optimisation” OR “Convex Optimisation” OR “Discrete Optimization” OR “Convex Optimization” OR “Automated Planning” OR “Ontology” OR “Automated Scheduling”

AND

Line 2 (Disciplinary Search Terms): “Landscape Architect*” OR “Landscape Design*” OR “Landscape Plan*”

Scopus initially returned 528 results and IEEE returned 67. The search query could not be effectively executed in the JSTOR database due to character limitations and a catalog method which returned too many irrelevant results. We attempted to custom code our search using URL hacks, but the results were still highly problematic. To ensure due diligence and not leave a resource entirely, we attempted a simple Boolean-limited search using “Landscape Architecture” and “Artificial Intelligence”. The initial return was >6000 results, and a quick browse of the first several dozens of these results found the included articles to be completely irrelevant to the topic. However, after doing an advanced search in which the publication title had to contain the word "landscape", we were able to narrow the results to a return of 56 articles, three of which contained a directly relevant subject matter (Lindhult, 1988; McCarthy & Portner, 1980; von Wodtke, 1988). While these articles are not included in the formal results of our systematic search, they will be touched on in the Discussion section. Furthermore, to account for other sources that may not have been included in the systematic search process, we investigated Google Scholar, Google. On Google Scholar and Google (web search) we used the same two Boolean-limited search terms as used with JSTOR. These did not result in any substantially different outcomes. Where possible, we included articles in the discussion.

Data Collection

Metadata and bibliographic information on the initial search results were exportable from all databases and done so in two ways. The first was to export the saved searches in .RIS format to Zotero reference management software, where each article's bibliographic information along with links to full text were organized into database-specific folders. The second data collection method was an export of the saved searches into .CSV files, one from each database. The data were then cleaned and combined into a common attribution structure joined into a single .CSV file, which served as the principal dataset for our review and analyses. A cleaned table of the data is included in Supplemental Materials.

Study Selection Coding

While the initial search returned a somewhat digestible literature chunk, it also returned many duplicates and articles which seemed irrelevant to the purposes of this review—either because the work did not constitute a true investigation of AI, did not utilize AI methods, or did not reasonably fall into the scope of landscape architecture/design or landscape planning, despite the use of the Boolean operators to narrow the search.

To decide whether a study met the inclusion criteria of the review, we created a Python script to further refine our master database. The code iterated through each item, by combining the title, abstract and keywords and then identifying the frequency of keywords used that matched our search terms. We used the same disciplinary search terms ("landscape architecture", "landscape design" and "landscape planning") and then separated each of the subfields of AI with their specific terms (each term listed was in quotes and shortened words utilized * for Boolean limiting):

- **Machine Learning**: machine learning, supervised learning, unsupervised learning, reinforcement learning, deep learning, k-means clustering, hierarchical clustering, fuzzy clustering, model-based clustering, linear discriminant analysis, monte carlo, deep belief, deep boltzmann, deep learning, convolutional neural network, stacked autoencoders, recurrent neural network, deep neural network;
- **Knowledge-based Systems**: knowledge-based system, expert system, intelligent agent, case-based reasoning, linked system, ontology;
- **Computer Vision**: computer vision, scene reconstruction, motion analysis, image restoration, recognition;
- **Robotics**: robotic, climbing, actuation, locomotion;
- **Natural Language Processing**: natural language processing, speech processing, text mining, text analy;

- **Optimization**: optimiz, optimis, discrete optimi, convex optimi, evolutionary comput, evolutionary algorithm, genetic algorithm, differential evolution, particle swarm, swarm intelligence.

The script then coded each literature with the number of instances each of the disciplinary terms and subfield keywords indicated in the matched fields, as well as a general search for "artificial intelligence." We further refined our data by eliminating any instances where no keywords were present. This process provided a validation of the database search, by offering complete control over the included literature. Further, as the script processed each literature row, it identified if a duplicate article was found using year + title, since a DOI was not always present. Duplicates were denoted in a separate file, then the authors manually confirmed and removed them (85 in total).

Once all literature was coded, we then manually coded all dissemination venues (journal, proceeding, book, etc.) for: 1) alignment to the disciplinary search terms and 2) review rigor of the dissemination venue. Alignment of the field consisted of journals that are predominately associated with the discipline, including adjacent journals or proceedings. For instance, venues primarily aimed toward computer science or engineering were considered a low alignment for LA. Further, review rigor was evaluated based on the reputation of the journal, including impact scores (factors, cite score, etc.) and the review process. Coded values included: 1 = high alignment and review rigor, 2 = combination of low/high or mid for both, and 3 = low alignment and review rigor. These dissemination values (1-3) were then referenced with each article. The full list of all venues and the tier scoring is provided in Supplemental Materials.

The resulting master dataset now provided a means to filter literature using:

- Appropriateness of the venue and review rigor;

- Alignment with one or more of the disciplinary terms;
- An AI-related keyword.

The results and trends provided are delineated from different filtering mechanisms used. The bulk of our commentary and detailed review of articles were from those with a score of 1 for appropriateness of venue and review rigor, which also matched at least one disciplinary and AI search term. These are referred to as *tier 1* articles. We reviewed each filtered result and coded them further across two additional criteria: degree of contribution and relevancy to the landscape search terms. For the degree of contribution, we coded one of the following:

- Mention: merely mentions a disciplinary and AI term
- Discourse: theoretical or commentary
- Application: applies AI technique or approach
- Creation: develops new technique or heuristic

For relevancy, we denoted if an article seemed central to activities or knowledge related to the landscape architecture discipline. There were instances where we recoded an article that may have had a landscape-oriented search term but was completely irrelevant to AI, or vice versa. Broader trends metrics include articles with a score of 2-3 for appropriateness of venue and review rigor. These articles were not reviewed in depth and are referenced as *tier 2* for the purposes of this literature review. Tier 2 does not necessarily mean the contribution is of less value, particularly if the article aligns primarily with other fields.

Further, we noted that articles with terms aligned with *optimization* were often not AI-related, instead using the term to describe other quantitative or qualitative techniques. When used quantitatively, optimization overwhelmingly referred to a linear or stochastic technique to optimize a space or design, typically with a set of environmental variables. Additionally, some optimization articles focus on parametric modeling with mentions of optimization, but again were clearly focused on the optimization of the model or design element without a coupled AI-approach. We anticipate that several articles in tier 2 may be aligned with optimization, but not with AI. After completing our search, we filtered all disciplinary results where optimization was indicated without any other AI keyword. We then read through all titles to identify potential articles that likely used AI techniques but may have not stated this explicitly or used a term that may have been missed by our search terms. Any article we suspected may have used AI-coupled approaches were flagged (roughly a dozen). Unfortunately, precisely delineating the degree to which AI is embedded across all optimization articles is nearly impossible. This is because every article would need to be read in-depth (some of which are unavailable in full text) and others with substantial interpretation (many have inadequate documentation of methods).

Review Results and Trends for AI-LA Applications

Results of Literature Review

A total of 600 articles were identified that met both the landscape keyword requirement and the AI keyword requirement. These were published across over 300 different venues ranging from top-tier journals, conference proceedings, individual university publications and book publishers. Of the venues, 70 were tier 1 (priority for review), 31 were tier 2, and 207 were tier 3 (with 90% of those receiving the lowest ranking due to applicability to discipline and review rigor). Of the 600 articles that met the tier 1 filter, 31 were associated with keyword “Landscape Architecture”, 29 with “Landscape Design” and 150 with “Landscape Planning”, with ten of these overlapping more than two of these terms.

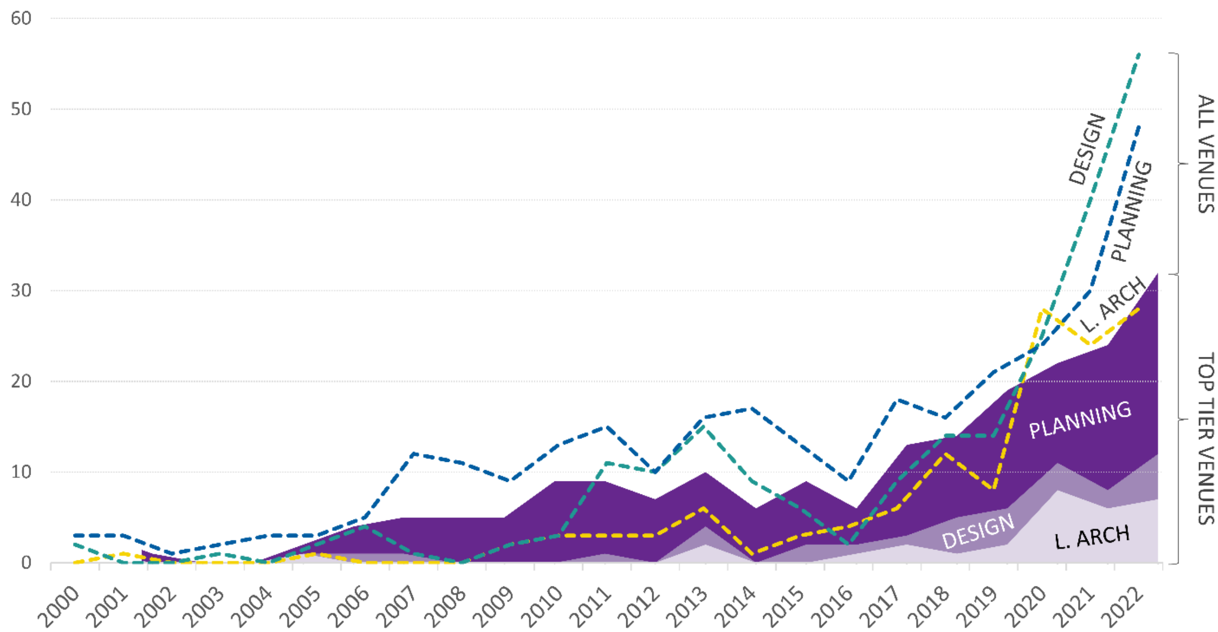
Upon reviewing all publications with keywords, the authors identified roughly one hundred articles that meaningfully apply to the discipline and AI simultaneously and represent the greater themes in the literature. The vast majority of these were application-based, with a handful of others oriented towards theoretical or speculative discourse and a very select few denoting a new advancement or creation.

Trends

The recent popularity and growth in AI-related works has been substantial. Figure 1 illustrates the rates of publication for each of the three disciplinary keywords. The figure shows publications from 2000 to the end of November 2022 for all literature that met both AI and disciplinary terms, as well as those literature published in top tier venues. As the chart indicates, publications with the term “landscape planning” emerged earlier and was consistently producing more than the other terms. While this is true for top tier venues, the trend has shifted recently with “landscape design” emerging with more publications when all non-disciplinary venues and lower tier venues were considered. From top tier venues, “landscape architecture” and “landscape design” seem to have a similar output frequency with the latter slightly higher. Broadly, the data show continued growth in the topic, with an extremely fast rise in publications when considered in all venues.

Figure 1

Publication Counts of All Matching Keywords that met both discipline and AI keywords (2000-2022).



Note: Lines show the results across tier 1 ranked dissemination publications (darker lines) and All tiers (lighter colors). Y-axis is count of publications.

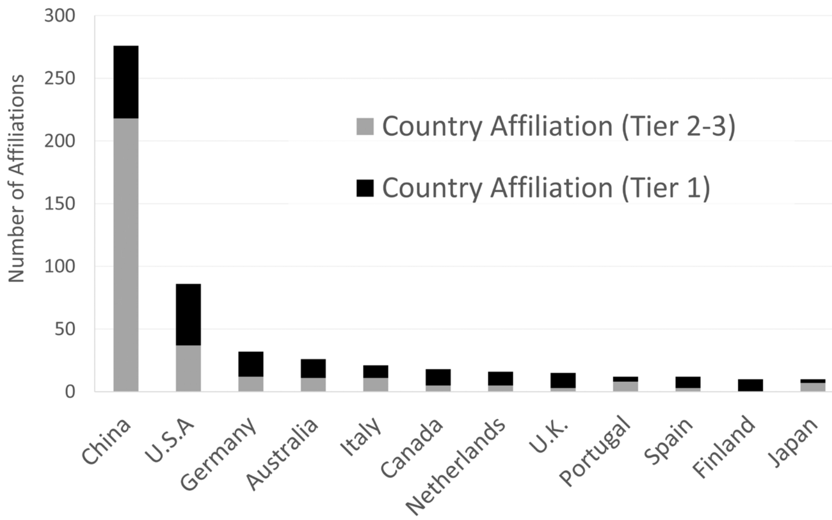
Across all three terms, there were 12 publications before 2000, with the first in 1978 that used a multiple hierarchical clustering method to help create a database of natural resources for assessment and planning (Frondorf et al., 1978). The articles during this time period were focused on database development, computer vision techniques and impact assessment. Some were methodological (primarily within computer science venues) and other were applications (primarily environmental journals). After 2000, there was a gradual increase in published works, with the majority of works being published in the five years. In general, publications have continued to rise across the umbrella landscape terms, with a significant drop during 2014-2016. The most rapid rise has come since 2016.

It should be noted that in our review, the terms landscape design and planning incorporated very broad definitions, with landscape design incorporating projects of a range of areas, while planning was typically oriented toward larger areas. It was also more apparent that both landscape design and landscape planning were terms used in other disciplines when they wanted to mention how their development or application of AI might align with other disciplines. We noted that landscape architecture was not used as frequently in mentions, even though the discipline does conduct both design and planning across scales.

We also identified author country affiliation across all publications. In total, we found 791 counts of country affiliations (meaning numerous articles were partnerships with scholars of more than one country). Twelve countries were identified as having more than 10 affiliations across all tiers, those countries are shown in Figure 2. Over one-third of the world's countries, with representation from all continents, have published something related to our search terms (67 countries). A full list of all affiliations is included in the Supplementary Documentation. The rapid rise of AI-related publications across all tiers seems to emerge broadly across the world with Chinese scholars leading this effort. It is important to recognize the substantial diversity of projects and venues where authors publish – and the proportion of tier 1 to all tiers differs substantially by country. Of the top 20 countries affiliated two thirds have about half of the publications in a tier 1 venue, with over half of all countries publishing at least fifty percent of articles in tier 1 venues. The overall trend indicates a growing interest in AI globally, which may represent a likely increase in funding related to this work, the expertise necessary to operationalize AI within the disciplines and partnerships being formed across disciplines.

Figure 2

Author Country Affiliations showing the difference of affiliations by tier ranking.



AI Subfield Prevalence

We conducted an analysis of the distribution of AI techniques within the discipline (landscape architecture, design and planning). The analysis observed all 600 publications that returned one or more matching disciplinary keywords and AI keywords (including "artificial intelligence"). Since artificial intelligence is not a single technique, for the purposes of reporting here, we eliminated any article that did not mention one of the subtypes of AI. There were 62 instances where only "artificial intelligence" was used as a keyword without any other subtypes indicated as a keyword. Of the 538 articles remaining, there were 597 total keywords instances where one of the AI keywords was used (indicating several articles with more than one AI subtype keyword included). The distribution of the subfields is provided in Figure 3.

Figure 3

AI Subfield Distribution Counts of All Matching Keywords (discipline and AI)

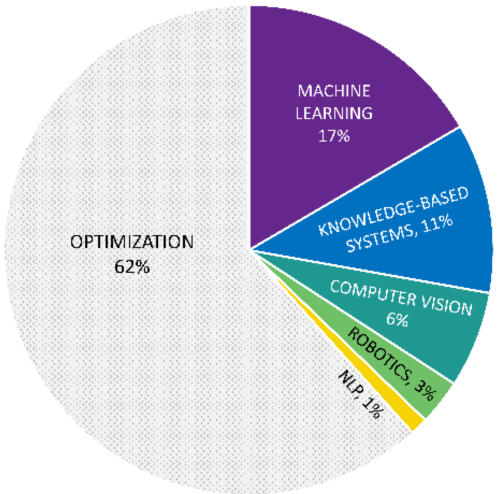


Figure 3 demonstrates the vast proportion of works involve machine learning and optimization, a pattern which mirrors that of other AEC industry disciplines (Abduljabbar et al., 2019; Abioye et al., 2021). We investigated our data further, counting not only whether an article mentioned a subfield, but also the total frequency of mentions of keywords. It is difficult to make inferences about the meaning of the frequency of word use, but there is a slight increase in the use of optimization and machine learning relative to the other subfields. This is likely because most recent AI advancements have been within the realm of machine learning or optimization, though this is quickly changing as fields natural language processing, robotics, and computer vision are making exponential progress (Malone et al., 2020).

As we acknowledged earlier in the Methods, the keyword search for optimization overestimates the number of contributions to literature in artificial intelligence because optimization is a term that can be used qualitatively and parametrically where automated learning is not central to the process but could be replaced with a stochastic or recursive algorithm without learning. Subsequently, without having access to full text for all articles, we conducted a review of titles and keywords manually to identify instances where optimization was clearly indicating an AI technique. We found less than 5% of the optimization articles fit this criterion, but even after reviewing articles we could access in full text, it was not always clear if their methods were actually AI because of limited documentation. As such, we have visualized, in Figure 4, the distribution of all non-optimization techniques to emphasize the role of three primary techniques used in the field. Likewise, the distribution of these subtypes through the years (starting in 2000) is provided in Figure 5. This distribution shows a trend in the subtypes that are associated with publications, suggesting machine learning and computer vision applications have grown almost tenfold, whereas the other subtypes are dropping in proportion. This is likely due to the increasing availability of tools and training scholars are using, as well as the a natural shift away from other techniques (Abdullah et al., 2006).

Figure 4

Subset of AI Subfield Distribution Counts of All Matching Keywords (discipline and AI)

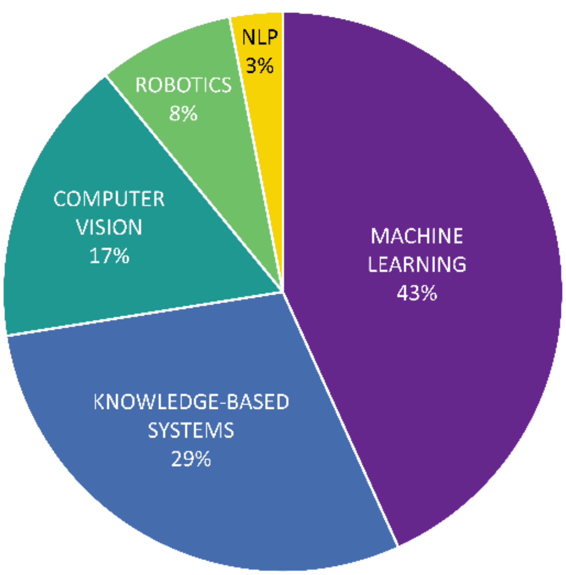
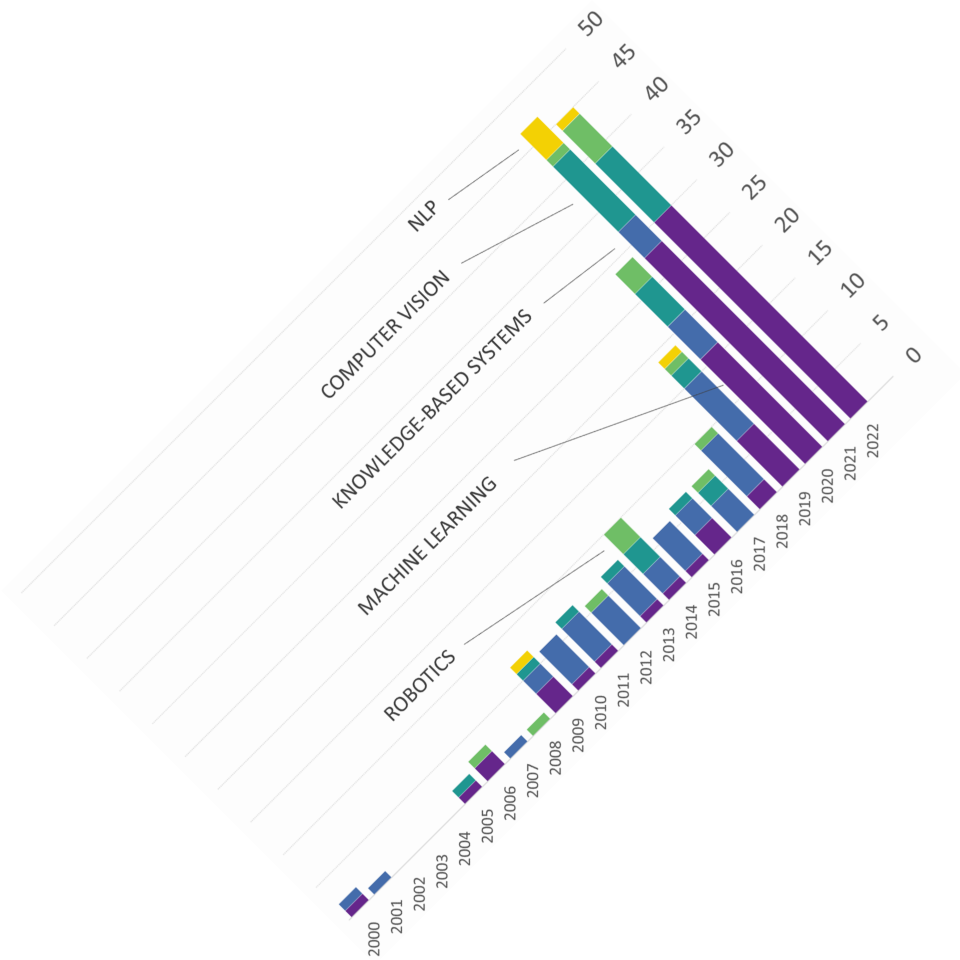


Figure 5

Temporal distribution and use of different subfields of AI from Figure 4 (only showing 2000-2022)



Salient Themes in AI-LA Research and Practice

A close reading of the literature reveals significant themes in AI-LA knowledge work. These themes range from a fine-grained focus on optimizing aesthetics or design process to using self-improving algorithms for large-scale ecological modeling and forecasting, to analyzing policy efficacy and public sentiment of open spaces through natural language processing. They are as follows.

Design generation and evaluation. AI-driven applications for landscape design are proliferating rapidly as landscape practitioners are learning how to extrapolate the technology to improve design process and products. The review illustrates this occurring across a range of scales, from Zhang et al.'s computer vision driven classification method for design details of Suzhou-style private gardens (2021) to Naderi and Raman's decision trees for pedestrian landscape designs (Naderi & Raman, 2005), to a slew of academics and professionals' use of machine learning for generating concepts at the urban scale (Koma et al., 2017; Raman et al., 2022; Slager & De Vries, 2013). There is also an emerging trend of AI applications for design evaluation, ranging from improving machine perception of greenery (Suppakittpaisarn et al., 2022) to the use of computer vision, machine learning, and optimization techniques for post-occupancy evaluation of user experience and ecosystem services in public open spaces (Schlickman, 2020; Wael et al., 2022; X. Wang, 2021; J. Yang et al., 2022). Outside of the results found in academic databases, our web searches revealed an abundance of AI-powered design applications being introduced or operated. Some are directly relevant to landscape design, such as Autodesk and Sidewalk Labs' tools for urban landscape design (Harrouk, 2020; Hickman, 2020); while others are more general but have potential use and impact for design. These include apps like NVIDIA Canvas, which allows users to make rough, color-coded brush strokes and instantly iterate them into landscape renderings of various styles (Tack, 2021) and AI-powered text-to-image generators like Midjourney, DALL-E 2, or Stable Diffusion, which create conceptual renderings from user-generated text strings (Brezar, 2022; Dreith, 2022; Monge, 2022).

Perhaps the most obvious pervasion of AI applications into landscape architecture and design workflows will be through the already burgeoning computational design ecosystem. In 2017, Proving Ground introduced LunchboxML, one of the first published plugins for machine learning in the Grasshopper/Rhino3D environment (Miller, 2017), and a slew of ML plugins have proliferated since. The following year, Cantrell and Mekies assembled a group of leading professionals and academics to conjecture the role of parametric and computational design in landscape architecture in a series of essays (2018), some of which anticipated a prompt pervasion of AI applications into design (Ervin, 2018). The review results combined with perusal of non-academic sources suggest such anticipation to be accurate, and also suggest the need for a better way of documenting the phenomenon.

Ecological modeling. Computational ecology has been prolific in the AI literature, and the field's methods have begun to creep into modeling applications tooled for landscape design and planning purposes. For instance, Zhang and Bowes trained ML models that outperformed typical models in real-time predictions of groundwater table response to storm surge in Coastal Virginia (2019), and in turn posited a more machine-driven landscape monitoring regime. Abdollahi et al. (2022) devised a new optimization approach to modeling urban ecosystem service zones based on landscape patterns. On the other side of the urban-rural transect, Benke et al. introduce a sophisticated application of geovisual analytics (driven by agent-based modeling) to model the movements of ruminants in the landscape using satellite tracking data. While possibly not central to the discipline as of yet, the concept of using advanced modeling to predict patterns of grazing animals over large landscapes could be useful to consider as part of a design process. This is especially true for animals that may use intentionally designed large areas. Taking the idea of machine-driven management further, Goodwin et al. (2022) and van Strien and Grêt-Regamey (2022) both introduce ML methods for classification of landscape typologies. Taken with the other autonomous management methods, a provocative question arises of whether AI utilization could foster a land management regime that is entirely automated from start to finish.

There are also significant AI developments in forest planning and management. Salient examples from the review include techniques to optimize (here we cite AI-optimization) for timber harvest (Eyvindson et al., 2018; W.-Y. Liu & Lin, 2015), land use modeling (Lin et al., 2009), habitat-specific restoration (Westphal et al., 2007), measuring forest connectivity (Peng et al., 2019; Shanthala Devi et al., 2013) and spatial design of forests (G. Liu et al., 2006); machine learning applications for species distribution modeling (Alegria et al., 2021; Ngarega et al., 2021); modeling and planning for effects of fire in the forest landscape (Miranda et al., 2020; Stamou et al., 2016; Zema et al., 2020); and modeling complexities of varied forest landscapes (Ask & Carlsson, 2000; Gärtner et al., 2008; Hummel & Cunningham, 2006). These works represent only a sample of what has been done in Forestry—the discipline has been prolifically producing optimization methods in recent decades (Kaya et al., 2016) and AI has creeped significantly into urban forestry (César de Lima Araújo et al., 2021)—but are representative of the research authors deemed relevant to landscape planning or design, whether in titles or keywords.

Predictive analytics. Simulation and forecasting are another obvious anecdote for trending methods in landscape and spatial planning, and the review gives evidence for it. Subjects cover anything from using gaming technology, agent-based modeling (ABM) and AI to simulate potential pedestrian and social life in urban spaces (Almahmood & Skov-Petersen, 2020) to forecasting climate and emissions scenarios at the landscape scale (Bergier et al., 2019; Ngarega et al., 2021), optimization for estimating green infrastructure potential (Dong et al., 2022), and landscape simulations for improving predictive forest management (Hummel & Cunningham, 2006; Kampichler & Sierdsema, 2018; Stamou et al., 2016). While predictive analytics only had a handful of results falling under the umbrella term of "landscape planning", the fact that they are among the most common methods in AI-driven urban planning, internet of things (IoT) or Smart Cities conceptualizations (Souza et al., 2019) makes them very relevant to the landscape disciplines, as many decisions and models will inevitably creep into the operational territory of a landscape architect or planner focused on urban environments.

Landscape policy evaluation. A number of studies utilized AI methods to model ecosystem services. For instance, Groot et al. used evolutionary algorithms for generating planning and design solutions for multi-functional landscapes (2018); Queiroz et al. used k-means clustering to map and classify ecosystem services bundles (2015); while others modeled socio-ecological determinants, associations, or natural capital stocks and flows associated with ecosystem services (Lorilla et al., 2020, p.; Mouchet et al., 2014; Zank et al., 2016). Other projects utilized AI as part of evaluating landscape policy outcomes (both potential and actual). These include Berkhardt et al., who used machine learning to generate land use classifications from remote sensing imagery in order to measure conformity to and impacts of water conservation measures; Wang et al.'s Monte Carlo simulation technique to measure cooling and energy saving potentials of shade trees and urban lawns in Phoenix (2016); clustering methods for prioritization of green corridor development (Shapira et al., 2013); and development of machine learning tools for maximizing biodiversity benefits in conservation planning (Thomson et al., 2020).

Sentiment analysis and social media. Sentiment analysis (SA), or sentiment modeling, is a burgeoning research area that uses text and image data mining and to understand public opinion of issues, services, or social phenomena, among other things (L. Zhang & Liu, 2017). The methodology has grown precipitously over the last decade and pervaded across a wide variety of fields, mostly due to the abundance of user data generated in social media (Yue et al., 2019). The landscape and urban design disciplines are included in this creep (C. Yang & Liu, 2022), and review results suggest future growth as public engagement methods evolve among researchers and practitioners. Much of the work to date centers around public green space satisfaction. Song et al. utilized computer vision (including face and object detection models) to analyze and annotate imagery captured from social media platforms to inventory and assess characteristics such as temporal patterns of park use, social dynamics, activities, and demographics (2022). Jahani et al. applied artificial intelligence techniques to identify the prevalence of bird sounds in urban green spaces and their association with mental restoration (2021). Ghermandi et al. extracted online geolocated photographs from social media platforms then used computer vision cloud services to characterize human-open space interactions in urban green spaces (2022). Wang et al. zoomed out to a regional scale as they employed machine learning techniques to assess green space satisfaction of 50 parks in Beijing (2021). They also introduced a landscape-feature lexicon to help improve granularity of landscape sentiment analysis. Other studies focus on measuring sense of place in important cultural or touristic landscapes such as the Las Vegas Strip, USA (Song et al., 2021) or Mt. Huangshan, China (Chai et al., 2021), or on simply understanding discrepancies between policy measures and user experience using natural language processing of user-generated text data (Wartmann et al., 2021).

Knowledge systems for AI-LA applications. Another less prolific but important grouping of studies are theoretical or speculative pieces touching on the permeation of AI methods into landscape practice and the need to formulate knowledge frameworks that help designers and planners adapt to it. Zhang provides a historical sketch of cybernetic environments, positing that landscape designers have previously had influence on their development and should reclaim that influence to drive the future (2020). Cantrell et al. argue through synthesis of current developments that AI’s fast-growing influence presents an epistemological crisis for landscape architecture and that the profession may need to rethink its authorial role in solving wicked problems of the day (2021). In accordance with this frame, Fernberg et al. suggest addressing the crisis involves formalizing operational language into ontological frameworks for AI systems (2021) and that there is a need to grow more systematic knowledge of AI in landscape architecture. Exemplary efforts to do so include Tebyanian's review and primer for machine learning in urban landscape design (2020) and Ervin's history and taxonomy of digital landscape architecture, which gives historical context to computational developments and associated progression in landscape architecture while providing commentary about terminology and definitions—including one of the first references in the literature to the concept of 'bionic' landscapes (2020a).

Discussion

In carrying out the review process, the authors drew some distinct impressions of the state of AI in landscape architecture. Broadly, sentiment toward AI within the field is growing rapidly. This is depicted by the diversity of AI-based implementation across all publications, the global distribution of work and likely the recognition of the importance of design from within more computationally centric fields. Yet even amongst the most non-technical, discipline-focused venues for landscape architecture, planning, and design, there appears to be an uptick in publications. Further, the sophistication and implementation of AI methods may demonstrate the increased training and access to techniques that are being afforded researchers, as well as funding opportunities globally. Importantly, researchers within the discipline who are interested in AI should become aware of the vast interest from other disciplines who want to engage in the discipline, in particular being aware that much of the growth in the topic is associated with the term "landscape design". More broadly, we reflect on Fernberg and Chamberlain (2019) who ask about the role technology specialists might play within the future of landscape architects. To what extent will landscape architects (here we speak more broadly toward designers and planners as well) develop and embrace AI taking agency on how it is implemented within the discipline, or will technology designers from outside the discipline shape the discipline using AI?

It is important to underscore that the while scope of this review focuses on direct relevance to the umbrella terms “landscape architecture”, “landscape design”, and “landscape planning”, the breadth and depth of AI-related research increases significantly with the inclusion of terms or activities that could feasibly fall under the umbrella of the landscape architecture discipline but have greater relevance or recognitions in allied fields or disciplines. For example, research advancements of automation in agriculture and ecology are longstanding, and now converging to offer unique solutions to global food security problems. Researchers have seen success in applications ranging from vegetation biomass and cover estimation in fire-damaged landscapes (Anderson et al., 2018), measuring forest tree defoliation using smart-phone photos (Kälin et al., 2019), or using image-based deep learning models for disease detection in agriculture (Mohanty et al., 2016) to thermal mapping waterbodies, forest monitoring, and aerial seeding using UAS (Amorós & Ledesma, n.d.; Hogan et al., 2017; Minařík & Langhammer, 2016; Novikov & Ersson, 2019; Sai et al., 2020; Vovchenko et al., 2020). Combining artificial intelligence (AI) applications in agriculture with emergent methods in agroecology shows the potential to address pressing problems in 21st century food systems such as climate change uncertainty, optimizing data flows, or crop efficiency (Barbieri et al., 2018; Cherkauer et al., 2018; Leippert et al., 2020). Most if not all of these applications have some relevance to landscape architecture or landscape planning—as some designers work in agricultural contexts or are interested in applications for ecological restoration in their site planning—but the subjects of the studies in and of themselves may not be considered central to the practices, teachings, or research of landscape architecture.

Another interesting area of convergence that may appear less obvious is in robotics. While the literature search only returned one article on robotics in the landscape disciplines—Westort and Shen's exploration of robot-assisted, in-situ landscape gardening (2017)—the authors see robotics as an emerging theme. The exponential growth of robotics in the AEC industry as suggested by Abioye et al. (2021) and Emaminejad and Akhavian (2022), the man established architectural robotics labs (*International Map of Robots in the Creative Industry*, n.d.), and an uptick in landscape-oriented robotics projects from institutions such as Louisiana State University and ETH Zurich (Harmon et al., 2022; Hurkxkens et al., 2020, 2022; Johns et al., 2020)—projects not picked up in the literature search because of term mismatch—there is clear evidence that this subfield of AI has potential for an outsized impact on the landscape disciplines, particularly design.

While a distinction between relevant AI research in agriculture or robotics and landscape design is fairly intuitive, the line becomes thinner when considering fields like urban design and urban planning, which overlap significantly with landscape disciplines in interests, theory, and methods (Van Assche et al., 2013). For instance, there are a number of extensive and already highly cited reviews of artificial intelligence in urban planning subjects such as land planning dynamics (Wu & Silva, 2010), planning for smart cities and big data (Allam & Dhunny, 2019; Yigitcanlar et al., 2020), transportation planning (Abduljabbar et al., 2019), and urban forestry (César de Lima Araújo et al., 2021; Nitoslawski et al., 2019). All of these have direct relevance to landscape design in urban contexts but would be otherwise unknown in a review that only includes the keywords "landscape architecture," "landscape design," or "landscape plan"—

which could in turn mean hundreds of informative studies on landscape-relevant AI applications go unnoticed from parochial scoping in terms.

Furthermore, the same dilemma applies to the more specialized terms of landscape architecture. If, for example, a reader would rely on the current study which focuses more broadly on the discipline, they would consider AI development to be overwhelmingly nascent with just a few dozen relevant studies. But if they were to perform a search using "stormwater management," one of the specializations of which licensed landscape architects are required to have some knowledge, they would find an abundance of well-established literature on AI applications for stormwater plans (Imran et al., 2013). In the authors' view, this exercise paints a complicated picture wherein the vast majority of contributions to AI development relevant to landscape architecture come from researchers and practitioners outside the discipline; a paradox where AI-LA research and practice is at once established and emerging, quite possibly to the ignorance of many in the profession in either sense. Such a notion suggests that practice-based researchers should be aware that using only discipline-specific terminology in precedent research could unintentionally blind them to relevant information if they are too parochial in keyword usage. On the other hand, a more robust output of AI-LA research from within the discipline could bolster the relevance of its lexicon and help to avoid constant borrowing and fitting of knowledge from outside it. In other words, the knowledge domain unique to landscape architecture could effectively build a new appendage that relates to AI and its use in practice and scholarship.

Given these limitations, we suggest that future work can more comprehensively illuminate the role of AI in landscape research and practice by expanding the scope of the research and utilizing a broader but systematic lexicon of disciplinary terms. For example, a future study could include a full-scale systematic literature review that takes the current work's AI search terms protocol and queries literature using established disciplinary frameworks such as the Landscape Architecture Body of Knowledge (LABOK Task Force, 2004) or the core landscape knowledge domains developed by Langley et al. (2018). Doing so could likely provide a more encompassing panorama of AI-related work that includes the facets of the profession that clearly fall under its purview but do not always carry the labels of "landscape architecture", "design", or "planning". Besides expanding the terminology, future AI-LA reviews or other investigations should also seek to bridge the knowledge accessibility gap between academia and practice. While the current work illustrates practice-driven AI research and applications as published in the industry standard Landscape Architecture Magazine and white papers from a handful of practice-based research labs, the question of how to appropriately (and systematically) compile knowledge from industry and synthesize it with academic literature remains largely unsolved. A protocol for addressing this problem will provide mechanisms for consistent and defensible longitudinal research on AI's transformations of the profession in coming decades.

As part of this special issue in Landscape Journal, we set out to explore how artificial intelligence has and is influencing landscape architecture, design, and planning. In conducting this review one of the more difficult decisions was selecting the bounds of a discipline, that is, by definition, rather interdisciplinary. Those reading this article are likely to have read and most certainly will read articles from a variety of different disciplines that relate or conduct research on landscapes. In many contexts the definitions of architecture, design and planning within landscape often blend, especially when referenced from outside the discipline. Ironically, in our search we not only discovered the increase in AI-related publications within these fields of study and practice, but a significant body of literature published in venues and by authors outside of these disciplines that give mention to their potential contribution to one or more of these three landscape terms. However, the wide range of different publication venues cataloged from our search and ranking techniques makes it difficult to ascertain the role AI might play within the discipline in the future. This is because most of the articles associated with the discipline come from lower tier venues where stated relevance to practice and research are vague.

The question of what defines landscape architecture, or landscape design or landscape planning is an ontological and socio-cultural question. In our section, "Terms" of Landscape Architecture we provide some context for why we set out to identify these three terms and to ascertain the contribution of AI within these narrower definitions of what these fields practice. We discovered an increasing trend of AI-related publications in venues central to these disciplines and that the rapid rise of this work has surged in the past few years. From within landscape architecture the rise has only increased recently. For instance, in the 2022 issue of the Journal of Digital Landscape Architecture, the authors identified several new publications that applied artificial intelligence techniques, with some of those being direct applications and others referencing the significance of the techniques (Barbarash et al., 2022; Fengjing et al., 2022; Khalilnezhad, 2022; X. Liu & Tian, 2022; J. Yang et al., 2022).

One of the significant challenges of this research endeavor was identifying if and to what extent AI is playing a role in practice and education. Most literature reviews, including our own, often focus on peer-reviewed publications, or at a minimum, dissemination products that show up in literature related databases. Unfortunately, outside of Landscape Architecture Magazine (LAM) and the LAF Case Studies repository, there are not any obvious centralized venues for publishing practice-oriented work, at least in the US. While LAM has published AI-related articles (B. Cantrell, Ellis, et al., 2017; Fernberg & Chamberlain, 2021; Petrich, 1986; Zeiger, 2019b), these are limited in number and primarily contributions from academic scholars. We ask whether or not this is an indication of the lack of AI-related work being conducted in practice or if there is a knowledge and dissemination gap. As discussed in emerging themes, we are aware of several efforts from landscape architecture practice involving AI applications, but these contributions are not included in searchable databases. Such a lack of compilation can make identifying contributions from practice very difficult and limit the democratization of these works, even if that is not the intent.

It is at the intersection of disciplinary recognition, ontology and the dissemination of works from the fields identified that we see a conundrum. Does landscape architecture, design and planning play a key role in proliferating or at least applying AI-related work? Are scholars within the field publishing in other disciplinary journals and not giving credit to the contribution to their field or is dissemination not taking place, or is there really a limited amount of work? In any case, we argue that researchers and practitioners should consider including search terms that relate to the broader landscape disciplines, while also including AI-related keywords in abstracts and metadata associated with publications. This may help to raise awareness of the contributions within the field and bring greater recognition to the application of these techniques to other disciplines, as well as make this information more readily available to students, practice and scholars. A specific example of this could be the use of the term “landscape design”. Interestingly, it appears the overwhelming increase in publications across all venues is associated with this term but comes from venues outside the discipline. Further, in the articles we reviewed that used this term, we noticed that it often serves as a catch-all that might be more appropriately delineated as landscape architecture or landscape planning. Thus, in an effort to promote our own disciplinary contribution toward AI, future publications may want to consider adding “landscape design" to keyword searchers where publications are AI centric. This may increase the likelihood of knowledge sharing within and outside landscape centric disciplines. When considering the general pulse of publications across all venues, the relative growth and access of AI-related techniques shows plausible continued growth of AI-related articles.

Conclusion

After reviewing hundreds of articles, websites, books, and proceedings, we believe our observations can be reasonably summed up in three important takeaways:

1. Interest and contributions toward AI are growing steadily and significantly in the landscape discipline, both in academic research and professional applications.

2. Applications and discourse from all subfields of AI have grown exponentially over the past three years. This, in our view, suggests the emergence of a new technological paradigm for the discipline.

3. Landscape researchers in all sectors (e.g. academia, practice, government) would be well served to formalize, compile, and contribute to a clear AI-LA knowledge framework and/or AI-LA standards of practice to ensure proper workforce preparedness (whether in pedagogical or professional settings).

4. To promote AI knowledge sharing across all disciplines, more universally accepted terms (e.g. landscape design), should be included in AI publications within the discipline.

5. The need for scholars and practitioners to improve the democratization of knowledge sharing by ensuring publications are indexed and easily accessible (e.g. open source) from a variety of databases (e.g. Google Scholar, Scopus).

Engagement with technology driven by artificial intelligence, both practically, speculatively, and critically, is increasing year over year in landscape architecture, design, and planning, and will continue to do so. This literature review is the first attempt at providing a formal epistemic baseline for said engagement and incites a more systematic approach to compiling the knowledge it produces. As artificial intelligence systems continue to permeate everyday landscape practice, the workforce will have to confront a number of adaptive challenges. How and where do we integrate AI into existing design and planning processes? Do those processes fundamentally change because of said integration? How will landscape practitioners ensure that the AI systems mediating their workflows are producing socially and environmentally equitable outcomes? We argue that such questions can only be answered if there is a formal framework for understanding how AI has, does, and will affect the state of practice. The review shows evidence that AI-LA knowledge is nascent even if rapidly growing, hence current gaps in the literature could be reasonably identified or filled with a more systematic method for measuring AI's influence in the more detailed subsets of landscape disciplines, especially one that bridges dissemination gaps between academia and professional practice. If researchers, professionals, and educators act now to develop this protocol, it could serve as leverage for landscape to take the lead in shaping a techno-vernacular of the future. If we hesitate, we run the risk of causing unnecessary root shock to the profession because of failure to get ahead of the next technological tipping point AI is pushing us towards.

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LANDSCAPE ARCHITECTS AND AI TRANSFORMATION: A CULTURAL MAPPING EXERCISE[3]

Abstract

Artificial intelligence (AI) has increasingly pervaded the landscape industry, and scholars are trying to understand to what extent it might influence the future of landscape architecture practice, if not redefine practice itself. Apart from understanding the technical capabilities and possibilities of AI, such an exploration also requires landscape practitioners to understand their industry as a functioning, perceptible culture and then discern how the groups within that culture would respond to AI developments in a specific way at a specific point in time. This paper attempts to do so using the Cultural Topography (CTops) methodology, an established research approach within strategic culture and security studies that enables scholars and practitioners to better understand cultural factors influencing decision-making in specific groups.

Keywords

landscape architecture, cultural topography, artificial intelligence, technology, professional culture

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[3] This chapter will be submitted directly to the Editor-in-Chief of Landscape Journal who has shown interest in publishing analyses of the discipline that utilize novel social science methods.

Introduction

Artificial Intelligence (AI) has undoubtedly hit the mainstream. The explosive surge of generative AI tools (gen AI) across a variety of industries caused market analysts to dub 2023 AI's "breakout year" (Chui et al., 2023). Landscape architecture is one of these industries caught up in experimentation and reflection on AI advancement (Fernberg & Chamberlain, 2023). While the current discourse on AI in landscape architecture has acknowledged its potential impact on design processes and business practices (Belesky, 2023; Holmes, 2023a), there is still a need for deeper and more systematic reflection on the industry's specific responses to AI advancements. How landscape architects respond—whether with enthusiasm, resistance, indifference, or a mix of these attitudes—depends on motivational drivers that are not yet thoroughly explored in the profession. In this paper, I aim to systematically assess the landscape architecture (or LA) profession as a distinct culture. This includes examining its unique identity markers, values, behavioral norms, and perceptual lenses, all of which shape its responses to various issues. To make this assessment, I will utilize the Cultural Topography Analysis (CTops) method, an established research approach within strategic culture and security studies that enables scholars and practitioners to better understand cultural factors influencing decision-making in specific groups.

Origins of Cultural Topography (CTops) and Application to Landscape Architecture

First introduced in a 2011 *Studies in Intelligence* article, the CTops method was primarily meant as a tool for U.S. intelligence analysts to better describe "the inertia of culture" and make cultural factors less peripheral in their reports to key decisionmakers and policymakers (Johnson & Berrett, 2011). CTops has two main branches of academic pedigree. The first is Strategic Culture, in particular the first-generation work of figures like Colin Gray who posits that the distinctive ways leaders, groups, and nation-states make decisions are culturally encoded and bolster the claim through discursive assessment (Gray, 1984, 1999). Strategic Culture scholarship serves as a barometer or framing for the research question in the wider context of established work—for example, the paradigm of Strategic Culture can be framed as "a challenge to the theoretical constructs of realism and neorealism, or as a companion theory that agrees with most assumptions of these models but insists that rationality be regarded as culturally encoded" (Johnson, 2023). The second foundation is Grounded Theory, an approach originating from the field of anthropology that aims to generate new theories or conceptual frameworks based on the systematic analysis of empirical data, particularly in areas where existing theories may not adequately explain complex phenomena or when researchers aim to explore new or under-researched topics (Glaser & Strauss, 1967; Timonen et al., 2018). While it has proven remarkably useful amongst intelligence and policymaking professionals (Johnson & Maines, 2018) or academics focused on military studies (Brummer & Oren, 2022; Finlinson, 2022; Johnson, 2018; Matheson, 2022; Potter, 2022; Taylor, 2022) the strategic nature of the CTops methodological approach also suggests its potential value at the nexus of theoretical and applied academic research in landscape architecture. The use of Grounded Theory has found value amongst LA researchers for a variety of investigations (Allen & Davey, 2018; Shen, 2023; Swaffield & Deming, 2011) Its more targeted variation in the CTops methodology offers the ability to understand landscape architects as a distinctive cultural group by facilitating the discovery of unique patterns, values, norms, and behaviors that, first, define their professional identity, then gain insights into their decision-making process regarding AI advancement. Further, the hybridization of strategic culture and grounded theory emphasizes an inductive approach that allows researchers to analyze the experiences, perspectives, and practices of landscape architects without any preconceived notions, which can otherwise be hard to temper when the analytical tools come from the culturally immersed perspective of those originating within the discipline. Finally, the insights gained from a CTops approach can contribute to a richer understanding of the landscape architecture profession's culture for those who are not immersed in it, fostering better collaboration among interdisciplinary teams that include landscape architects.

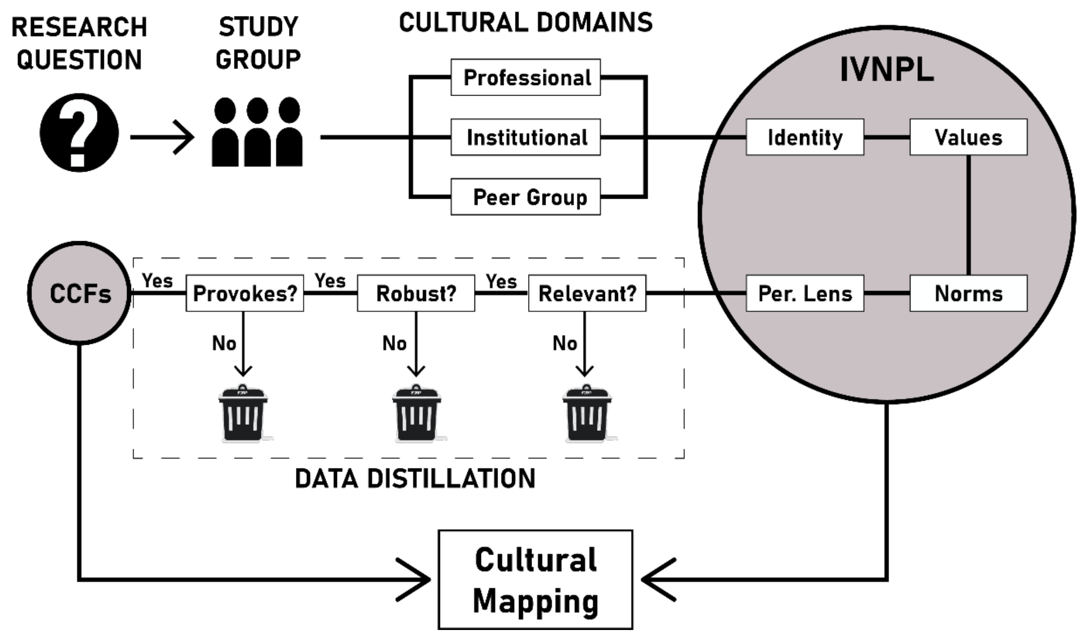
The primary building block of CTops is the Cultural Mapping Exercise (CME), a process that investigates a group's identity, values, norms, and perceptual lens (IVNPL), providing insights into the motivations and constraints on a certain issue at a certain point in time. Those CMEs in aggregate, "across time, spanning multiple issues, and on diverse groups within a society may aid in understanding that society's 'Cultural Topography'" (Johnson & Berrett, 2011). In other words, combining multiple CMEs can reveal areas of alignment and division among key stakeholders. My intent with the current study is to provide a CME for the perceptions of the landscape architecture industry toward AI advancement, particularly in the current zeitgeist of generative AI-fueled frenzy. The following section delineates my specific implementation of the CME approach.

Methods and Scope

The CME is typically broken down into a step-by-step process, which can be expanded or collated according to research needs (Johnson, 2023). My particular approach (see Figure 6) is adapted to the research problem as follows:

Figure 6

CTops Research Process



Note: Cultural maps of a particular group and issue are made by cataloging data across multiple cultural domains using macro categories, distilling them into critical cultural factors (CCFs), and then mapping the CCFs back to macros and operational context.

1. **Identify a Research Question scoped around a specific issue** – How does the professional culture of landscape architects influence their response to AI advancement? What factors catalyze or hinder industry-wide adoption of AI-driven workflows?
2. **Isolate a relevant group for focused study** – For this CME, I define landscape architects (LAs) as anyone who 1) actively practices landscape architecture, regardless of their official title or academic background, and 2) contributes to the

professional discourse via the study's source materials (all English language) utilized for the CME.

3. **Amass an initial range of cultural domains from which members of this group may draw cultural cues** – a cultural domain can be religious, ethnic, national, organizational, or peer group-oriented. In the case of this CME, the chosen domains from which to source data were professional/organizational (entities such as the American Society of Landscape Architects or Landscape Architecture Foundation fall under this umbrella), institutional (such as scientific or political organizations LAs often interact with), and peer group subcultures, such as LA netizens in the forum and blogospheres.
4. **Conduct research cataloging data across macro categories** – Engaging with a variety of cultural data sources, I cataloged patterns of thinking and past precedents that could illustrate likely behavior from LAs related to AI and other emerging tech advancements. These findings were organized under four macro categories: Identity, Values, Norms, and Perceptual Lens (IVNPL). The specific definitions of these macros are drawn directly from Johnson's primer on CTops (2023) and are as follows:
   - ***Identity:*** The character traits the group assigns to itself, the reputation and role it pursues, and the "identity goods" – individual roles and statuses – designated to members. Sometimes referred to as the "I am" statements (e.g., "I am a *designer"* or "LAs are plant nerds," etc.)
   - ***Values****:* Material goods or personal characteristics that result in increased status for members, including deeply held beliefs about what is desirable,

proper, and good that serve as broad guidelines for social life. ASLA Professional Awards are examples of artifacts that signal industry values.

- ***Norms:*** Accepted, expected, and preferred modes of behavior, including shared understandings concerning taboos, business practices, or even self-expression.
- ***Perceptual Lens:*** The cognitive filter through which this group views the world, including the default assumptions that inform its opinions and ideas about self and others. ASLA leaders believe, for example, that LAs will "rapidly scale up Climate- and Biodiversity-positive solutions in the U.S. and…the world" because of their unique interdisciplinary skill set (Green, 2022).

5. **Distill Findings to Critical Cultural Factors** – Critical cultural factors (CCFs) are those that separate interesting findings from the relevant ones and give measurable insight into group thinking in response to an issue. This is done using three measures:
   - ***Relevance*** – Events, individuals (e.g., charismatic leaders), or group dynamics (e.g., social codes) in question significantly influence collective thinking and actions on the specific issue. This is assessed by measuring the direct impact on decision-making processes and behaviors within a group.
   - ***Robustness*** – frequency across sources, endurance, cultural pervasiveness, alignment with rewards and punishments, prominence in key decision-makers' discourse, and manifestation across IVNPL research categories.
   - ***Likelihood of provoking a response*** – whether the CCFs create red lines, incentives, or calls to action that correlate with IVNPL.

6. **Map CCFs back to cultural domains** – After revealing CCFs, I then mapped them back to the cultural domains from which they were drawn to assess how widely they are shared across those domains. This step is meant to reveal where further CME research might be best utilized for eventually building a fuller cultural topography.
7. **Place CCFs in the wider context of operational realities** – After revealing the cultural tendencies of LAs toward AI adoption, I placed the CCFs within the wider state of practice to better understand how AI integration is likely constrained or enabled due to operational context (e.g., funding, technical ability, ethos, etc.).

Data Sources

The data for this paper were drawn from a wide variety of sources as defined by the chosen cultural domains (see *Appendix A* for a detailed list). These include guiding documents for professional organizations such as the American Society of Landscape Architects (ASLA) and Landscape Architecture Foundation (LAF), non-academic publications, such as magazines and industry websites, institutional sources, such as academic journals, and more informal cyber spaces such as chat rooms, blogs, and forums. Thick descriptions of the author's observations in three conferences (state chapter and national ASLA annual conferences) and one webinar (an LAF webinar panel on AI in landscape architecture) were also utilized. Many of these fall outside the typical source pool for academic papers but are vital to include in a CME. Most working professionals in landscape architecture do not have ready access to academic databases—or at least make it apparent they do not consult them in the many industry articles, reports, and public project documents that lack citations—and often rely on open-access papers, industry forums, personal connections, and conferences to be a part of the disciplinary discourse.

Thus, if an analysis of LA culture is to be truly authentic, it must include data from places that authentically express culture without the formality and filters of peer-reviewed articles.

Scope Note

Previous inquiries have revealed that the landscape architecture industry comprises thousands of practitioners who do not all share the same theoretical foundations, individual frames of reference, or even similar personal or professional backgrounds, and are thus difficult to lump into a clear, distinct cultural group (McAvin et al., 1991; Swaffield, 2002). There are also many people who practice landscape design but do not call themselves "practicing landscape architects" or PLAs—an occupational status granted by the Landscape Architectural Accreditation Board (LAAB). For this exercise, I define landscape architects as anyone who 1) actively practices landscape architecture, regardless of their official title, and 2) contributes to the professional discourse via pertinent source materials (all English language) utilized for the CME. In drawing this soft boundary, I acknowledge that the analysis will likely skew towards practitioners who give special attention to the topic of AI and might be ignoring some corners of the broader culture. It will also likely skew toward the English language and sometimes, more specifically, toward practice in the U.S. and Canada; these points will be addressed further in the concluding section. Finally, it is also important to note that this analysis employs a variety of lingo often used in landscape architecture communities. For example, landscape architects often refer to themselves as LAs in shorthand or informal settings as borne out in the many blogs I perused—thus I employ it often in describing those spaces—but it is seldom used in official documents. Many industry buzzwords have very specific definitions in the scientific literature but carry a different implicit cultural meaning across LA communities. The use of terms like this should be understood as an interpretation of the cultural data rather than the author's attempt to provide an accurate understanding of the term itself. If I show evidence that "sustainability" is a core value of LAs, for example, it does not necessarily mean that their understanding of the term is correct, only that it is significant to their culture. This ontological tension will be touched upon further in the ensuing discussion.

Results

For the ease of interpreting results from an analytical method that is altogether new to landscape architecture circles, I have organized the subsections according to the IVNPL macro categories. Further, CMEs need not take such a linear approach as CTops analyses can take on a variety of narrative structures (Johnson, 2023).

Identity: AI Development Illuminates Duality in LA Self-Perception

Far and away the most impactful insight drawn from this study is the fact that AI advancement, perhaps more than any other technological shift in the profession, illuminates a duality in the core LA identity features, rooted in their self-perception as both adept technicians on one hand and creative problem solvers most often using the moniker *designer,* on the other. Several variations of this self-perception exist in both LA and related creative professions: generalist synthesis vs. expert focus, T-shaped skills like those championed by IDEO (Brown, 2010), scientist and artist (*ASLA Your Path to Landscape Architecture*, n.d.), and so on. LA dualism is evident throughout the modern history of the discipline and is especially well represented by the careers of two of its most influential figures: Frederick Law Olmsted and Ian McHarg.

Frederick Law Olmsted and the Caricature of All-encompassing Designer

Though the term "landscape architecture" had been coined decades earlier (Meason, 1828; Repton & Loudon, 1840), Frederick Law Olmsted was the first to popularize and professionalize its use as both a parks administrator and then one of the most recognized parks designers in the country (U.S. Library of Congress, n.d.). Whether it be the scholarships (*Olmsted Scholars Program*, n.d.), lecture series (Joseph Disponzio, 2014), Library of Congress archives (*About This Collection: Olmsted Associates Records*, n.d.) bearing his name, or the multi-institutional celebration of his 200th birthday with a memorial tree planted in his honor on Capitol Hill, there is no questioning Olmsted's place as the "founder of American landscape architecture" (AOC Staff, 2023) Even in an ahistorical digital age of AI-generated images and cosmopolitan Pinterest board aesthetics, some of the most popular posts on the official subreddit dedicated to landscape architecture are progress reports from a couple renovating an obscure Olmsted-designed residential garden (CommunityBig9626, 2023a, 2023b, 2023c, 2023d). Despite his stature as the profession's founder, however, Olmsted's choice to use the nomenclature of landscape architect was made reluctantly, and that reluctance pervaded his entire career until posthumously calcifying into a norm amongst LAs of evading a simple definition of their work. This is largely because he was a truly masterful generalist who had demonstrable success as a farmer, scientist, sailor, journalist, social reformer, and wartime public health administrator before conceptualizing his calling as a park designer and master planner (Charles E. Beveridge, 2000; Jackson, 2001; Martin, 2011, p. 2; National Association for Olmsted Parks, n.d.) Even in lectures given during the culminating years of his career, Olmsted admitted, "I have never found a satisfactory name for the calling" of a landscape architect (Olmsted, 1880, p. 1). Other common terms of the time such as "architect," "landscape gardener," or "landscape engineer" were too reductionist, and to him, the term "landscape architect" was one simply "given me by a competent body, and which, though I did not choose it, I have accepted and I have come to think the least objectionable of the designations commonly applied to those of my calling" (Olmsted, 1880, p. 1).

Olmsted's vision for this tepidly named calling was that of the consummate creative problem solver of the built environment, a now cemented identity marker amongst LAs. The ideal LA would have an unparalleled ability to design spaces for healthful, transcendent human experience, and bring those plans to fruition through deft navigation of administrative, social, and scientific affairs—the ultimate frontier leader. This ability is displayed and canonized by Olmsted himself, most especially in his execution of the Central Park and Jackson Park projects, the large-scale projects that essentially bookended his career (Larson, 2004). By the time of the latter, the other prong of the LA identity marker was also on display as he was at a stage of advocacy dedicated to dispelling "the perception that landscape architecture was simply an ambitious sort of gardening and to have his field recognized instead as a distinct branch of the fine arts, full sister to painting, sculpture, and brick-and-mortar architecture" (Larson, 2004, p. 50). These two descriptions taken together make up the professional identity many LAs speak of as being a "designer" of environments; they also illustrate a tension inherent in outward presentations of themselves—technical and sociopolitical chameleons on the one hand, creative and artistic types on the other.

A McHargian Inflection: LA Identity Discourse Tools Up to Meet Bigger Ambitions

The initial oscillation between technocratic and design-minded identities of the Olmsted era is amplified in the mid-to-late 20th century when fine arts favoritism is challenged by a burgeoning environmental movement to reassess the true impact of LAs' work. An overwhelming saturation of sources point to Ian McHarg as the leading figure in this shift. McHarg is recognized in professional, academic, periodical, and informal forums alike as probably the most important contemporary figure in 20th century landscape architecture (Fleming et al., 2019; Herrington, 2010; Landscape Architecture, 2017; Ok_Cheesecake7806, 2023; Steiner et al., 2019). If Olmsted was the founding father of the profession, McHarg was the reformer. His approach was grounded in the idea that landscape architecture should look beyond the limits of parks and gardens to confront larger, more pressing ecological problems of the day—a perspective seen as moving away from an elitist beaux arts past of the profession towards a more utopian, public function (Fleming, 2019). McHarg's seminal book, *Design with Nature*, argues for a systematic method for landscape design and planning, where the natural features of a site (geology, hydrology, vegetation, wildlife corridors, etc.) are carefully analyzed, and the analysis determines the forms and intensity of development (McHarg, 1969). Now largely taken for granted, the "layer cake" method later became the building block for revolutionary technologies like geographic information systems (GIS), and the book became inspirational fodder for landmark environmental activism and legislation in the following decade (Steiner et al., 2019).

Despite his influence, McHarg's methods also faced criticism for being too scientific and deterministic, neglecting the cultural and artistic aspects of landscape architecture. Indeed, his rationalist polemics sparked debate within the profession about balancing humanist and scientific perspectives in design and planning processes. It also seemed to stir a small but spirited identity politic that has been in disciplinary discourse ever since. It is reflected in informal corners of the blogosphere (advc288, 2020; O'Connell, 2006) or quips about being called a gardener in Super Bowl ads (American Society of Landscape Architects (ASLA), 2023), as well as in centralized discourse, such as books on the need for more scientific LA approaches, articles on art and meaning in landscape, or design manifestos about the twilight of the discipline (Hohmann & Langhorst, 2004; Kullmann, 2016; Olin, 1988; Stilgoe, 2015; Treib, 1995). The result is a renaissance, person-like professional confidence in the best of times, and full-scale identity crises in more reflective periods. LAs in nearly every position or level of public visibility in the profession have switched or nearly switched professions because of a perception that they might be more *impactful* in another field (Accomplished-Ad9376, 2023; BurntSienna57, 2019; *I Want out of LA*, 2019; *I'm Leaving the Industry, and Here's Why*, 2022; Kyle_Boughton, 2021; McKee, 2022; OJB, 2021, pp. 13, 176). This vague resemblance of an inferiority complex has, however, been reassessed as a sign of humility borne by Olmsted and all who followed; it comes by the nature of a working medium that is inherently complex and transdisciplinary: the landscape. The simplest way it is often expressed is in memes and quips by notable LAs, saying they are "a shade-loving species." They need to become more visible, and in turn, more credible in the halls of power by clearly expressing their values to the public (Conklin et al., 2021; The Dirt Contributor, 2016).

Values: Ecology, Aesthetics, Equity Pillars of Contemporary LA Practice

While many values were identified during the CME process, three stood out as saturated across all cultural domains: ecological stewardship, social equity, and aesthetic experience. The most highly praised artifacts in the cultural data tend to be visual expressions of these values being intertwined and embedded in the physical form of designed projects. All these values can be bolstered or hindered by emerging AI systems, and this section will explore some of those possible points of flow and friction.

Ecological Stewardship Professed Cornerstone Value for LAs. Emerging Tech Can Help Them Better Honor It.

Ecological stewardship stands as a cornerstone value of current landscape architectural practice. The vernacular at recent conferences and in online professional networks is particularly laden with related concepts, such as sustainability, resilience, green infrastructure, biodiversity, and conservation (bordo26bordo26, 2023; From_same_article, 2019; *Scale Up: ASLA 2023 Concurrent Education Sessions*, 2023; Thick_Bad_9408, 2022; utkum97, 2022). This is also apparent in guiding documents of professional organizations (American Society of Landscape Architects (ASLA), 2022; *Landscape Architecture: A Solution to the Climate Crisis*, 2022; *New Landscape Declaration*, 2016), the nomenclature of what is now the industry's "green" certification (*SITES: Developing Sustainable Landscapes*, n.d.), and the many accolades given by those organizations to projects that espouse "sustainable solutions" to environmental design problems (*2022 ASLA Professional Awards*, 2022; *LAF Fellows*, 2023; American Society of Landscape Architects (ASLA), 2017). One difficulty with terms under the environmental stewardship umbrella is that they are quite broad and elusive and often evade simple definitions in the scientific communities from which they are typically sourced (Moore et al., 2017; Toman, 2006). However, it may at times serve LAs to keep it that way so that there is a broad way of fulfilling any mandate to uphold the value of their projects. For example, a quick and dirty definition of a sustainable project is often laid out by LAs and their organizations as something that is socially equitable, environmentally sound, and economically feasible (Bean & Yang (Mayla), 2009; *Sustainable ASLA*, 2023). If a project were to not meet the definition or those laid out in say ASLA's Code of Environmental Ethics, it would be dishonoring the LA stewardship value. Yet LAs are often implicitly given grace if elements of the project fall short, so long as it is beautiful and excels in one of the above aspects of sustainability (Block, 2019; France, 2003; Orr, 2008; Weller & Fleming, 2016). This is largely because, just as sustainability and stewardship are hard to define, they are hard to encode and enforce without specific legal frameworks (Selman, 2008; Sorvig & Thompson, 2018); and even if there are frameworks, they might not naturally translate to the specific elements of site-oriented landscape architecture work. Another major difficulty is the fact that there are too many ecological or sustainability measures for LAs to keep track of in any given project at once, and most don't have the advanced computational skills of their counterparts in the sustainability sciences to do so (Picon, 2013). In this sense, LAs welcome AI and other emerging tech tools to help them more comprehensively meet sustainability standards. There are, for instance, new tools for LAs to calculate the carbon impacts of their projects at the site scale in the early stages of the design process, giving them more certainty about whether their project is objectively "sustainable" (Conrad & Tran, 2020; Hardy & Frechette, 2023); such tools could be further enhanced by AI to both calculate carbon and iterate with the user on alternatives that would improve their design. To critics of the profession, an AI, or parametrically-driven turn, would build upon the technological roots spawned in the McHargian era as it refines the resolution of geospatial technologies to the site scale (Holmes, 2021; Picon, 2013), and in turn allows them to better live up to the LA stewardship value.

Equity: For LAs AI Must Enhance Inclusivity, Be Wary of Bias

Some sources suggest that social equity has always been a founding value of landscape architecture (Charles E. Beveridge, 2000; Corpus, 2021), but its definition in recent years has taken on a more specific, and notably progressive, flavor (*Biden Overturns Design Mandates*, 2021; Landscape Architects Design Vibrant, Resilient, and Just Communities for All:

Recommendations for the Biden-Harris Administration, 2020; chipjohn, 2023; Hou, 2021). For 21st-century LAs, equity is manifested in the creation of inclusive, accessible public spaces that serve all community members. Official organizations and informal peer networks alike seem to consider it an honorable duty to provide solutions that cater to the needs of diverse populations, with particular attention paid to minority and low-income communities, not just through physical access but also cultural and economic sensitivity in community engagement processes (American Society of Landscape Architects (ASLA), n.d.; Green, 2017; *LAF Diversity, Equity, and Inclusion Resources*, n.d.). Transgressions against this value, such as designs whose successes exacerbate inequality, can lead to professional criticism and public backlash (Bliss, 2017). Reflecting on Equity as a core LA value, the response to AI advancement is less clear. On one hand, recent conferences and webinars on AI reflected hopefulness for using AI and adjacent tools to facilitate more equitable community engagement and co-design; on the other, many of the same LAs expressed concerns that it would exacerbate systemic inequities in aspects like representation, labor, and bias (Domlesky et al., 2023; Fernberg, 2023; Saldana Ochoa et al., 2023) which are longstanding concerns of critics in the tech industry (Bender et al., 2021a; Christian, 2020; Gulsrud et al., 2018).

Aesthetics Keystone LA Value, Most Threatened by AI Advancement

If stewardship is the cornerstone, and social capital a foundational building block, then the pursuit of beauty is the keystone LA value that holds the two together and may even, at times, supersede them in practice. LA aesthetics involves creating spaces that are pleasing to the senses while also fulfilling their functional human needs (Nassauer, 1995). For LAs, the question of whether a landscape is beautiful is just as integral as whether it is ecologically appropriate, and this fact is, in their view, not given proper credence in scientific circles (Barth, 2022;

Johnsen, 2021; Meyer, 2008; G. Mitchell, 2018; Sanchez, 2019). They have even developed theories of ecological aesthetics to bridge that gap (Gobster, 1999; Gobster et al., 2007; Koh, 1988). Transgressions against this value, such as neglecting local vernacular or cultural relevance, can lead to professional disapproval and public dissatisfaction. Action is rewarded when it enhances the visual appeal of spaces, while restraint is appreciated when it prevents the imposition of inappropriate aesthetics (Orr, 2008). Professional organizations emphasize this value by encouraging designs that resonate with the local cultural and environmental context, and preservationist non-profits often center their operations around assigning value to a historic or cultural landscape, often driven by aesthetic judgments (*About TCLF*, n.d.). To them, landscape beauty entails striking a balance between context, form, and function, and the projects most lauded by industry awards and other accolades are often reflections of that (Bahr et al., 2023). A recent ASLA professional award, for example, was honored because "the project addresses stormwater management through new and dynamic landscapes that captivate users' curiosity while framing views and providing programming for the community" (David Rubin Land Collective, 2023); a statement that exemplifies *design decision-making* as the driving, unifying force.

The same sentiment echoes in the informal spaces, such as the r/Landscape Architecture subreddit (an online community), where one of the most upvoted posts includes images of Junya Ishigami's Water Garden and discussion on how it blended nature, user experience, and art (spikyhibiscus, 2021). There is also evidence in these forums to suggest that just as the human experience of built work is fundamental to the LA conception of beauty, so too are aesthetics of the creative process itself. Many of the top-rated posts center around the experiential nature of design acts, such as sketching, drafting, and modeling (Flagdun, 2020; nerfherder-8, 2021;

Procrastinating-Man, 2020; redninja24, 2021). Thought leaders also emphasize these processes in venues, such as the ASLA national conference in sessions dedicated to the value of drawing in the profession (Batts et al., 2021). The general impression across all cultural domains is that engaging in a creative act like drawing—be it with pen and paper or stylus on tablet screen—is emblematic of the critical thinking and creativity required to produce the very best design work. This key role of "creativity" in the design process is possibly the reason LA's perception of AI development is the most polemical when mapped back to the aesthetic value. Recent advancements in generative AI (genAI) for imagery such as Dall-E, Midjourney, or Stable Diffusion, for example, have stirred lively debate. On one hand, groups of LAs think genAI will significantly enrich aesthetics by enabling landscape architects to create, visualize, and present beautiful designs with greater speed and efficiency; on the other, this potential is not so obvious to LAs whose intuitions towards design tools are historically more analog and who feel that drawing is a more controllable, inclusive, and collaborative engagement tool (*AI Is Gonna Fundamentally Change This Profession*, 2023; ASLA staff, 2016; DawnnnLandscape, 2023b, 2023a; fingolfin_u001, 2023; Roy, 2023a, 2023b; SayNo2Tennis, 2023; vSheepy, 2023).

Norms: Landscape Architects' Tech Leadership Ambitions Belie Actual Technology Adoption Norms

This section will investigate and unravel the paradoxical relationship between landscape architects' stated leadership ambitions and their actual practices in adopting technological innovations. It argues that despite the profession's recent rhetorical commitment to leading the way in integrating novel technologies within their design and implementation processes, LAs' technology adoption norms reflect patterns of codependency on either client service needs or their counterparts' experimentation in related fields rather than on a culture of pioneering.

Guiding Documents and Professional Discourse Suggest Ambitions of Technological Leadership

The landscape architecture industry is in a chapter of transformation wherein many professional organizations and well-established thought leaders have declared the need for designers to be at the helm in addressing issues, such as climate change, advocacy, and environmental equity and to leverage new technology to do so ("Dystopia or Utopia, the Future Looks Bright for Landscape Architects," 2017; *New Landscape Declaration*, 2016; Hickman, 2022; Holmes, 2018; The Dirt Contributor, 2016). The most recent strategic plan from the American Society of Landscape Architects includes an entire section on innovation and digital transformation (American Society of Landscape Architects (ASLA), 2022); interviews with practitioners of all levels suggest getting ahead of tech advancements (Daniel Tal, n.d.; LAM Staff, 2020); the most well-established LA publications are even generating new discussion around the potential of artificial intelligence to push the profession to new levels of innovation (Holmes, 2023a). Some LA researchers and practitioners have begun imagining the potential for a greater disciplinary discourse on computational design (B. Cantrell & Mekies, 2018), proposing that landscape is a profoundly more complex system than that of a building or singular piece of infrastructure and thus needs to construct a system more responsive to the many factors and contexts in which it is embedded (B. E. Cantrell & Holzman, 2015). To them, landscape architecture seems poised to lead the way in envisaging the future techno-vernacular of environmental design.

Actual Technology Adoption Norms Reflect Economic Necessity or Codependence on Allied Professions

Yet despite a professed belief from professional organizations and thought leaders of LAs' potential to lead the way in technological innovation of the built environment, their actual practices in doing so are much more varied and reliant on other disciplines. Exceptions certainly exist—McHarg's methods inspired the creation of GIS, for instance (Fleming, 2019), and LAs were early and influential adopters—but nearly every other technology adoption shows LAs in a habit of late-stage adoption (Boyd, 2016; Leia_Sillywalker, 2017; Picon, 2013; selfsearched, 2022). Computer-Aided Design (CAD) use was initially scattered but became nearly ubiquitous as a practical matter in engineering, architecture, manufacturing, industrial design, and landscape architecture (Sarcar et al., 2008). Recent years have seen drones and virtual reality surge in popularity in LA offices and classrooms, largely for cost efficiencies and perspectives already gained from pioneering research in adjacent disciplines (Daugherty, 2019; Portman et al., 2015)

Parametric design systems' ability to quantitatively define relationships between data and objects has inspired new ways of thinking about complicated design problems for decades in architecture, but only recently pervaded landscape practice (B. Cantrell & Mekies, 2018; Schumacher, 2016). It has also inspired other more direct applications of CAD software, such as Building Information Modeling (BIM), where every element in a design model is given measurable properties, actions, and functions that can produce highly accurate visualizations, shop drawings, cost estimates, and predictions of design performance (e.g., thermal, structural, material factors, etc.) over time (Azhar, 2011); or the integration of statistical modeling methods with design software allowing designers to add more empirical soundness to their projects without necessarily needing deep knowledge of statistics (Abdulmawla, 2018).

While there are certainly instances of BIM, parametricism, virtual reality, or any other tech du jour being used for intrinsically motivated exploration amongst LAs (Ackerman, 2019a, 2019b; Calil et al., 2021; Canfield, 2020; Hill et al., 2019; Shakespeare, 2021), they often represent award-winning exceptions to the rule of adopting workflows for economic efficiency and better collaboration with allied disciplines. Professional surveys and chat rooms suggest that even though computational design and other emerging technologies show signs of sustained growth in the future, it will most likely be because of client needs, cost engineering, or because architects and engineers require their use and not for heuristic design exercises (Ackerman, 2021; George & Summerlin, 2019; Much-Instance6100, 2023; Paulson, 2017; Pedersen, 2020). All in all, LA firms show a pattern of going with the flow of technology adoption rather than making waves with its use.

The discrepancy between ambition and behavioral norms suggests a wider cultural and institutional inertia caused by perceived threats to the aesthetic and creative integrity of LAs' work, lack of investment in technological exploration or literacy, and the perceived barriers presented by traditional workflows that make new technology adoption appear more financially risky or not suited to specific needs of landscape work. Such inertia can undermine the profession's goals of being innovators and reinforce a perception amongst many LAs that the profession lags, rather than leads, in the realm of technology.

Perceptual Lens: For LAs, AI is a Tool, Not a Partner, in the Creative Process

As was first mentioned in the Methods section, the purpose of a cultural mapping exercise is to understand the behavior and decision-making of a particular group at a particular moment in time. This moment is one of synthesis where LAs are iterating the alchemy of their identity, norms, and core values to form a distinctive perceptual lens of their role in the world and the way technology should or shouldn't be used in fulfilling it.

Cultivating Beautiful, Equitable, Ecologies: The Role of LAs in Solving Wicked Problems

One of the more prominent ways LAs are redefining their role is by asserting their role in addressing the growing array of complex and multifaceted "wicked problems" that beset 21st-century living. These challenges encompass issues like climate change, urbanization, ecological degradation, inequality, and biodiversity loss, which all have profound implications for the design of our shared landscapes (R. Buchanan, 1992, 2019; Dulic et al., 2016; Orland et al., 2016; Rittel & Webber, 1973). No longer is the landscape designer to be confined to aesthetics in their spatial interventions; rather, they must at once evoke beauty, demonstrate an understanding of social systems and be ecologically responsible. This confrontation with the complexity of modern-day problems has prompted a dramatic evolution in the profession, pushing landscape architects towards the mantel of interdisciplinary leadership and fostering an increasing sense of ecological stewardship within their professional identities (Weller, 2015). Annual lobbying trips to state and national capitals by affiliates of the American Society of Landscape Architects (ASLA) reinforce an assertion into civil visibility as advocates communicate the imperative to have landscape architects involved in tackling problem sets, such as climate change, biodiversity loss, social equity, and environmental justice to policymakers (Roxanne Blackwell, n.d.). Meanwhile, industry thought leaders from the Landscape Architecture Foundation (LAF) interface with private philanthropists, academics, and professionals to bring about change within the industry. LAF's most prominent work of late, the *New Landscape Declaration: A 21st Century Call to Action for Landscape Architecture*, most forcefully postures the position of landscape designers in the fray of wicked problem-solving:

> As designers versed in both environmental and cultural systems, landscape architects are uniquely positioned to bring related professions together into new

> alliances to address complex social and ecological problems. Landscape architects bring different and often competing interests together to give artistic physical form and integrated function to the ideals of equity, sustainability, resiliency, and democracy. (*New Landscape Declaration*, 2016).

The LAF statement at once illustrates a clear connection to that original bimodal identity embodied by Olmsted, while also showing its evolution through time to a McHargian-like merger born out of necessity to address wicked global problems—a near full circle. It also expresses the interplay between the profession's most currently prominent values statements and the ways technology might elevate or disrupt them.

LAs See Digital Technology as Tool for Unlocking Efficiency, Bemoan its Overuse

Landscape architecture is not fundamentally a technophobic profession. Landscape architects across the industry, from the most elitist leadership circles and institutional publications to online forums of entry-level workers, hold a view that sees the potential for new computer software or digital workflows to improve their work as designers (austinhooton1, 2023; B. Cantrell & Mekies, 2018; Daniel Tal, n.d.; Hannah, 2012; Holmes, 2021). This is especially true regarding those tasks landscape architects consider to be the more analytical parts of their work, such as site data collection and environmental analysis, as well as those involving collaborative information sharing with clients or other disciplines such as building information modeling (BIM) (Ackerman, 2019a; austinhooton1, 2023; Daniel Tal, n.d.; George & Summerlin, 2019; Hannah, 2012; Much-Instance6100, 2023). In these same professional conversations, LAs often tout digital workflows to the extent that such can augment their creative capabilities and optimize decision-making processes by freeing up time and cognitive load. This sentiment is tempered, however, when LAs perceive and bemoan an overreliance on certain digital tools to engage in what they would call creative or artistic activities that make the profession special, such as drawing and sketching or other forms of visual representation. The shining example of this dichotomy is the decades-long discourse over when, where, how, or if an LA should use digital (e.g., Adobe Photoshop, iPads, etc.) vs analog drawing tools (e.g., pen and paper) in the design process (Fernberg & Chamberlain, 2021; Lemmel, 2017; The Cultural Landscape Foundation, 2013). In the mind of many landscape architects, activities like drawing are the ultimate expression of the critical thinking processes endemic to design and what make them intrinsically valuable to society; thus, any technology that seems to hamper that expression is met with skepticism. The same internal conflict can be seen with LAs perception of artificial intelligence, where excitement about predictive analytical capabilities is counterbalanced by a prevailing sense of unsettlement and ambivalence towards it as a “creative” aid.

Discussion

Throughout the past decade, landscape architecture has been readily adopting algorithmic, information models, and other computational systems into curriculum and professional workflows, experimenting with design processes, such as terrain modeling (Hermansdorfer et al., 2020; Hurkxkens et al., 2017), monitoring public spaces for design assumptions (Zeiger, 2019a), modeling uncertainty in a “synthetic" ecology (B. Cantrell & Holzman, 2014), or reflecting temporality in CAD workflows (Tebyanian, 2016), to name a few. The use of computation in landscape design is burgeoning, and according to a professional survey, shows signs of sustained growth in the future (George & Summerlin, 2019). Yet in recognizing this, the survey’s authors also note that the growth has thus far been, and will most likely continue to be, gradual and mostly focused on software that increases production efficiency rather than heuristic design exercises.

Just as LAs have seen and tried to harness the potential of design software and other technologies to enhance their workflows, so too do they see the allure of AI. LAs see that the use of AI can revolutionize design and management processes, rendering them more efficient and precise. For instance, AI can simulate various design scenarios, generate site analyses, or monitor real-time environmental changes, reducing the time and resources necessary for these tasks (Barbarash et al., 2022; Fernberg et al., 2023; *Sidewalk Labs Reimagines Urban Planning with New Delve Generative Design Tool*, 2020; Z. Zhang & Bowes, 2019). AI's predictive capabilities and its potential to handle complex environmental data evoke an eagerness to explore new possibilities for design, improving sustainability metrics, and automating tedious or time-consuming aspects of their work. By harnessing AI's power, they hope to tackle unprecedented urban challenges and create resilient, dynamic landscapes that cater to society's needs while preserving natural beauty (B. Cantrell, Martin, et al., 2017; Fernberg, 2023; Holmes, 2023a; vSheepy, 2023).

Despite the acknowledged potential of AI to be a boon for the profession, landscape architects grapple with the fear that embracing it might erode the human touch and artistic intuition that defines their profession as well as challenge the core of their identity as "creatives." AI systems can leverage vast amounts of data from various sources, such as geographic information systems (GIS), climate models, historical land use patterns, and ecological data, and apply complex algorithms to this data to develop and evaluate landscape design solutions that are tailored to the specific and multi-faceted requirements of any given project. Furthermore, AI has the capacity to learn and improve its designs over time, providing a dynamic and evolving design tool. While CAD and personal computing transformed the way landscape architects visualize and communicate their designs, AI has the potential to transform the very process of design itself. Such a transformation would behoove LAs to address the dichotomy of their multi-faceted identity traits once more.

The potential for AI to streamline tasks raises concerns about the loss of traditional craftsmanship (i.e., thinking through sketching) and the reduction of design to mere numerical outcomes, neglecting the nuances and emotional significance of landscapes that seem otherwise difficult to quantify. The LA mindset oscillates between strong doubts that AI will have any impact at all on the profession, deep fear that it will make them obsolete, or the somewhat balanced notion that AI will become yet another tool in the designer's toolbox to get their job done better (Belesky, 2023; fingolfin_u001, 2023; SayNo2Tennis, 2023; vSheepy, 2023). All three of these sentiments are channeled through the perceptual lens that a unique process of design driven by creative thinking is what makes LAs truly valuable but that their products (often visual) are proof of this process; thus, a tool like an AI-powered image generator can make LAs feel that they are relinquishing some of that proof (ASLA staff, 2016; Gow_T, 2019; Holmes, 2023b). In this way, AI may cause disruption in the landscape architecture industry on a scale beyond previous technological advancements. On the one hand, AI advancement allows LAs to embrace their generalist side, letting things like machine learning applications handle analytical tasks that involve more factors than they can address alone (e.g., ask a large language model to provide a workflow for addressing climate, citizen input, and restoring biodiversity in a neighborhood park). On the other, handing over the reins to an AI system to do tasks historically endemic to a "creative process" could very well threaten LAs' sense of agency and authorship.

AI's emergent role as creative contributor will likely push the LA mind to question what exactly the core of their identity is as a "designer" and their potential symbiosis with machines.

Recommendations for Landscape Architects

As landscape architects stand at the crossroads of creative tradition and technological transformation, it's imperative to navigate the future with foresight and prudence. If policy and practice do not find ways to anticipate AI ubiquity, it may become an existential issue for the discipline. The integration of AI into the profession offers immense potential, but it also comes with its set of challenges and pitfalls. Here are some guiding principles and recommendations for the journey ahead:

1. **Establish an AI-LA Code of Ethics:** The integration of AI into landscape architecture must be rooted in a strong ethical foundation. As AI systems are trained, there's a risk of perpetuating biases present in their training data—the racial or gender stereotypes reinforced in some large language models are a salient example (Bender et al., 2021a). Landscape architects must ensure that AI tools are used responsibly, prioritizing fairness, transparency, and inclusivity. This includes being vigilant about the sources of data, understanding the underlying algorithms, and actively seeking to mitigate any biases.

2. **Cultivate AI Literacy:** To harness the full potential of AI, landscape architects must equip themselves with the necessary skills and knowledge. This doesn't mean becoming experts in AI algorithms but rather developing a foundational understanding of how they work, along with their implications and limitations. Professional organizations, academic

institutions, and industry leaders should prioritize AI education, offering training programs, workshops, and resources to empower practitioners.

3. **Foster Interdisciplinary Collaboration:** The future of landscape architecture in the age of AI is not one of isolation but collaboration. Landscape architects should actively seek partnerships with technologists, data scientists, and AI experts. Such collaborations can lead to the development of tools and platforms tailored to the specific needs of the profession, ensuring that technology enhances, rather than dilutes, the essence of landscape architecture.

4. **Anchor the LA Identity:** In the whirlwind of technological change, landscape architects must anchor their professional identity. While tools, techniques, and even products of practice might evolve, the core values of sustainability, beauty, equity, and creativity can, and should, remain steadfast. Landscape architects should see AI not as a challenge to their identity but as an opportunity to redefine and strengthen it. This may mean finding better ways of perceiving and presenting ourselves.

5. **Embrace Adaptability:** The pace of technological change is relentless, and what seems cutting-edge today might become obsolete tomorrow. Landscape architects must cultivate a mindset of adaptability, being open to new tools and techniques while also critically evaluating their implications. This means being proactive in seeking out new knowledge, experimenting with new tools, and being willing to pivot when necessary.

Conclusion

The integration of AI into landscape architecture offers a world of possibilities. From autonomous drones to AI-powered geographic information systems (GIS) or spatial computing, AI advancements can serve as force multipliers, helping landscape architects better live out their ambitions to build a more beautiful, equitable, sustainable world. At the same time, these technologies will not be readily accepted if LAs do not seem to bolster their values on their terms. Over-reliance on tech could be perceived as weakening the role of traditional environmental knowledge and intuition, an essential component of sustainable design practices; it may inadvertently contribute to social inequity through digital divide issues; or it may risk an oversimplification and homogenization of aesthetics.

By reassessing and reinforcing the creative processes, business practices, core values, and labor expectations, landscape architects can maintain their unique professional identities while leveraging the benefits of AI. A deeper understanding of AI's functions and the underpinning of data models and sources can also help dispel fear and misconceptions. Because most AI applications currently revolve around massive models trained on massive datasets, LAs need to understand how they are made and when it is ethical to use them for design commissions. Perhaps most importantly, establishing a collective front via industry-wide conversations and setting standards for AI-LA practice is paramount in this adaptation process. This way, the profession can harness the power of AI while preserving the essential creative, human touch that defines the spirit of landscape architecture and its mythos of generalist design leader.

Beyond the above recommendations, I believe the most important obstacle to overcome for LAs in the Age of AI is cultural inertia. This inertia—predominantly caused by entrenched traditional practices that value economic efficiency over innovation, lack of technological literacy, and concerns over creative agency—acts as a powerful deterrent against the adoption of novel technologies. Consequently, landscape architecture, when compared to peer disciplines like architecture and engineering, risks being viewed as a field resistant to change and progress, hampering its growth and reducing its appeal to the new generation of technologists and innovators. However, these norms can be disrupted through strategic investment. By allocating resources to enhance technological literacy, foster a culture of innovation, and address the challenges presented by the adoption of new technologies, LAs could better demonstrate the leadership they profess. Such an investment is not merely financial but extends to time and commitment to reshaping organizational culture, training programs, and policy changes. This commitment to technological progress would catalyze the integration of cutting-edge tools and techniques into the field, thus augmenting its standing in an increasingly digital world.

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Table 1

Data Sources Table

Source	Source Type	Domain	Relevant Macros			
			I	V	N	PL
ASLA Climate Action Plan	Guiding Document	Professional		•	•	
ASLA Code of Env. Ethics	Guiding Document	Professional		•		•
Landscape Architecture Magazine	Industry Publication	Professional	•	•	•	•
Other Mags (e.g. Metropolis, LA)	Industry Publication	Professional	•	•	•	•
ASLA Blogs (The Dirt, The Field)	Industry Website	Professional		•	•	•
News Pages (e.g. ASLA Updates)	Industry Website	Professional			•	•
ASLA Nat'l Conference Sessions	Direct Observation	Professional	•	•	•	•
ASLA State Chapter Conferences	Direct Observation	Professional	•	•	•	•
LAF Landscape Declaration	Guiding Document	Professional	•	•		•
LAF Webinars	Programs/Resources	Professional		•	•	•
Int'l Org Websites (IFLA, LI, etc.)	Industry Website	Professional	•	•		•
LAF Case Studies Archive	Research Studies	Institutional		•	•	•
Peer Reviewed Journal Articles	Research Literature	Institutional	•	•		•
Academic Books, Reports, etc.	Research Literature	Institutional			•	•
CELA Conference Proceedings	Research Document	Institutional		•		•
ECLAS Resources	Academic Website	Institutional	•	•	•	•
Landscape Architecture Subreddit	Online Community	Peer Group	•	•	•	•
Quora	Crowd Source Site	Peer Group			•	•
Individual/Org Blogs (e.g. Land8)	Websites	Peer Group	•	•	•	•
LAF Webinar Chats	Direct Observation	Peer Group		•	•	•
LinkedIn Profiles and Posts	Social Media Site	Peer Group	•		•	•

Note: This table lists data utilized for the CME and codes them according to relevant macro categories identity(I), values(V), norms(N), and perceptual lens(PL).

PROBLEMATIZING AI OMNIPRESENCE IN LANDSCAPE ARCHITECTURE[4]

Abstract

This position paper argues for and offers a critical lens through which to examine the current AI frenzy in the landscape architecture profession. In it, the authors propose five archetypes or mental modes that landscape architects might inhabit when thinking about AI. Rather than limiting judgments of AI use on a single axis of acceleration, these archetypes and corresponding narratives exist along a relational spectrum and are permeable, allowing LAs to take on and switch between them according to context. We model these relationships between the archetypes and their contribution to AI advancement using a causal loop diagram (CLD) and with those interactions argue that more nuanced ways of approaching AI might also open new modes of practice in the new digital economy.

Keywords

Artificial intelligence, Landscape architecture, System dynamics, Mental models

Introduction

Amidst the ever-evolving discourse on technology and design, the role of Artificial Intelligence (AI) in shaping the contours of landscape architecture (LA) processes has become a significant industry trend (Fernberg & Chamberlain, 2023). This intersection, rich with both potential and pitfalls, necessitates a nuanced understanding of how human designers think about AI's impact and the diverse ways it interweaves with the state of the practice. While tech-focused researchers and practitioners have been investigating subjects under the AI umbrella for some time,

[4] This chapter was co-authored and will be submitted for publication to the Journal of Digital Landscape Architecture with Phillip Fernberg as lead author and Zihao Zhang (City College of New York) as second.

it has only recently hit the mainstream consciousness; largely due to the explosion of generative tools such as ChatGPT, Midjourney, and Stable Diffusion. After a few years of debate, experimentation, and contemplation, society's enthusiasm for generative tools has shifted from initial excitement to introspection and reassessment. Jackie Fenn and colleagues might suggest the generative hype cycle is reaching its so-called *trough of disillusionment* (Fenn & Blosch, 2018). AI was the 2023 buzzword of the year (Bhattacharya, 2023) and captured an inevitable ubiquity in which it seems to be everywhere and nowhere all at once. Most seem to know the term, but many are only familiar enough to default to popular culture caricatures of singular intelligent agents operating at odds with human will and creativity (B. Cantrell & Zhang, 2018). Moreover, we posit the current AI discourse is at once too one-dimensional and too focused on judging the merits of AI-driven technology rather than critiquing the way humans think about and use it. Overcoming this myopia requires diversifying perceptions of AI and our relationship to it.

Discourse on human-tech relations is well established in architecture and aesthetics, including work like Negroponte's speculation on emergent architectural machines in computer-aided design or CAD (NEGROPONTE 1970), or technology philosopher Don Ihde's models of the personal computing revolution of the 1990s (Ihde, 1990). Building on previous theories, our work addresses the specific problems of human-AI relations in the context of landscape architectural practice. In this position paper, we introduce various AI-LA archetypes representing different perceptual lenses landscape architects (LAs) might take toward AI development; describe the benefits and drawbacks each one brings to praxis; and then model interactions between these archetypes. In doing so, we argue how their interactions can inspire how the industry might adapt, resist, or reshape itself in response to AI's influence. These polymodal archetypes are not mutually exclusive identities. Rather, they are permeable mental modes one can find themselves moving between at any given time.

Problematization: AI-LA Archetypes and Narratives

The Optimizer

The quintessential "move fast and break things" persona, the Optimizer believes that AI represents an aggregate of tools that evolved to help LAs get better, smarter, and more efficient and should be accelerated at all costs. To them, AI is the bridge to bypass busy work (think redrafting, sheet formatting, and image post-production) for more billable hours spent on the meaningful parts of the design process. The most valuable byproduct for optimizers is being able to do *more* of their most valuable work *faster*. Such could mean happier employees, better products, and outpacing the competition. Examples of Optimizers in action are the companies using websites like Civitai.com where enthusiasts of Stable Diffusion share their checkpoint and Lora models. These smaller, fine-tuned models work like libraries that can be added to basic Stable Diffusion to perform special tasks. For example, one can fine-tune their Stable Diffusion and create a Lora model that mimics one artist's art style. At the multinational firm SWA, a team of designers has trained a Lora model that can produce hand-sketch drawings in the style of one of their Principals (Domlesky et al., 2023). Quickly, we will expect more firms with the resources to adopt their own proprietary AI systems to optimize their workflow.

When developing AI-LA tools, Optimizers must be sure to examine the reality of technological determinism that underpins their effort to "revolutionize" the LA industry. They are often prone to rosy views of technological advancement and dismissive of its accompanying challenges. For instance, an Optimizer might assume that with AI, people will inevitably work fewer hours per week—the opposite is often true—and overlook the busy work or bureaucracy created by new AI workflows—humans still must learn how to interact with AI systems and manage their workloads. Furthermore, the development of AI systems, often framed as inclusive and enabling, can create other inequities among firms, institutions, and individuals. Take the example of accessibility, where only those individuals and organizations with extra resources and capacity can afford subscriptions to "test out" the newest and most advanced generative tools. Software subscriptions can quickly add up in firm budgets or get lost in university bureaucracies, as was recently the case when Author Zhang attempted to use studio funds to give students access to Midjourney. Optimizers should realize that AI should not only optimize efficiency and speed but also other factors, like workers' well-being and equity.

The Resistor

The Resistor mindset sees the current wave of AI tech as a threat to creative agency and human thriving. Overreliance on AI dilutes humanist endeavors in the eyes of the Resistor. The art piece *Théâtre D'opéra Spatial* embodies the sort of provocation that puts Resistors to work. Created using Midjourney, Jason Allen submitted the piece to the Colorado State Fair's annual art competition using the name *Jason M. Allen via Midjourney;* he won the blue ribbon for emerging digital artists. While Allen and other artists like him have been unabashed in their machine-assisted methods, their achievements were offset by backlash and mass protests of other artists against AI-generated artwork in late 2022. Perhaps, a milestone was the case of *Zarya of the Dawn*, a comic book generated using Midjourney that was first granted copyright in late 2022, then revolved in February 2023 after the US Copyright Office found out the images were AI-generated. The following year, the US Copyright Office held a series of public hearings about rules and policies around generative AI content's copyright. In late October, a federal judge in California dismissed a lawsuit by visual artists who accused Stability AI, Midjourney, and DeviantArt of misusing their copyrighted work in connection with the companies' generative AI systems (See Table 1 for other cases and hearings regarding copyright and intellectual property of AI-generated content).

Table 2

Sampling of AI-related court cases and hearings through 2023

Case/Hearing	Date	Summary
Thaler v. Perlmutter	August 2023	U.S. District Court ruled against copyright protection for AI-generated art, upholding the human authorship requirement for copyright.
OpenAI Copyright Case	July 2023	Legal challenge to OpenAI regarding the use of copyrighted materials for training AI models, with fair use as a key argument.
Getty Images v. Stability AI	January 2023	Getty Images filed a copyright claim against Stability AI in the U.K. High Court over the use of copyrighted images in AI training.
U.S. Copyright Office Initiative	March 2023	The initiative was launched to examine AI's impact on copyright law and policy, including the scope of copyright in AI-generated works and the use of copyrighted materials in AI training.
Zarya of the Dawn	February 2023	The US Copyright Office believed that images in the work that were generated by the Midjourney technology were not the product of human authorship, thus canceling the original copyright certificate.
House Judiciary Subcommittee Hearing on AI and Copyright Law	May 2023	Examined the intersection of AI and copyright law, focusing on the use of copyrighted works in AI training and copyright protection for AI-assisted works.
Senate Committee Hearing on AI and Copyright	July 2023	Discussed AI's role in copyright matters, implications for various industries, and issues like fair use and metadata solutions in AI training models.
Artists' AI Copyright Lawsuit v Midjourney, Stability AI	October 2023	A U.S. judge pared down a lawsuit filed by artists against Midjourney and Stability AI, related to the use of copyrighted materials in AI-generated art.
Beijing Internet Court Recognizes Copyright in AI-Generated Images	November 2023	The Beijing Internet Court issued a decision recognizing copyright in AI-generated images.

Many landscape designers also worry as the plaintiffs of intellectual property cases that the images of their designed landscape will be used in training generative AI models. They worry that AI makes design cheap and generic, perpetuates bias, or possibly infringes copyright (Belesky, 2023). The underlying logic of the tension between these Resistors and generative AIs is likely the crisis of authorship. Uncarefully trained generative AI models overtly erase what Foucault would call the "author function," leaving creative work without a name to whom to attribute meaning and liability, and perhaps most importantly, to give social credit for its accomplishment (Foucault, 1969).

However, as it may be necessary to pin down an author for its function in legal purposes, we invite the Resistors to embrace an assemblage perspective, which might provide a sense of ease. Assemblage thinking posits that humans have always been co-evolved with other nonhuman actors around us, including tools and languages, and thus what we thought to be human agency and creativity has always been "distributive," to use Jane Bennett's term. In landscape architecture, AI tools are merely another type of actor that further diversifies and hybridizes the already "polluted" human creativity. Just as the profession has come to assert the integral role of ecological indeterminacy driving concepts—think of projects like SCAPE's Living Breakwaters and Field Operation's Fresh Kill Park where designers' agency and creativity are dissolved in a network of more-than-human actors—so too can Resistors accept a unique role for AI in the creative actor network.

The Stoic Instrumentalist

While colleagues buzz with either enthusiasm or apprehension about AI's role in their field, the Stoic approaches the change with a pragmatic indifference. They regard AI as just another tool to aid in their day-to-day tasks of drafting and designing landscapes. Even after living through the previous eras of "Photoshopization" or Parametricism, the romance of things like manual sketching still holds value for them, yet they neither resist nor embrace the digital transition. AI is no different; each workday, they dutifully utilize their AI-assisted design software without fanfare, appreciating its utility but not swept up in the novelty. In a workspace where others are either thrilled or threatened by the encroaching technology, their apathetic stance towards the digital wave is a quiet divergence from the norm, or so they think, as this is likely the most normative archetype of the bunch. For them, technology encapsulated in the form of AI is merely a facilitator, not a revolutionizer, in their enduring pursuit of shaping beautiful spaces and places. This sentiment has been evident in places like online forums, comment sections, or discussion spaces in public lectures, where a common reaction to AI provocations might be that it is "just another tool" in the toolbox (Fernberg & Chamberlain, 2021; Saldana Ochoa et al., 2023). To mitigate this indifference, the Stoics' mentality needs reflection, such as that of Science Technology, and Society (STS). STS is a field of study meant to open the black box of "ready-made" technology by showing the development of technical artifacts that were historically contingent on social values and biases (Bijker et al., 1987). STS has put more responsibility on society to regulate and influence the development of powerful technology like AI. By the same token, the Stoic mentality must shift to engage AI as a culture, rather than merely a tool, and make sure our voices as landscape architects are heard in this AI revolution.

The Superuser

With grounding from Randy Deutsch's book *Superusers* on the emergence of technology specialists in the AEC industry (Deutsch, 2019), this archetype navigates AI acceleration with a balanced blend of curiosity and practicality. The Superuser approach to AI mirrors their approach to any new technology; they are tinkerers at heart, delving into the mechanics, potentials, and limitations of the tools at their disposal. Computational thinkers at their core, Superusers distinguish themselves from other archetypes by co-evolving with technology rather than didactically leveraging (Optimizers), reacting to (Resistors), regulating (Protectors), or showing indifference to it (Stoics). In their hands, AI becomes a facilitator and partner, aiding in the efficient translation of creative ideas into tangible designs. Superusers might be embedded in firms, academic circles, or running their technology-focused consultancies, but they are also convenors. They share their explorations and findings, both within their workplaces and external peer networks, fostering a collaborative culture of examining technology in the profession. The greater collective of ongoing JoDLA contributors is an emblematic group of Superusers (Ervin, 2020b, 2022). While the ingenuity of the Superuser mental mode is generally a benefit to any technological reflection, it can also suffer from myopia that favors tinkering with tools and methods over the more nuanced management of people and processes that are affected by the use of those tools or methods. If the Superuser does not have to counterbalance, they may fail to see the bigger picture of how an AI intervention is to scale at the team, classroom, firm, or department level.

The Protector

The Protector archetype is akin to the caricatures of AI ethicists and safety advocates, representing a fusion of technical savvy with a deep commitment to safety, equity, and ethical considerations in the face of AI advancement. The Protector is a cautious integrator, meticulously balancing the innovative potential of AI with the imperatives of environmental stewardship and social justice. They may take positions like those of Timnit Gebru, Fei Fei Li, Nick Bostrom, or Kate Crawford, whose critiques emphasize the need for transparency in AI, the importance of diverse perspectives in technology development (Bender et al., 2021b; F.-F. Li, 2023), and understanding AI as a sociotechnical system, where its impacts are as much social and environmental as they are technical. Designers in this archetype operate with the assumption of Helen Armstrong that AI has already transformed our profession and that it “is going to steamroll right over us unless we jump aboard and start pulling the levers and steering the train in a human, ethical, and intentional direction" (Armstrong, 2021). Their approach is not just about harnessing AI for efficiency or creativity in design but ensuring that these technological advancements serve broader societal goals, protect natural ecosystems, and promote inclusivity and fairness in both urban and natural landscapes. They are the guardians of ethical AI integration in landscape architecture, always vigilant about the potential consequences of AI on communities and the environment. This mental mode is evident in the work of educators such as Marc Miller at Penn State University or Charles Waldheim of Harvard who use AI to help students put a critical lens on the past, present, and future of the profession (MILLER, 2022; WALDHEIM, 2022). Protector mode was also at work in both LA students and practitioners throughout the past year in public venues such as conference sessions, webinars, and symposia with concerns on all these issues well-articulated (Domlesky et al., 2023; Fernberg, 2023; Saldana Ochoa et al., 2023).

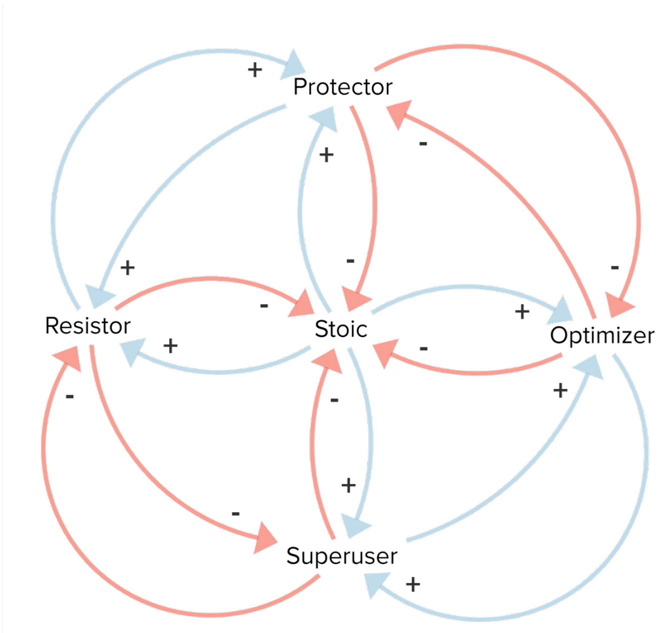
Modeling Interactions between Archetypes

While we have cited work, firms, and individuals to help characterize the AI-LA archetypes, they should not be understood as fixed identities, but rather mutable mental modes or perceptual lenses that can be taken on at any given time by any person, including those previously cited. Here we explain how those modes interact with each other and contribute to or impede AI advancement. An effective representational method is the causal loop diagram (CLD), developed and popularized in a subfield of systems theory called System Dynamics. System Dynamics is a modeling approach to understanding and simulating the behavior of complex systems over time. It has found use in everything from industrial processes to business and policymaking (Meadows, 2008; Sterman, 2000). A CLD is a system dynamics tool typically used to visually depict feedback loops and interdependencies among variables in a system. It consists of nodes representing the entities—in this case, the archetypes—and arrows indicating causal relationships between them.

Those arrows also include notations of polarity, which distinguish between reinforcing loops (positive or negative feedback) and balancing loops (both positive and negative feedback).

Figure 7

AI-LA Archetypes causal loop diagrams



Note: Blue lines and (+) represent positive polarity and feedback mechanisms. Red lines and (-) represent negative polarity and balancing mechanisms.

In our AI-LA Archetype CLD (see Fig. 7), every archetype has individual relationships with the others and resides in various multi-archetype feedback loops. Optimizers see AI as a set of tools to enhance efficiency and creativity. They are likely to push for the adoption of AI technologies to optimize work processes, potentially increasing productivity and innovation. Their influence would typically be associated with positive feedback loops in relation to Superusers, accelerating the adoption and development of AI within the landscape architecture profession, and balancing loops in relation to decelerating or neutral forcers like Resistors, Protectors, or Stoics. Resistors view AI as a threat to creative integrity and human values. They may act as a balancing force against the unchecked proliferation of AI technologies by optimizer-led coalitions, advocating for caution and consideration of the broader implications. They contribute to negative feedback loops with Protectors, decelerating the adoption of AI or calling for regulations and balancing loops with the others.

Stoics are pragmatically indifferent to AI, using it as just another tool without significant enthusiasm or resistance. They represent a stabilizing force in the system, neither accelerating nor decelerating change but maintaining a steady state of use. They create a net balancing loop, providing a counterbalance to both the Optimizer and Resistor ends of the spectrum. Superusers are technologically adept and curious, exploring and integrating AI into their practice while sharing their knowledge with others. They are positive feedback for Optimizers but with a focus on the practical and communal exploration of AI's possibilities, and a balancing force to the others. Protectors are deeply concerned with the ethical, equitable, and environmental implications of AI. They may support AI innovation but are cautious about its impact, ensuring that AI serves a greater societal good. Protectors create negative feedback loops with Resistors (positive polarity) and balancing loops with others, ensuring that the adoption of AI doesn't compromise ethical standards or societal values.

Concluding Invitation: Test, Critique, Iterate

We hope the reader pondering the prospect of AI in their firm or classroom might use the AI-LA archetypes model as a resource for switching their mental mode according to context in their research, praxis, or pedagogy. One has the flexibility in this framework to oscillate between mindsets according to the needs of a given situation. An analysis of outdated digital business practices in a firm, for example, might need leaders to put on their Optimizer hats to improve workflows using AI-driven tools and free more time for their designers to be focused on what matters most for creative production; then they will need to call on Superuser mode to think about how to implement the changes. An update of company policy in reaction to said changes would require the same leaders to take a Protector mindset to ensure equitable labor practices even with these new efficiencies. On the other hand, the same analysis could find a firm "over-digitized" with an overcomplicated tech stack and workflows that bog down designers. In this case, taking on the skeptical mentality of the Resistor is useful, finding that indeed their team simply does not want AI to be involved in some aspects of their practice, and so on. Utilizing the AI-LA Archetypes for explorations like these offers a more polymodal view of AI, encouraging landscape architects, scholars, and practitioners to embrace a more fluid, thoughtful approach to integrating AI into their work. We also acknowledge the limitations inherent in this exploration—the rapid evolution of technology, the subjective nature of speculative models, and the complexity of capturing the entire spectrum of a professional field as diverse as landscape architecture. Thus, our model must be tested in the real world. We invite readers to utilize AI-LA archetypes in thought experiments, developing technology strategies for their practice, and classroom discussions; to offer critique where the model falls short; and to build on it where they see potential. However it is used, we hope this work is a valuable springboard to more nuanced reflection on landscape architectural practice in an AI-driven world.

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CONCLUSION

The primary objective of this dissertation was to explore the intersection of artificial intelligence (AI) and landscape architecture and provide a greater understanding of how AI's evolving role could reshape the profession. It intended to provide a comprehensive review of AI's presence in landscape architecture, analyze its cultural context within the field, and propose new frameworks for discussing AI adoption.

Chapter 1 provided a systematic review of the intersection between Artificial Intelligence (AI) and Landscape Architecture (LA) in the research literature, identifying key trends, themes, and applications. It revealed a rapid growth in AI-related research within LA, emphasizing the increasing relevance of machine learning, optimization, and computer vision. It discussed how AI-driven applications are influencing design generation, evaluation, ecological modeling, and policy evaluation in landscape architecture. It also highlighted the role of AI in advancing the field through innovative approaches in design, planning, and environmental management, suggesting a continued and expanding influence of AI technologies in the discipline. The short answer to the question of whether, and how, AI is part of disciplinary research: AI-LA research has been happening for some time and it's growing exponentially. To ensure workforce readiness in both educational and professional realms, researchers and practitioners across all sectors should establish knowledge frameworks and standards of practice specific to the integration of artificial intelligence in landscape architecture (AI-LA).

Chapter 2 employed the Cultural Topography (CTops) methodology to understand the profession's cultural response to AI. It delved into landscape architects' identity, values, norms, and perceptions, examining how these factors influence their reaction to AI advancements. A broad survey of many different sources of cultural data scrutinized the industry's historical context and current challenges, emphasizing the dual identity of landscape architects as both technicians and designers. It also highlighted LA's benefits and concerns of AI integration, its perceived potential impact on professional practices and design processes, and the broader cultural implications within the discipline. The findings point to a need for LAs to increase computational literacy and find more flexible ways to anchor our core professional identity amidst rapid technological change.

Chapter 3 critically examined the now near-ubiquitous influence of Artificial Intelligence (AI) in the zeitgeist, landscape architecture included. It challenged simplistic discourses surrounding AI and proposed more nuanced perspectives through the creation of five distinct archetypes: the Optimizer, the Resistor, the Stoic Instrumentalist, the Protector, and the Superuser. Grounded in real-world examples from practice and literature, the archetypes offer a spectrum of attitudes and approaches toward AI integration, allowing for a more versatile understanding of how firms or faculties might discuss AI adoption in their practice. The work posited that utilizing the archetypes and flexible mental modes could help LAs move beyond binary judgments of AI's impact (bad or good) or a one-dimensional spectrum of AI acceleration (it never stops) and encourages landscape architects to see multifaceted approaches to integrating, or not integrating, AI into their workflows.

It has been an enlightening journey, to say the least. The research has illuminated AI as not just an outlier or fad, but as a significant and emerging frontier in the field of landscape architecture. From smartphones and personal assistants to search engines and the conundrum of social media-driven public discourse, artificial intelligence has pervaded the way we work, travel, legislate, recreate, and live in our homes. It has affected and continues to profoundly affect, landscape architecture with capabilities to carry out anything from rudimentary analytical and project management tasks to autonomously engaging in creative acts endemic to the design process—and everything in between. My exploration has revealed that AI is not just a tool but a potentially transformative force that could reshape the very fabric of landscape architecture. By delving into the current state of AI applications in the field, I identified both the potential and the challenges of its integration, offering an insightful overview of the present landscape and envisioning future possibilities. Moreover, it has addressed crucial gaps in the existing literature, providing clarity on the definition and scope of AI in the context of landscape architecture. It has outlined how AI is being used in research, pedagogy, and practice, identifying areas where further exploration and understanding are needed. In doing so, it has hopefully helped set the stage for future research and development in this inflection point for the industry. With AI-driven opportunities come challenges, including the need for interdisciplinary collaboration, ethical considerations in AI deployment, and ensuring that AI tools are accessible and understandable to landscape architects. The key will be in harnessing AI, not just as a tool for efficiency, but as a partner in creativity. This, in turn, would enable landscape architects to think differently about our processes and design spaces that are more socially responsive, economically sustainable, and eco-positive.

After almost four years of research and observation, I have come to believe that the most salient questions brought to bear by AI acceleration are not questions about AI at all, but rather existential reflections on the foundations of the discipline. What is the value proposition of landscape architecture as a profession? Does emerging technology change that value proposition? If not, does it at least affect how landscape architecture professionals present their value to the world? In other words, do we measure the impact of landscape architects by the unique processes they employ to shape the built environment or by the products or outputs themselves? As in the rest of society through history, technological advancement has been a perennial disruptor in landscape architecture. Does AI-driven technology truly present uniqueness in complicating our culture or ways of doing beyond that of other technology? After all, we have always had instrumentation to perform our duties, have we not? This dissertation certainly does not answer any of the above questions; some of those answers will likely not emerge for another decade or two, while others may, in fact, never emerge. But I hope it lays the groundwork for researchers, practitioners, and educators to delve deeper into the AI-LA nexus and at least begin answering them. Maybe along the way, we will discover AI's full potential for the betterment of our built and natural environments by unlocking more landscape architects' potential for the same.

APPENDIX A. Chapter 1 Supplementary Documentation (All Data)

Literature Matrix Full Search: This document contains the full publications list used in the review, with duplicates already removed.

Ranking and Priority: This contains the full list of all publications from the Literature Matrix Full Search. In it, we identify any scoring we could conjur from online searchers (not differentiating cite score, impact factor or others). We also identified venues that were primary computer science or engineering, which are denoted and assigned a lower tier because they are not primary to the disciplines for this review.

Country Affililation Counts: These are all country affiliations across all authors. The first three affiliation columns identify the total number of affiliations per article. So if there are 3 authors from China, it would only denote China one time. If the article had an author from the United States and Germany, then both those countries would be designated.

Authors	Author(s) ID	Title	Publication Year	Publication Title	Volume	Issue	Art. No.	Page start	Page end	Page count	Cited by
Suppakittpaisarn P.,	571928453	How do computers see landscapes?	2022	Landscape and Urban Planning	227		104547				
Yang J., Fricker P.,	577460338	From Intuition to Reasoning: Analyzing	2022	Journal of Digital Landscape Architecture	2022	7		71	81		
Tebyanian N., Wu H.,	572178243	Uncertainty Considerations in Green	2022	Journal of Digital Landscape Architecture	2022	7		549	560		
Łukaszkiewicz J.,	150359174	THE INFLUENCE OF WOODLOTS ON THE	2022	Public Recreation and Landscape Protection - With				385	389		
Schlickman E.,	572223362	Assessing automation: Methodological insights	2020	Journal of Landscape Architecture	15	3		48	59		
Ma B., Dong Y., Liu	572256936	Soft multimedia assisted new energy	2022	Soft Computing	26	23		12957	12967		1
Shavazipour B.,	571935420	Interactive decision support and trade-off	2022	Canadian Journal of Forest Research	52	11		1423	1438		
Jian Y., Liu Z., Gong J.	572112786	Response of landscape dynamics to socio-	2022	Land Use Policy	122		106354				
Liu Z., Lv J., Yao Y.,	579421701	Research Method of Interpretable Urban	2022	Journal of Geo-Information Science	24	10		2045	2057		
Wei S., Cheng S.	577342012	An artificial intelligence approach for	2022	Frontiers in Environmental Science	10		994389				
Han J., Lee S.	572191731	RESIDENT'S SATISFACTION IN STREET	2022	International Archives of the Photogrammetry,	48	4/W4-		45	52		
Langenheim N., Sabri	571955336	ADAPTING A DIGITAL TWIN TO ENABLE REAL-	2022	International Archives of the Photogrammetry,	48	4/W4-		95	100		
Zhao Y., Kasimu A.,	572190950	Spatiotemporal Changes in The Urban	2022	Land	11	10	1745				
Yang C., Liu T.	572264689	Social Media Data in Urban Design and	2022	Land	11	10	1796				
Xiao H., Guo Y.,	506621014	Evaluation and Construction of Regional	2022	Applied Sciences (Switzerland)	12	19	9600				
Wang Y., Shi X.,	572172392	How do urban park features affect cultural	2022	Urban Forestry and Urban Greening	76		127713				
Liu J., Wang Z., Wang	572081813	Comprehensive Performance Evaluation	2022	Beijing Daxue Xuebao (Ziran Kexue Ban)/Acta	58	5		909	915		
Li X., Wang X., Jiang	577755028	Prediction of riverside greenway landscape	2022	Journal of Cleaner Production	367		133066				2
Chen H., Dong Y., Lin	572217825	Research on optimization method for low	2022	Beijing Linye Daxue Xuebao/Journal of Beijing	44	9		116	126		1
Sun B., Zhang H.,	575533186	Microclimate Optimization of School Campus	2022	Buildings	12	9	1375				
Wael S., Elshater A.,	578889720	Mapping User Experiences around Transit	2022	Sustainability (Switzerland)	14	17	11008				
Goodwin C.E.D.,	571946000	Multi-tier archetypes to characterise British	2022	Environmental Research Letters	17	9	95002				
van Strien M.J., Grêt-	551906465	Unsupervised deep learning of landscape	2022	Environmental Modelling and Software	155		105462				
Chiles C.R., Melo	572144904	How can structure and composition of	2022	Forest Ecology and Management	518		120250				
Dong J., Guo F., Lin	576433294	Optimization of green infrastructure networks	2022	Science of the Total Environment	834		155307				4
Karunaratne S.,	578868632	Assessing Surface Urban Heat Island Related to	2022	Remote Sensing	14	16	4047				
Gao Y.-J., Wang C.-L.,	578745394	A New Perspective of Sustainable Perception:	2022	Sustainability (Switzerland)	14	15	9184				
Abdollahi S.,	577658728	Optimization of geographical space of	2022	Environmental Monitoring and Assessment	194	8	527				
Zhang C., Lin D.,	566662113	The Effects of the Ecological Conservation	2022	International Journal of Environmental Research	19	13	7701				1
França L.C.D.J.,	571919834	Forest landscape planning and management: A	2022	Trees, Forests and People	8		100275				
Wang F., Yuan X.,	573145518	Integrating ecosystem services and landscape	2022	Environmental Science and Pollution Research	29	28		43138	43154		3
Li G., Cai J.	576577509	Spatial and Temporal Differentiation of	2022	Sustainability (Switzerland)	14	8	4652				
[No author name	[No author	25th Italian Conference on Geomatics and	2022	Communications in Computer and Information	1651 CCIS					461	
Zixin L., Várady G.,	579517702	Application of visual simulation in the	2022	Pollack Periodica	17	2		168	174		
Liu Z.	579460289	The Application of Genetic Algorithm in the	2022	Mathematical Problems in Engineering	2022		8768974				
Zhang Y., Yang G.	572038292	Optimisation of the virtual scene layout based	2022	IEEE Access				1	1		
Jia Z.	579357057	Garden Landscape Design Method in Public	2022	Journal of Environmental and Public Health	2022		2721247				
Li J.	572163760	Ecological Effects of Local Materials in	2022	International Transactions on Electrical Energy	2022		7340002				
Akay H.	369752028	Towards Linking the Sustainable Development	2022	Water Resources Management							1
Wu X.	572238276	Research on waterfront landscape design	2022	Proceedings of SPIE - The International Society for	12339		123391D				
Zhang J., Gu L.	579311676	RESEARCH ON THE OPTIMIZATION OF	2022	Revista de Gestao Social e Ambiental	16	2	e02979				
Cao Y.	579307067	Application Research and Case Analysis of	2022	Scientific Programming	2022		7122276				
Qingfang T.	579210791	Game Analysis System of Landscape Garden	2022	3rd International Conference on Electronics and				1461	1464		
Pradipkumar V.H.,	579180492	Automatic Identification of Tree Species from	2022	Journal of the Indian Society of Remote Sensing							
Lyu G., Zhang D., Liu	579183594	Research on the Predictive Analysis of Park	2022	Computational Intelligence and Neuroscience	2022		2762554				
Kinoshita A., Fukuda	579154516	Enhanced Tracking Method with Object	2022	Proceedings of the International Conference on	2			457	466		
Zhang Y.	579075218	Application of Landscape Architecture 3D	2022	International Transactions on Electrical Energy	2022		9918171				
Deng T.	578964344	Optimization of Residential Landscape Design	2022	Computational Intelligence and Neuroscience	2022		6321101				
Chen Y., Wang X.,	578605126	Wavelet Transform-Based 3D Landscape Design	2022	International Journal of Antennas and Propagation	2022		1184198				
Liu X., Wang J., Rui	578926654	Application of GIS Technology-Supported Cross	2022	Computational Intelligence and Neuroscience	2022		8339895				
Lu Y., Chen B., Xin Y.,	578581238	Simulation Design of Intelligent Garden Based	2022	Mathematical Problems in Engineering	2022		6826060				
Huang C., Zheng Y.	578875517	Application of 3D Virtual Scanning Technology	2022	Wireless Communications and Mobile Computing	2022		5495825				
Zhao Q., Ren Y.	577504582	RESEARCH ON THE PLANNING MODEL OF LOW-	2022	Journal of Environmental Protection and Ecology	23	5		2027	2036		
Tian Z., Wang Y., Xue	572208341	Optimization of Urban Landscape Planning and	2022	Mathematical Problems in Engineering	2022		2991188				
Ren Q.	578838398	Construction of Ideological and Political	2022	Wireless Communications and Mobile Computing	2022		6299168				
Zhu L.	578806286	Urban Landscaping Landscape Design and	2022	Computational Intelligence and Neuroscience	2022		1353668				
Cheng S., Wu C., Wei	572005275	The Application of Artificial Intelligence in the	2022	5th International Conference on Inventive				1168	1171		
Wang C.	578756976	Optimization of Three-Dimensional Model of	2022	Journal of Function Spaces	2022		7002983				
Ban N., Liu X., Zhu C.	578709563	Landscape Ecological Construction and Spatial	2022	Wireless Communications and Mobile Computing	2022		4976361				
Shan P., Sun W.	572000337	Data-Driven Winter Landscape Design and	2022	Security and Communication Networks	2022		8218468				
Xie J., Wang D.	572216753	Street Landscape Planning and Design Guided	2022	Computational Intelligence and Neuroscience	2022		3146637				
O'Neill E.G.,	572214980	Determining Accurate Biofuel System	2022	Computer Aided Chemical Engineering	49			1927	1932		
Li Z.	578832874	Exploration of Energy-Saving Chilling Landscape	2022	Journal of Function Spaces	2022		1851623				
Wang R., Zhang Q.,	578482068	Research on Path Planning Based on the Fusion	2022	Lecture Notes in Computer Science (including	13457			229	239		
de Morais C.F., Mello	578437667	Multiscale Planning Approach in the Analysis	2022	Lecture Notes in Computer Science (including	13380			315	327		
Zhu Y., Cheng K.	578275449	Rural Landscape Design Update and	2022	Mathematical Problems in Engineering	2022		1364349				
Shao N.	578264336	Research on Architectural Planning and	2022	Computational Intelligence and Neuroscience	2022		1745593				1
Chen Y.	578187020	Generate Lanscape Paintings From Text to	2022	2022 IEEE 5th International Conference on Artificial				145	149		
Yu X., Yu H., Liu C.	576825115	Construction of Garden Landscape Design	2022	Computational Intelligence and Neuroscience	2022		8332180				
Qin F.	578100758	Modern Intelligent Rural Landscape Design	2022	Wireless Communications and Mobile Computing	2022		8246368				
Cui Y.	578104650	Research on garden landscape reconstruction	2022	Acta Geophysica							
Wang Q., Wang H.	572079989	Evaluation for the spatiotemporal patterns of	2022	Environmental Geochemistry and Health							2
Ji M., Lu J., Zhang X.	577859221	Construction of a Landscape Design and	2022	Computational intelligence and neuroscience	2022			8307398			
Su F.	577374570	Modular Information Fusion Model of	2022	Lecture Notes on Data Engineering and	138			201	208		
Deng Y., Zhou L.	577636197	Construction and Application of Interactive	2022	Computer-Aided Design and Applications	20	S1		35	45		
Liu D.	577587390	Application of Modern Urban Landscape Design	2022	Scientific Programming	2022		1610427				
Li S.	577381555	Design of Public Landscape Environment	2022	2022 IEEE Asia-Pacific Conference on Image				1136	1139		
Fan J.	577377174	Design of 3D Interactive Landscape Roaming	2022	2022 IEEE Asia-Pacific Conference on Image				1143	1145		
Lin H., Ni H., Xiao Y.,	572022794	Couple simulations with CFD and ladybug +	2022	Journal of Asian Architecture and Building							1
Ying Y., Jiang K., Ren	577300599	Research on Town Ecological Landscape	2022	Computational Intelligence and Neuroscience	2022		5159448				1
Xu P., Wei C.	577302312	Modularized Information Fusion Design of	2022	Mathematical Problems in Engineering	2022		5377872				
Liu T.	577089877	Multidimensional Nonlinear Landscape	2022	Advances in Multimedia	2022		5477516				
Bai Y.	576995971	Sustainable Development Garden Landscape	2022	Journal of Electrical and Computer Engineering	2022		3726801				
Yu L., Zhang L., Gong	576815124	An Optimization Model for Landscape Planning	2022	Scientific Programming	2022		2955283				1
Wang W.	576581870	Environmental Landscape Design Based on	2022	Journal of Electrical and Computer Engineering	2022		9955825				1
Yin N., Cai M.	576519472	Urban Road Landscape Design and Digital Twin	2022	Discrete Dynamics in Nature and Society	2022		8020549				
Chernaya V.V.,	572125559	Developing rehabilitation services: Medical and	2022	International Journal of Healthcare Management	15	2		100	106		
Ren C., Medvegy G.	576789345	Reconstruction place script to awake the	2021	Pollack Periodica	16	3		164	168		1
Wang H., Wang B.,	561254117	Simulation and optimization of land use pattern	2021	Chinese Journal of Ecology	40	10		3391	3400		
Shaked T., Degani A.	572031127	Shepherd: A fabrication-oriented tool for	2021	Association for Computer Aided Design in							1
Lan Z., Yue B., Wang J	575567930(	Analysis method and application of spatial mech	2022	Xi'an Jianzhu Keji Daxue Xuebao/Journal of Xi'an Uni	54	1		120	126		
Song Y., Ning H., Ye X.	572192302	Analyze the usage of urban greenways through s	2022	Environment and Planning B: Urban Analytics and City Science							1
Wang Y., Chen L.	575537512(	Architectural and Landscape Garden Planning In	2022	Security and Communication Networks	2022		8577269				
Zhang Y.	574222036(	Artificial Intelligence Technology in Urban Envirc	2022	Lecture Notes in Electrical Engineering	791			571	578		
Sun Q., Bao M., Huan	574373583(	Boundary delimitation of the proposed Songnen	2022	Beijing Linye Daxue Xuebao/Journal of Beijing Forest	44	1		103	112		
Jia J.	572247267	Computer-aided design method of parametric m	2022	Computer-Aided Design and Applications	19	S3		55	64		
Burkhardt J., Chan N.	572049070	Conformity and Conservation: Evidence from Ho	2022	American Journal of Agricultural Economics	104	1		228	248		
Fu Y., Yu C., Metawa	572596567(	Design of Environmental Art Optimization Syster	2022	Lecture Notes on Data Engineering and Communicat	123			128	134		
Yu C., Altalbe A., Du N	572191777	Environmental Landscape Art Design Using Dyna	2022	Fractals	30	2	2240077				
Guo J., Jiang C., Wang	575795290(	Exploring ecosystem responses to coastal exploi	2022	Ecological Indicators	138		108860				
Sun X., Yang P., Tao Y.	571953007	Improving ecosystem services supply provides in	2022	Science of the Total Environment	802		149849				4
Ghermandi A., Depiet	121411091(	In the AI of the beholder: A comparative analysis	2022	Landscape and Urban Planning	217		104261				2
O'Neill E.G., Martinez	572214980	Integrated spatially explicit landscape and cellul	2022	Computers and Chemical Engineering	160		107724				
Ma R.	574431141(	Intelligent Evaluation Model for Landscape Cons	2022	Proceedings - 4th International Conference on Smart Systems and Inventive Technolog				1731	1734		
Yi D., Wang Q.	574850822(	Intelligent Optimization Algorithm in Virtual Des	2022	Lecture Notes on Data Engineering and Communicat	123			995	1002		
González-García A., P	572253044	Protected areas as a double edge sword: An ana	2022	Global Environmental Change	74		102522				
Fu F., Deng S., Wu D.,	560089693(	Research on the spatiotemporal evolution of lan	2022	Sustainable Cities and Society	80		103760				
LIU L., WU J.	571899917	Scenario analysis in urban ecosystem services re	2022	Landscape and Urban Planning	224		104433				
Xun Y., Ren G.	574214587(	Smart Garden Planning and Design Based on the	2022	Computational Intelligence and Neuroscience	2022		8522751				
Van Phan T., Matos R.	572113763	Temperature Changes on Land Surface in the Co	2022	Lecture Notes in Civil Engineering	203			1427	1435		
Cilek A., Berberoglu S	538677148(	The use of regression tree method for Sentinel-2	2022	Environmental Science and Pollution Research	29	16		23665	23676		
Huang J., Wang Z.	575596693(	The Use of Scientific Programming Method unde	2022	Scientific Programming	2022		8661969				
Wang H., Hu Y., Yan H	572216107	Trade-off among grain production, animal husba	2022	Science of the Total Environment	817		153015				
Chai C., Song Y., Qin Z	572241874(	A thousand words express a common idea? Und	2021	Land	10	6	549				
Jahani A., Kalantary S.	571945683	An application of artificial intelligence technique	2021	Urban Forestry and Urban Greening	61		127088				6
J. Zhang; Z. Xie		An Intelligent Plant Landscape Design Method D	2021	2021 International Conference on Networking Systems of AI (INSAI)				206	211		
Niu L., Han F.	573251981(	Analysis of the 3D Application Evaluation Systen	2021	Scientific Programming	2021		4595808				
Huang L.	572230406	Application of Big Data in Improving Landscape F	2021	Journal of Physics: Conference Series	1852	3	32024				
Luo G., Guo Y., Wang	572226610(	Application of computer simulation and high-pre	2021	Environmental Technology and Innovation	24		101801				
Märzinger T., Kotík J.,	572045194	Application of hierarchical agglomerative cluster	2021	Applied Sciences (Switzerland)	11	23	11122				2
Hsu C.-Y., Ou S.-J.	558984936(	Application of Solar Radiation Analysis Technolo	2021	IOP Conference Series: Earth and Environmental Scie	721	1	12003				
Sun S., Meng Q., Ma Y	572624913(	Application of virtual reality technology in lands	2021	Proceedings - 2021 International Symposium on Artificial Intelligence and its Applicatio	91			95			1
Zhao J., Chen R., Hao	572114705	Application progress and prospect of machine le	2021	Beijing Linye Daxue Xuebao/Journal of Beijing Forest	43	11		137	156		
Wang S.	571945284(	Application research of artificial intelligence tec	2021	Advances in Intelligent Systems and Computing	1244 AISC			341	348		1
Liu Q.	572244481	Artificial intelligence aided analysis of flexible sp	2021	Proceedings - 5th International Conference on Intelligent Computing and Cc			9432290	1776	1779		
Wartmann F.M., Kobl	353314147(	Assessing experienced tranquillity through natur	2021	Landscape Ecology	36	8		2347	2365		3
Kido D., Fukuda T., Ya	572171489	Assessing future landscapes using enhanced mix	2021	Advanced Engineering Informatics	48		101281				2
Jafarzadeh A.A., Mah	571939028	Assessing synergies and trade-offs between ecos	2021	Land Use Policy	111		105741				1
Shan P., Sun W.	572000337	Auxiliary use and detail optimization of compute	2021	Arabian Journal of Geosciences	14	9	798				3
Bastille-Rousseau G.,	365998190(	Characterizing the landscape of movement to id	2021	Conservation Biology	35	1		346	359		6
Zhang Q., Lu S., Liu L.,	572109377	Color Enhancement of Low Illumination Garden	2021	Traitement du Signal	38	6		1747	1754		
Ye F., Ying K., Su E., W	572056790	Comfort and Safety Evaluation of Tunnel Portal I	2021	Tongji Daxue Xuebao/Journal of Tongji University	49	2		218	226		4
Yi W.	572888786(	Computer Aided Landscape Design and Image R	2021	Proceedings of the 2nd International Conference on Electronics and Sustainable Comm				1208	1211		
Hu B.	572234018	Deep Learning Image Feature Recognition Algori	2021	Complexity	2021		9921095				1
Huang L.	572248628	Design of landscape ecological environment mo	2021	Fresenius Environmental Bulletin	30	6		6207	6214		
Zhang L., Huang C., Zh	572217250	Design optimization for urban landscape from th	2021	Fresenius Environmental Bulletin	29	10		9095	9102		3
Charles M., Bakshi B.F	572092785	Designing industrial landscapes for mitigating air	2021	AIChE Journal	67	10	e17347				

[No author name avai	[No author	2nd EAI International Conference on Multimedia	2020	Lecture Notes of the Institute for Computer Sciences	327 LNICST					948		
[No author name avai	[No author	7th International Conference on Actual problem	2020	Key Engineering Materials	864 KEM					302		
Ervin S.M.	367239489(	A brief history and tentative taxonomy of digital	2020	Journal of Digital Landscape Architecture	2020	5		2	11		1	10.14627/5
Bar-Sinai K.L., Shaked	357484691(	A pedagogical protocol for iterative robotic fabri	2020	Archnet-IJAR	14	3		453	468		2	10.1108/AR
Zhou X., Lian X.	572177294	Analysis of Landscape Sculpture and Its Environn	2020	Journal of Physics: Conference Series	1550	3	32095					10.1088/17
Yu D.	572175935	Analysis on Landscape Design Based on Digital M	2020	Journal of Physics: Conference Series	1533	2	22071					10.1088/17
Phillips M.C., Stein R.,	572173010(	Analyzing Pre-Trained Neural Network Behavior	2020	2020 Systems and Information Engineering Design Symposium, SIEDS 2020			9106628				1	10.1109/SIE
Lv Y.	572162585	Application analysis of computer augmented rea	2020	IOP Conference Series: Materials Science and Engine	750	1	12153					10.1088/17
Zhao X.	572181466	Application of 3D CAD in landscape architecture	2020	Computer-Aided Design and Applications	18	S1		120	132		3	10.14733/C
Wang Z., Gao Y.	572172793	Application of artificial intelligence and Zen spac	2020	Proceedings of the International Conference on Electronics and Sustainable			9155795	173	176		1	10.1109/ICI
Xie H., Wei L., Li P.	572085163(	Application of Computer Virtual Reality Technolc	2020	Journal of Physics: Conference Series	1575	1	12123					10.1088/17
Tebyanian N.	572178243(	Application of machine learning for urban landsc	2020	Journal of Digital Landscape Architecture	2020	5		217	226			10.14627/5
Ghani N.A.M., Yeun L.	572155931	Artificial Neural Network Analysis on BMS datase	2020	2020 IEEE Conference on Big Data and Analytics, ICBDA 2020			9289759	51	56			10.1109/ICI
Meng Y., Wu N., Li Y.,	361494469(	BIM Impact Assessment of Landscape Architectu	2020	Journal of Physics: Conference Series	1533	4	42093				1	10.1088/17
Louder E., Wyborn C.	572020610	Biodiversity narratives: Stories of the evolving cc	2020	Environmental Conservation	47	4		351	359		10	10.1017/S0
Wang J., Liu M., Li W.	572192852	Color Matching Simulation of Ocean Landscape I	2020	Journal of Coastal Research	108	sp1		173	177		1	10.2112/JCI
Mu B., Liu C., Tian G.,	571892620	Conceptual planning of urban-rural green space	2020	Sustainability (Switzerland)	12	7	2863				10	10.3390/su
Xu Y., Yang Z., Li Y.	572154982	Construction method of ventilation corridor woc	2020	Beijing Linye Daxue Xuebao/Journal of Beijing Forest	42	2		135	148			10.12171/j.
Li L.	572217420	Construction of landscape architecture art desig	2020	International Journal of Arts and Technology	12	4		335	351		1	10.1504/IJA
Benke K.K., Norng S.,	670176375	Development of pedotransfer functions by mach	2020	Geoderma	366		114210				11	10.1016/j.g
Zhou X., Lian X.	572177294	Discussion on Development Trend of Landscape	2020	Journal of Physics: Conference Series	1550	3	32035					10.1088/17
Mo H., Zhao Y., Wen	572079652(	Ecological regionalization for the ecological prot	2020	Journal of Environmental Accounting and Manageme	8	2		139	150			10.5890/JE
Wang P., Qiao S.	572101189	Emerging Applications of Blockchain Technology	2020	Wireless Communications and Mobile Computing	2020		6623466				8	10.1155/20
Cervelli E., Scotto di P	567308945(	Energy crops in marginal areas: Scenario-based	2020	Ecological Indicators	113		106180				10	10.1016/j.e
Wang Q., Zeng X.	572199407	Energy-saving optimisation method for green sp	2020	International Journal of Global Energy Issues	42	6-May		393	408			10.1504/IJG
Miranda A., Carrasco	551443116(	Evidence-based mapping of the wildland-urban i	2020	Environmental Research Letters	15	9	94069				8	10.1088/17
Shujian L., Guan W.	107389190(	Experimental Research on the Visual Characteris	2020	E3S Web of Conferences	165		4026					10.1051/e3
Wen B., Burley J.B.	572155936	Expert opinion dimensions of rural landscape qu	2020	Sustainability (Switzerland)	12	4	1316				4	10.3390/su
Li J.	572094218(	Future Research Method of Landscape Design B	2020	Advances in Intelligent Systems and Computing	965			92	100			10.1007/97
Brown A.J., Allen P.S.	572112794(	Identifying obstacles for autonomous mowers in	2020	Acta Horticulturae	1298			113	120			10.17660/A
Wu P.-L., Chen S.-Y.	567631712(	Innovation in optimization of virtual space exper	2020	Sensors and Materials	32	10		3419	3428			10.18494/S
Lin L., Li M., Chen H.,	571886505	Integrating landscape planning and stream quali	2020	Ecological Indicators	117		106557				6	10.1016/j.e
Yu D.	572175935	Interior Landscape Design and Research based o	2020	Journal of Physics: Conference Series	1533	3	32038				2	10.1088/17
[No author name avai	[No author	International Conference on Materials Science a	2020	Materials Science Forum	1005 MSF					173		
Du J., Long Y.	572207662	Landscape image layout optimization extraction	2020	Complexity	2020		6620216					10.1155/20
Lu C., Zhang X.	572185876	Museum landscape design based on the combin	2020	E3S Web of Conferences	179		2130					10.1051/e3
Nikologianni A., Betta	516656750(	New integrated approaches to climate emergen	2020	Sustainability (Switzerland)	12	20	8419	1	11		2	10.3390/su
Bessonov I., Zhukov A	572033880	Optimization of the technology for the productic	2020	E3S Web of Conferences	164		14016				7	10.1051/e3
Berčič T., Ažman-Mor	571918687	Parametric terracing as optimization of controlle	2020	Water (Switzerland)	12	3	634				3	10.3390/w1
Lu W.-T., Pei H., Zhan	571916259	Performance evaluation of horseshoe-shaped ur	2020	Fresenius Environmental Bulletin	29	7		5901	5910			
Liu Z., He C., Yang Y.,	557147982(	Planning sustainable urban landscape under the	2020	Journal of Cleaner Production	244		118709				19	10.1016/j.jc
Huynh H.X., Truong B	270677389(	Plant Identification Using New Architecture Conv	2020	Vietnam Journal of Computer Science	7	2		197	208		2	10.1142/S2
Bao T.Q., Kiet N.T.T.,	571944392	Plant species identification from leaf patterns us	2020	Journal of Information and Telecommunication	4	2		140	150		11	10.1080/24
Cilek M.U.	572010547	population-based optimization of playgrounds' s	2020	Fresenius Environmental Bulletin	29	7A		6056	6063		1	
Zema D.A., Lucas-Borj	572191746	Predicting the hydrological response of a forest	2020	Computers and Electronics in Agriculture	170		105280				17	10.1016/j.c
[No author name avai	[No author	Proceedings - 2020 International Conference on	2020	Proceedings - 2020 International Conference on Computers, Information Processing and Advanced Education,						422		
Almahmood M., Skov	571929825(	Public space public life 2.0: Agent-based pedestr	2020	Journal of Digital Landscape Architecture	2020	5		305	317		1	10.14627/5
Yan S., Fang Y.	572115752	Research on environment optimization system o	2020	IOP Conference Series: Earth and Environmental Scie	558	3	32002					10.1088/17
Jun Y., Xian S.X.	572207779	Research on Landscape Design Based on Digital	2020	Journal of Physics: Conference Series	1651	1	12071					10.1088/17
Zhao L., Zhou Z.	572213822	Research on Landscape Information Model Cons	2020	Journal of Physics: Conference Series	1693	1	12126					10.1088/17
Xia Y.	572191796	Research on the integration of regional cultural l	2020	Fresenius Environmental Bulletin	29	7		5996	6005			
Niedźwiecka-Filipiak I	241666122(	Sectoral analysis of landscape interiors (SALI) as	2020	Sustainability (Switzerland)	12	8	3192				2	10.3390/SU
Pan X., Lin Q.	572064687	Simulation and Optimization of the Scenic Beaut	2020	Advances in Intelligent Systems and Computing	928			287	292			10.1007/97
Piao H., Duan H., Zhu	572126207(	Simulation of Urban Landscape Around Subway	2020	Microprocessors and Microsystems			103495				5	10.1016/j.m
Yao W., Ding Y.	572208997	Smart city landscape design based on improved	2020	Complexity	2020		6693411				4	10.1155/20
Lorilla R.S., Poirazidis	572033925	Socio-ecological determinants of multiple ecosys	2020	Ecological Modelling	422		108994				9	10.1016/j.e
Rivieccio R., Di Bene (	560301424(	Soil rooting depth of Italy	2020	Journal of Maps	16	2		36	42			10.1080/17
Li S., Zhao Y., Xiao W.,	571912854	Spatial and Temporal Differentiation of Landscap	2020	Nongye Jixie Xuebao/Transactions of the Chinese So	51	1		203	213		3	10.6041/j.is
Thomson J., Regan T.J	740268228	Spatial conservation action planning in heteroge	2020	Biological Conservation	250		108735				11	10.1016/j.b
Guo Y., Tong L., Mei L	572155026(	The level of green development and obstacle fac	2020	Shengtai Xuebao	40	7		2463	2472		1	10.5846/stx
Eslamirad N., Malekp	572030004	Thermal comfort prediction by applying supervis	2020	Smart and Sustainable Built Environment	9	4		361	374		8	10.1108/SA
Liu X.	572187966	Three-Dimensional Visualized Urban Landscape I	2020	IEEE Access	8		9167242	149510	149521		9	10.1109/AC
Rui Z., Wukui W.	564801851(	Tourism Design of Forest Park Based on Artificial	2020	Advances in Intelligent Systems and Computing	1017			1937	1948			10.1007/97
Mirti A.V., Hawken S.	572240969	USING SCENARIO PLANNING to ENHANCE COAST	2020	ISPRS Annals of the Photogrammetry, Remote Sensir	6	3/W1		51	58			10.5194/isp
Diao J.-Q., Cui X.-Y.	571950369	Virtual interactive planning model of landscape a	2020	Lecture Notes of the Institute for Computer Sciences	327 LNICST			137	148		1	10.1007/97
Cillis G., Statuto D., Pi	571947440(	Visual quality assessment in a GIS environment a	2020	Public Recreation and Landscape Protection - With Sense Hand in Hand? Conference Pr				558	562			
Xie M., Li M., Li Z., Xu	361803924(	Whom do urban agriculture parks provide lands	2020	Sustainability (Switzerland)	12	12	4967				6	10.3390/su
Sun R., Li F., Chen L.	350705609(	A demand index for recreational ecosystem serv	2019	Journal of Environmental Management	251		109612				13	10.1016/j.je
León J., Reijnders V.M	572206410(	A Landscape-Scale Optimisation Model to Break	2019	Environmental Modeling and Assessment	24	4		369	379		6	10.1007/s1
Liu Y., Wang B.	572112345	Application Research of Virtual Reality Technolo	2019	Journal of Physics: Conference Series	1302	4	42050					10.1088/17
Peng J., Zhao S., Dong	366638021(	Applying ant colony algorithm to identify ecologi	2019	Environmental Modelling and Software	117			214	222		61	10.1016/j.e
Jaligot R., Chenal J., B	571903884	Assessing spatial temporal patterns of ecosysten	2019	Landscape Ecology	34	6		1379	1394		11	10.1007/s1
Wang B., Liu Z., Mei Y	572084131	Assessment of ecosystem service quality and its	2019	International Journal of Environmental Research and	16	7	1248				10	10.3390/ije
Sportelli M., Martello	572046772(	Autonomous mower management systems effici	2019	Agriculture (Switzerland)	9	6	115				2	10.3390/ag
Conrad E., Fazey I., Ch	357997337(	Choosing landscapes for protection: Comparing	2019	Landscape and Urban Planning	191		103621				6	10.1016/j.la
Hasan M., Ullah S., Kh	366854592(	Comparative analysis of SVM, ann and cnn for cl	2019	International Archives of the Photogrammetry, Rem	42	2/W13		1861	1868		13	10.5194/isp
Dawar K., Samuel A.J.	572097348	Comparing topic modeling and named entity rec	2019	2019 Systems and Information Engineering Design Symposium, SIEDS 2019			8735642				3	10.1109/SIE
Bergier I., Silva A.P.S.,	504610232(	Could bovine livestock intensification in Pantana	2019	Science of the Total Environment	655			463	472		17	10.1016/j.s
Green S., King G., Fab	572096612	Designing out Urban Heat Islands	2019	Intelligent and Informed - Proceedings of the 24th In	2			603	612			
Ou D., Yao X., Xia J., G	571921962	Development of a composite model for simulati	2019	Sustainability (Switzerland)	11	9	2678				1	10.3390/su
Othman R., Suid S., M	554903378(	Estimation of carbon sequestration rate of urbar	2019	Applied Ecology and Environmental Research	17	4		8089	8101			10.15666/a
Corrigan E., Nieuwenl	566739092(	Evaluating goal programming as a backcasting tc	2019	Forests	10	5	386				2	10.3390/f1
Reid K., Sisneroz J., Fu	557755316(	Evaluating landscape rose performance on redu	2019	Acta Horticulturae	1232			151	155			10.17660/A
Rouzies E., Lauvernet	572082741(	From agricultural catchment to management sce	2019	Science of the Total Environment	671			1144	1160		5	10.1016/j.s
Jacobs S.	572143197	From novel to relational: An approach to care fo	2019	Journal of Landscape Architecture	14	3		24	33		1	10.1080/18
Jiefei N., Tieming M.,	572120607	Garden plant landscape evaluation method base	2019	Journal of Physics: Conference Series	1325	1	12155					10.1088/17
Chunyu D., Li W.	571945245	High building layout design based on emotional	2019	Cluster Computing	22			5001	5007		1	10.1007/s1
Nguyen T.H., Granger	572122839(	High-resolution multi-objective optimization of f	2019	Applied Energy	238			1484	1496		11	10.1016/j.a
Khosravi R., Hemami	553614123(	Identifying landscape species for ecological plan	2019	Ecological Indicators	99			140	148		11	10.1016/j.e
Liu W., Zhan J., Zhao F	572020699	Impacts of urbanization-induced land-use chang	2019	Ecological Indicators	98			228	238		118	10.1016/j.e
Fedorca A., Russo I.-R	572096160	Inferring fine-scale spatial structure of the brow	2019	Scientific Reports	9	1	9494				9	10.1038/s4
Krasnoyarova B.A., Or	361756785(	Landscape-Ecological Assessment of Dry Lands o	2019	Arid Ecosystems	9	3		150	156		1	10.1134/S2
Zheng Q., Vega K.	572115676	Landscape-freestyle: Restyling site plans for land	2019	International Conference on Intelligent User Interfaces, Proceedings IUI				101	102		1	10.1145/33
Angelstam P., Mantor	700375214(	LTSER platforms as a place-based transdisciplina	2019	Landscape Ecology	34	7		1461	1484		27	10.1007/s1
Liang Y.	572081534	Modeling of modern eco-environment landscap	2019	Ekoloji	28	107	e107348	3107	3118		2	
Davydova O.V.	571994080(	New forms of synthesis in architectural and land	2019	IOP Conference Series: Materials Science and Engine	687	5	55001					10.1088/17
Lygum V.L., Poulsen D	558302836(	Post-Occupancy Evaluation of a Crisis Shelter Ga	2019	Health Environments Research and Design Journal	12	3		153	167		3	10.1177/19
Wu W., Wang B., Yang	572064663	Research on the simulation design of humanistic	2019	Informatica (Slovenia)	43	3		325	330			10.31449/ir
Cillis G., Statuto D., Pi	571947440(	Restoring biodiversity in a highly-intensive touris	2019	Public Recreation and Landscape Protection - With Sense Hand in Hand... Conference P				339	343		2	
Li S., Wang X., Zhang	572124660	Study on the Changes of Plant Ecological Commu	2019	E3S Web of Conferences	136		7030					10.1051/e3
Martín R., Yepes V.	572005380	The concept of landscape within marinas: Basis f	2019	Ocean and Coastal Management	179		104815				3	10.1016/j.o
Zhang Z., Bowes B.	572039383	The future of artificial intelligence (AI) and mach	2019	Journal of Digital Landscape Architecture	2019	4		2	9		3	10.14627/5
Wang J., Liu H., Chen	559667195(	The resilience research of the plant and soil opti	2019	Environmental Monitoring and Assessment	191	4	225				4	10.1007/s1
Kokla M., Mostafavi M	650784871	Towards building a semantic formalization of (sn	2019	ISPRS Annals of the Photogrammetry, Remote Sensir	42	2/W11		675	683		8	10.5194/isp
Li Y.	371243620(	Urban landscape design with low carbon energy	2019	AIP Conference Proceedings	2154		20007					10.1063/1.5
Quinta-Nova L., Roqu	360949276(	Using Geostatistics and Multicriteria Spatial Anal	2019	Communications in Computer and Information Scien	953			64	83		1	10.1007/97
Xiang Y.-N., Gao H.-G.	572050556	"DEPSIR-LM" model-based study on shaping of t	2018	Ekoloji	27	106	e106016	203	216		1	
Eva Thum V., Kinast P	572015821	"Undissected areas with low traffic and few over	2018	Naturschutz und Landschaftsplanung	50	4		110	119			
Wu C.-L., Chiang Y.-C.	572018858	A geodesign framework procedure for developin	2018	Habitat International	75			78	89		13	10.1016/j.h
Wong G.K.L., Jim C.Y.	562728617(	Abundance of urban male mosquitoes by green	2018	Landscape Ecology	33	3		475	489		9	10.1007/s1
Qi L., Zhao F., Sun J.	364921586(	An integrated multi-scale approach to restoring	2018	Ecological Engineering	125			98	105		2	10.1016/j.e
Anopin V.N., Rulev A.	571909639(	Assessment of the state and measures to impro	2018	IOP Conference Series: Materials Science and Engine	451	1	12185					10.1088/17
Eggers J., Lindhagen A	249225991(	Balancing landscape-level forest management b	2018	Urban Forestry and Urban Greening	33			1	11		14	10.1016/j.u
Herman K., Sbarcea M	572023747	Creating green space sustainability through low-	2018	Sustainability (Switzerland)	10	6	1857				13	10.3390/su
Hosny O.A., Dorra E.M	370413227(	Development of an automated optimizer for sus	2018	Automation in Construction	94			93	103		2	10.1016/j.a
[No author name avai	[No author	E3S Web of Conferences	2018	E3S Web of Conferences	49					1194		
Eyvindson K., Rasinmä	361602482(	Evaluating a hierarchical approach to landscape-	2018	Canadian Journal of Forest Research	48	2		208	215		2	10.1139/cjf
Groot J.C.J., Yalew S.G	700620651(	Exploring ecosystem services trade-offs in agricu	2018	Landscape and Urban Planning	172			29	36		29	10.1016/j.la
Peltonen-Sainio P., Ja	700636437	Field characteristics driving farm-scale decision-r	2018	Land Use Policy	71			49	59		12	10.1016/j.la
Chen H.	572050312	Graphic design of science and technology park b	2018	Proceedings - 2018 International Conference on Virtual Reality and Intellige			8531352	71	74			10.1109/IC
Field J.L., Evans S.G.,	555828987(	High-resolution techno-ecological modelling of a	2018	Nature Energy	3	3		211	219		34	10.1038/s4
Henze J., Schröter B.,	572030000	Knowing me, knowing you-capturing different kr	2018	Water (Switzerland)	10	7	934				6	10.3390/w1
Li S., Xiu D.-X., Shi T.-N	370199139(	Landscape ecological planning of coastal industr	2018	Chinese Journal of Applied Ecology	29	10		3357	3366		3	10.13287/j.
[No author name avai	[No author	MATEC Web of Conferences	2018	MATEC Web of Conferences	227					178		
Deveikiene V.	158364100(	Methodological guidelines for optimizing the int	2018	Landscape Architecture and Art	12	12		7	21		4	10.22616/J.
Kampichler C., Sierdse	700429757	On the usefulness of prediction intervals for loca	2018	Ecological Informatics	47			67	72		7	10.1016/j.e
Banek T., Krupiński P.,	561609481(	Optimization in landscape architecture	2018	E3S Web of Conferences	49		2					10.1051/e3
Tong H., Shi P., Bao S.	562151827(	Optimization of urban land development spatial	2018	Journal of Urban Planning and Development	144	2	5018006				12	10.1061/(A
Lee M.-J., Pae J.-H.	570135597(	Photo-fake conditions of digital landscape repre	2018	Visual Communication	17	1		3	23		4	10.1177/14
Vinky Rahman N., Gin	572013519(	Planning a tourism landscape in geosite area: Sir	2018	IOP Conference Series: Earth and Environmental Scie	126	1	12196				1	10.1088/17
Wang R.	572010842	Plant landscape planning and design of Nanshan	2018	Forestry Studies	68	1		25	32			10.2478/fsr
Chaubey I., Cibin R., F	572032585	Precision conservation for biofuel production	2018	Precision Conservation: Goespatial Techniques for Agricultural and Natural Resources C				253	283		2	10.2134/ag
[No author name avai	[No author	Proceedings - 3rd International Conference on Ir	2018	Proceedings - 3rd International Conference on Intelli	2018-January					775		
Cai J.	572035041	Research on Rainwater System Optimization Des	2018	IOP Conference Series: Earth and Environmental Scie	170	3	32002					10.1088/17
Gao B.	572029189(	Research on Thematic Landscape Design	2018	IOP Conference Series: Materials Science and Engine	371	1	12064					10.1088/17
Furlaud J.M., Williams	572004460	Simulating the effectiveness of prescribed burni	2018	International Journal of Wildland Fire	27	1		15	28		23	10.1071/WI
Liu Z., Zheng S., Fang	572034126	Simulating validation of ENVI-met vegetation mc	2018	Beijing Linye Daxue Xuebao/Journal of Beijing Forest	40	3		1	12		3	10.13332/j.
Guan W., Lin B.	572072065	Study onthe attraction evaluation of Xi'an great	2018	Xi'an Jianzhu Keji Daxue Xuebao/Journal of Xi'an Uni	50	5		708	713			10.15986/j.
Wei X., Bonenberg W	571930069	The case study of BIM in urban planning and des	2018	Advances in Intelligent Systems and Computing	600			207	217		4	10.1007/97
Toland A.	572033441	The learning machine and the spaceship in the g	2018	RA Revista de Arquitectura	20			216	227+318 and 323			10.15581/0
Frausto-Robledo A.	572025806	The role of query and convergence in next-gener	2018	Codify: Parametric and Computational Design in Landscape Architecture				171	179			10.4324/97
Yu Z., Guo X., Zeng Y.,	565310651(	Variations in land surface temperature and cooli	2018	Urban Forestry and Urban Greening	29			113	121		83	10.1016/j.u
Wang B., Lv X.-Q., He	572004228	Whole-transcriptome sequence analysis of verbe	2018	International Journal of Molecular Sciences	19	6	1751				8	10.3390/ijm
Wolfe M.L., Richard T	720279516	21st century engineering for on-farm food–energ	2017	Current Opinion in Chemical Engineering	18			69	76		8	10.1016/j.c
Wei H., Huang Z., Lin	567632017(	A decision support system for plant optimization	2017	Sustainability (Switzerland)	9	2	215				3	10.3390/su
Yuan C., Norford L., N	369319830(	A semi-empirical model for the effect of trees or	2017	Landscape and Urban Planning	168			84	93		31	10.1016/j.la
Yuan C., Norford L., N	369319830(	A semi-empirical model to evaluate urban wind	2017	Proceedings of 33rd PLEA International Conference:	2			2927	2934			
Hosny O., Nassar K.A.	370413227(	A sustainable environmental optimizer for urbar	2017	Proceedings of the International Conference on Industrial Engineering and Operations I				256	267		1	
Ma X., Guo P., Zhu J.,	563458446(	An optimization method for urban landscape de	2017	Boletin Tecnico/Technical Bulletin	55	11		533	539		2	
Haara A., Store R., Les	660335410	Analyzing uncertainties and estimating priorities	2017	Landscape and Urban Planning	163			56	66		13	10.1016/j.la
Yufu C.	571993233	Application and value analysis optimization of m	2017	Boletin Tecnico/Technical Bulletin	55	15		219	226		2	
Žmire A., Reljić D.T., B	570634090(	Application of landscape metrics in the process	2017	International Multidisciplinary Scientific GeoConfere	17	33		465	472		1	10.5593/sg
Jukneliené D., Valčiuk	571944126	Assessment of regulation of legal relations of ter	2017	Land Use Policy	67			65	72		10	10.1016/j.la
Golikov S.Y., Petukhov	571931513(	Creation of Artificial Landscapes Spatial Systems	2017	IOP Conference Series: Materials Science and Engine	262	1	12213					10.1088/17
Zhu Z., Chen X.	563973352(	Evaluating the effects of low impact developmer	2017	Water (Switzerland)	9	7	548				50	10.3390/w9
Liang F., Liu S., Liu L.	407618191(	Identification of rural landscape functional confli	2017	Nongye Gongcheng Xuebao/Transactions of the Chir	33	9		260	267		6	10.11975/j.
Cebrián-Piqueras M.A	571889787	Interactions between ecosystem properties and	2017	International Journal of Biodiversity Science, Ecosyst	13	2		53	66		12	10.1080/21
[No author name avai	[No author	IOP Conference Series: Materials Science and En	2017	IOP Conference Series: Materials Science and Engine	274	1				1105		
Chen L., Thapa B., Kim	571998429	Landscape optimization in a highly urbanized tou	2017	Sustainability (Switzerland)	9	12	2364				8	10.3390/su
Malek Ž., Verburg P.	567024477(	Mediterranean land systems: Representing diver	2017	Landscape and Urban Planning	165			102	116		51	10.1016/j.la
Law E.A., Bryan B.A., I	366751639(	Mixed policies give more options in multifunctio	2017	Journal of Applied Ecology	54	1		51	60		35	10.1111/13
Vazhnik V., Hansen J.I	571978581	Multiattribute optimization of farm plans to imp	2017	2017 ASABE Annual International Meeting								10.13031/a
Li X.	572000172	Optimization and development of city landscape	2017	Boletin Tecnico/Technical Bulletin	55	18		108	113			
Peyronnin N.S., Caffey	558390136(	Optimizing sediment diversion operations: Work	2017	Water (Switzerland)	9	6	368				37	10.3390/w9
Zhao X., Li G., Gao T.	560778618(	Research on Optimization and Biological Charact	2017	Procedia Engineering	180			550	561		2	10.1016/j.p
Koma S., Yamabe Y., T	572014073	Research on urban landscape design using the in	2017	Visualization in Engineering	5	1	1				7	10.1186/s4
Westort C., Shen Z.	572224705	Robot in the garden: Preliminary experiments pr	2017	Journal of Digital Landscape Architecture	2017	2		223	234			10.14627/5
Rostański K.	650797080(	Structural Sustainability-Heuristic Approach	2017	IOP Conference Series: Materials Science and Engine	245	5	52007				2	10.1088/17
Cialdea D., Cacucci S.	564310537(	The River's contract: An opportunity for new lan	2017	International Journal of Design and Nature and Ecod	12	3		314	323		4	10.2495/DN
Uyar G., Güven A., Ka	571960347	Using an analytical process to contextualise arch	2017	Proceedings - 11th International Space Syntax Symposium, SSS 2017				118.1	118.16		1	
Cyr G., Raulier F., Fort	660255430	Using operating area size and adjacency constrai	2017	Landscape Ecology	32	2		377	395		3	10.1007/s1
Prasad A.M., Iverson	740188200	A multistage decision support framework to guic	2016	Landscape Ecology	31	9		2187	2204		14	10.1007/s1
Navickas L., Olszewsk	571910518	CLASS: Contemplative landscape automated sco	2016	24th Mediterranean Conference on Control and Automation, MED 2016			7535987	1180	1185		5	10.1109/MI
Ketcheson S.J., Price J	264310268(	Constructing fen peatlands in post-mining oil sar	2016	Earth-Science Reviews	161			130	139		48	10.1016/j.e
Cracknell M.J., Cowoc	550304652(	Construction and analysis of Hydrogeological Lar	2016	Soil Research	54	3		328	345		6	10.1071/SR
Wang Z.-H., Zhao X., Y	555000466(	Cooling and energy saving potentials of shade tr	2016	Applied Energy	161			437	444		126	10.1016/j.a
Diamanti J.M.	567501536(	Energyscapes, architecture, and the expanded fi	2016	Postmodern Culture	26	2					2	10.1353/pm
Tang L., Wang H., Wa	157520220(	Landscape pattern optimization for Xianghe Seg	2016	International Journal of Sustainable Development an	23	4		305	311		11	10.1080/13
Zank B., Bagstad K.J.,	570792334(	Modeling the effects of urban expansion on natu	2016	Landscape and Urban Planning	149			31	42		77	10.1016/j.la
Lai S., Leone F., Zoppi	554275931(	Planning for the conservation of historic districts	2016	Green Energy and Technology	0			177	197		1	10.1007/97
Guo Y., Zheng W.	571921710	Relational model for network topology and appr	2016	Shenyang Gongye Daxue Xuebao/Journal of Shenyar	38	6		686	691			10.7688/j.is
Liu S., Hodgson M.E.	559701394(	Satellite image collection modeling for large are	2016	ISPRS Journal of Photogrammetry and Remote Sensi	118			13	21		18	10.1016/j.is
Sun Y., Chang Q., Han	571886463(	SWMM-based evaluation and improvement of d	2016	Progress in Civil, Architectural and Hydraulic Engineering - Selected Papers of the 4th Ir				1173	1178			
Stamou Z., Xystrakis F	571902792	The role of fire as a long-term landscape modifie	2016	Applied Geography	74			47	55		8	10.1016/j.a
Salomon D.	357320649(	Towards a new infrastructure: Aesthetic thinking	2016	Journal of Landscape Architecture	11	2		54	65		1	10.1080/18
Xie Y., Ma T.	740395947	A method for delineating a hierarchically networ	2015	Urban Geography	36	6		947	963		3	10.1080/02
Terribile F., Agrillo A.,	559960404(	A Web-based spatial decision supporting system	2015	Solid Earth	6	3		903	928		33	10.5194/se-
Rivera-Zamarripa L.A.	570155943(	Analysis and visualization of a many-objective op	2015	Springer Proceedings in Mathematics and Statistics	117			375	380		1	10.1007/97
Benke K.K., Sheth F.,	670176375	Application of geovisual analytics to modelling th	2015	International Journal of Digital Earth	8	7		579	593		7	10.1080/17
Gutzwiller K.J., Riffell	660382386(	Avian abundance thresholds, human-altered lan	2015	Landscape Ecology	30	10		2095	2110		17	10.1007/s1
Van Veelen P., Voore	565663452(	Design challenges of multifunctional flood defen	2015	Research in Urbanism Series	3			275	292		9	10.7480/riu
Vizzari M., Antognelli	357631112(	Ecosystem services along the urban–rural–natur	2015	Lecture Notes in Computer Science (including subser	9157			745	757		6	10.1007/97
Wu Z., Wang H.	572211691(	Establishment and optimization of green ecologi	2015	Chinese Journal of Ecology	34	7		1976	1985		9	
Yu Z.-W., Guo Q.-H., S	565310651(	Impacts of urban cooling effect based on landsc	2015	Chinese Journal of Applied Ecology	26	2		636	642		23	
König H.J., Podhora A	569627190(	Knowledge brokerage for impact assessment of	2015	Sustainability (Switzerland)	7	5		5027	5049		13	10.3390/su

Tomić D., Žmire A., Še	572110949	Landscape suitability evaluation as a tool for dev	2015	Dela	2015	44
Queiroz C., Meacham	120417142	Mapping bundles of ecosystem services reveals	2015	Ambio	44	1
Othman R., Abu Kasin	554903378	Novel landscape design model system approach:	2015	Jurnal Teknologi	77	30
Store R., Karjalainen E	660334290	Producing a sensitivity assessment method for v	2015	Landscape and Urban Planning	144	
Hartness A.	572242097	Reinforcement through opposition: Metrics and	2015	Representing Landscapes: Digital		
Thiis T., Ferreira A.D.	650758416	Sheltering effect and snow deposition in arrays	2015	Environmental Fluid Mechanics	15	1
Liu W.-Y., Lin C.-C.	163135279	Spatial forest resource planning using a cultural	2015	Environmental Modelling and Software	71	
Rudenko L., Maruniak	700503324	The landscape plans system as a tool for sustain	2015	Springer Geography		
Plieninger T., Bieling C	660348640	The role of cultural ecosystem services in landsc	2015	Current Opinion in Environmental Sustainability	14	
Gailing L., Leibenath M	361772527	The Social Construction of Landscapes: Two The	2015	Landscape Research	40	2
Sysuev V.V.	660215417	To the «optimization» of lands capes	2015	Vestnik Moskovskogo Universiteta, Seriya 5: Geograf	2015-Janua	4
[No author name avai	[No author	2013 International Conference on Information E	2014	WIT Transactions on Information and Communicatio	49	
[No author name avai	[No author	2014 International conference on Mechatronics	2014	Advanced Materials Research	971-973	
[No author name avai	[No author	2nd International Conference on Environmental	2014	WIT Transactions on Ecology and the Environment	181	

Liu G., Nelson J.D., W	557064932	A target-oriented approach to forest ecosystem	2000	Ecological Modelling	127	3-Feb		269	281		30	10.1016/S0	https://ww	Hugh Hamilton Limited, 850 West 15th Street, North Vancouver, BC V7P 1I	Liu, G., Hug	This paper introduces several concepts which underlie the development of a spatially and temporally explicit forest ecosystem design model.	Adaptive m	ecosystem modeling; fo		English	Article	Final	Scopus	2-s2.0-0034	0	1	0	0	0	0	0	0	0	2	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Fukahori K., Kubota Y.	660219806	Consistency evaluation of landscape design by a	2000	Computer-Aided Civil and Infrastructure Engineering	15	5		342	354		2	10.1111/08	https://ww	Dept. of Civ. and Environ Eng., Saitama University, Saitama 338-8570, Japa	Fukahori, K.	The planning of road structures must take into consideration both structural design and aesthetic design. Road planners and designers must keep in min		Architectur	Blackwell Pu	English	Article	Final	Scopus	2-s2.0-0034	0	1	1	0	0	1	0	0	0	0	TRUE	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
Ask P., Carlsson M.	572143894	Nature conservation and timber production in a	2000	Forest Policy and Economics	1	4-Mar		209	223		16	10.1016/s1	https://ww	S. Swedish Forest Research Centre, Swed. Univ. Agric. Sci., Box 49, S., Alna	Ask, P., S. S	Forestry has transformed the tree species composition and structure of Swedish forests. The fragmented ownership pattern in areas with no	Landscape perspective;		Elsevier	English	Article	Final	Scopus	2-s2.0-0011	0	0	3	0	2	0	0	0	0	0	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
Meinel G., Lippold R.,	650654505	Producing a state-wide high-resolution satellite	2000	International Archives of the Photogrammetry, Rem	33			843	851		1		https://ww	Institute of Ecological and Regional Development, Germany	Meinel, G.,	Means of producing state-wide mosaics using high-resolution satellite data (IRS-1C) are discussed with reference to Saxony in Germany. Spec	Compressio	Compactior	Internationa	English	Conference	Final	Scopus	2-s2.0-8504	0	0	1	0	0	0	0	0	0	2	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Borg Erik, Baruth Bett	710338937	Methoden und Verfahren der Fernerkundung fu	1998	Mitteilung - Deutsche Forschungsanstalt fuer Luft- u	98	3		325	332				https://ww	DLR Neustrelitz, Neustrelitz, Germany	Borg, Erik, D	Landscape planning aims to the imaginary anticipation of intended anthropogenic modifications of the landscape. Securing objective and optimized deci		Data reduct	DLR, Cologr	German	Article	Final	Scopus	2-s2.0-0032	0	0	2	0	0	0	0	0	0	2	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Toenjes Ralf	362386540	Control of scene reconstruction using explicit kn	1996	IEEE Workshop on Applications of Computer Vision - Proceedings				15	20		1		https://ww	Universitaet Hannover, Hannover, Germany	Toenjes, Ra	Applications such as landscape planing, environmental monitoring, and flight and driving simulators have a high demand for realistic landscape models.		Computatic	IEEE, Los Al	English	Conference	Final	Scopus	2-s2.0-0030	0	0	1	0	0	1	1	0	0	0	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
Anon	1;	Computer graphics smooth the way	1995	Mine and Quarry	24	8							https://www.scopus.com/inward/record.uri?eid=2-s2.0-0029378484&partnerID=40&r		Anon	Earlier this year Tarmac Quarry Products gained planning permission to start quarrying on a 50ha site at Tiln South, Nottinghamshire. The people of the		Animation;	Herald Hou	English	Article	Final	Scopus	2-s2.0-0029	1	0	0	1	0	0	0	0	0	0	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE
Yasuda K., Furuta H.,	740337762	Application of neural network to aesthetic desig	1993	Proceedings - 2nd International Symposium on Uncertainty Modeling and A			366718	534	541		2	10.1109/ISU	https://ww	NEWJEC, Inc., Japan; Kyoto University, Japan; Pacific Consultants, Co., Japa	Yasuda, K.,	The present study proposes to investigate whether the currently accepted criteria for assessing the bridge aesthetics and harmony with the environment		Expert syste	Institute of	English	Conference	Final	Scopus	2-s2.0-1994	0	4	0	0	0	2	2	0	0	0	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
Erickson T.	700524672	From interface to interplace: the spatial environ	1993	Lecture Notes in Computer Science (including subser	716 LNCS			391	405		33	10.1007/3-5	https://ww	Human Interface, Advanced Technology Group, Apple Computer, Inc, Cupe	Erickson, T.	Today's human-computer interfaces are cumbersome, sterile, and uninviting; they stand in stark contrast to the richness and depth of the everyday worl		Artificial int	Springer Ve	English	Conference	Final	Scopus	2-s2.0-8502	2	0	0	1	0	0	0	0	0	0	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE
Montalvo J., Sanz L.R.	700662439	Impact Minimization through Environmentally-b	1993	Journal of Environmental Management	38	1		13	25		12	10.1006/jer	https://ww	Departamento Interuniversitario de Ecologia, UCM-UAM, Universidad Com	Montalvo, J	This paper describes a procedure for minimizing the environmental cost of an activity in a city neighbourhood. It takes into account the corre	environmer	environmental impact a		English	Article	Final	Scopus	2-s2.0-0027	0	0	1	0	0	0	0	0	0	2	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Prentis E., Norton G.A	552849051	"MEADOWS" - an expert system for the establish	1992	Ecological Engineering	1	3		213	228		7	10.1016/09	https://ww	Centre for Environmental Technology, Department of Biology, Imperial Col	Prentis, E.,	MEADOWS is an expert system that provides advice on the establishment and management of diverse, wildflower grasslands on derelict land in urban ar		derelict land; expert sys		English	Article	Final	Scopus	2-s2.0-0027	0	1	0	0	0	4	0	0	0	0	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
Marusic J.	660292604	Forms of evaluation in landscape design [Oblike	1991	Urbani Izziv (Ljubljana)	18			37	45		2		https://www.scopus.com/inward/record.uri?eid=2-s2.0-0026306558&partnerID=40&r		Marusic, J.	Evaluation is the annotation of value to elements and characteristics of the landscape. It is in fact, a work of design, guided by a goal. It represents the se		environmental planning		Slovenian	Article	Final	Scopus	2-s2.0-0026	0	2	0	0	0	0	0	0	0	1	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Abdelmohsen, Faraha	740966903	GUIDELINES FOR ENERGY OPTIMIZATION THROU	1985					121	143				https://ww	King Abdul Aziz Univ, Jeddah, Saudi Arabia, King Abdul Aziz Univ, Jeddah, S	Abdelmohs	The first part of the paper gives criticisms of conventional practice in landscape architecture in overheated arid regions, in terms of efficient utilization of		BUILDINGS	Pergamon	English	Conference	Final	Scopus	2-s2.0-0022	4	1	0	0	0	0	0	0	0	1	TRUE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Vessart V.V.	650799585	On the geographical ensuring of town-building.	1980	Izvestiya, Vsesoyuznogo Geograficheskogo Obshches	112	2		111	117				https://www.scopus.com/inward/record.uri?eid=2-s2.0-0019149611&partnerID=40&r		Vessart, V.V	Examines the basic questions of the geographical ensuring of townbuilding in the confines of landscape planning. Directs attention to the low standard o		ecological research; lan		Russian	Article	Final	Scopus	2-s2.0-0019	0	0	3	0	0	0	0	0	0	1	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Guldmann J.-M.	700365699	Visual impact and the location of activities: A co	1979	Socio-Economic Planning Sciences	13	2		47	70		6	10.1016/00	https://ww	Department of City and Regional Planning, The Ohio State University, Colu	Guldmann,	The spatial processes of intervisibility and visual impact are analyzed and modeled quantitatively. Design optimization models are developed, dealing sim		convex combinations of		English	Article	Final	Scopus	2-s2.0-0018	0	0	2	0	0	0	0	0	0	3	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Frondorf A.F., McCart	245460854	Data-intensive spatial sampling and multiple hie	1978	Landscape Planning	5	1		1	25		4	10.1016/03	https://ww	School of Renewable Natural Resources, University of Arizona, Tucson, AZ,	Frondorf, A	Frondorf, A.F., McCarthy, M.M. and Rasmussen, W.O., 1978. Data-intensive spatial sampling and multiple hierarchical clustering: methodological approaches toward cost/time e				English	Article	Final	Scopus	2-s2.0-4934	0	0	1	0	2	0	0	0	0	0	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE

Country	Country Affiliation (All Tiers)	Country Affiliation (Tier 1)	Country Affiliation (Tier 2-3)	Proportion Tier 1 to All
China	276	58	218	21%
U.S.A	86	49	37	57%
Germany	32	20	12	63%
Australia	26	15	11	58%
Italy	21	10	11	48%
Canada	18	13	5	72%
Netherlands	16	11	5	69%
U.K.	15	12	3	80%
Portugal	12	4	8	33%
Spain	12	9	3	75%
Finland	10	10	0	100%
Japan	10	3	7	30%
Russia	8	0	8	0%
South Korea	8	2	6	25%
Taiwan	8	5	3	63%
Austria	7	3	4	43%
Brazil	7	2	5	29%
France	7	6	1	86%
Poland	7	3	4	43%
Hong Kong	6	4	2	67%
Iran	6	4	2	67%
Israel	6	3	3	50%
Sweden	6	6	0	100%
Switzerland	6	4	2	67%
Croatia	4	1	3	25%
Denmark	4	3	1	75%
Egypt	4	1	3	25%
Georgia	4	1	3	25%
Lithuania	4	2	2	50%
Malaysia	4	0	4	0%
Mongolia	4	0	4	0%
Romania	4	4	0	100%
Singapore	4	3	1	75%
Turkey	4	2	2	50%
Belgium	3	2	1	67%
Greece	3	2	1	67%
Hungary	3	0	3	0%
India	3	2	1	67%
Jordan	3	1	2	33%
New Zealand	3	2	1	67%
Norway	3	1	2	33%
Saudi Arabia	3	1	2	33%
Ukraine	3	1	2	33%
Vietnam	3	0	3	0%
Belarus	2	0	2	0%
Czech Republic	2	0	2	0%
Indonesia	2	1	1	50%
Ireland	2	1	1	50%
Latvia	2	1	1	50%
Slovakia	2	1	1	50%
Thailand	2	1	1	50%
Brunei	1	1	0	100%
Chile	1	1	0	100%
Cyprus	1	1	0	100%
Jersey	1	1	0	100%
Kenya	1	0	1	0%
Luxembourg	1	1	0	100%
Macau	1	0	1	0%
Malta	1	1	0	100%
Mexico	1	0	1	0%
Mozambique	1	1	0	100%
Nepal	1	1	0	100%
Pakistan	1	0	1	0%
Peru	1	0	1	0%
Slovenia	1	1	0	100%
South Africa	1	0	1	0%
Sri Lanka	1	1	0	100%

Dissemination Venue	Priority	Eng/CS	Impact Factor / Cite Score / Related
Agricultural and Forest Meteorology	1		5.734
Agriculture, Ecosystems and Environment	1		
Ambio	1		
American Journal of Agricultural Economics	1		
Applied Energy	1		
Applied Geography	1		
Biological Conservation	1		5.9
Building and Environment	1		
Canadian Journal of Forest Research	1		
Chinese Geographical Science	1		2.9
Complexity	1	X	3.3
Computer-Aided Design and Applications	1		
Computers and Electronics in Agriculture	1		
Computers, Environment and Urban Systems	1		
Current Opinion in Environmental Sustainability	1		7
Earth-Science Reviews	1		12
Ecological Economics	1		
Ecological Engineering	1		
Ecological Indicators	1		
Ecological Informatics	1		4.9
Ecological Modelling	1		
Ecology Letters	1		
Environment and Planning B: Urban Analytics and City Science	1		
Environment, Development and Sustainability	1		3.2
Environmental Impact Assessment Review	1		
Environmental Management	1		
Environmental Modeling and Assessment	1		2
Environmental Modelling and Software	1		
Environmental Monitoring and Assessment	1		2.5
Environmental Research Letters	1		
European Journal of Agronomy	1		5.1
Forest Ecology and Management	1		
Forest Policy and Economics	1		
Forest Science	1		
Forestry Chronicle	1		
Forests	1		
Geomatica	1		
Global Environmental Change	1		10.47

Habitat International	1		8
International Journal of Digital Earth	1		3.5
International Journal of Environmental Research and Public Health	1		3.39
Journal of Applied Ecology	1		6.53
Journal of Applied Sciences	1		2.67
Journal of Arid Environments	1		2.21
Journal of Coastal Research	1		
Journal of Digital Landscape Architecture	1		
Journal of Environmental Management	1		
Journal of Environmental Planning and Management	1		2.73
Journal of Geographical Systems	1		
Journal of Landscape Architecture	1		
Land	1		
Land Use Policy	1		
Landscape and Urban Planning	1		
Landscape Ecology	1		
Landscape Planning	1		
Landscape Research	1		
Nature Energy	1		60
PLoS ONE	1		
Remote Sensing	1		
Science of the Total Environment	1		
Scientific Reports	1		
Sustainability (Switzerland)	1		3.5
Sustainable Cities and Society	1		7.6
Urban Climate	1		5.71
Urban Forestry and Urban Greening	1		
Urban Geography	1		
Visualization in Engineering	1		9
Water (Switzerland)	1		3.16
Water Resources Management	1		3.537
Wetland Science	1		2.2
49th World Congress of the International Federation of Landscape Architects, IFLA 2012	2		
ACADIA 2012 - Synthetic Digital Ecologies: Proceedings of the 32nd Annual Conference of the Association for Computer Aided Design in Architecture	2		
Agriculture (Switzerland)	2		
Applied Sciences (Switzerland)	2	X	
Archnet-IJAR	2		0.9
Automation in Construction	2	X	8
Big Earth Data	2	X	4
Building Simulation	2		

Chinese Journal of Applied Ecology	2		0.91
Codify: Parametric and Computational Design in Landscape Architecture	2		
Computer-Aided Civil and Infrastructure Engineering	2	X	
Connection Science	2		1.9
Environmental Conservation	2		3
Environmental Science and Pollution Research	2		5.5
Eurasian Soil Science	2		1.3
Geoderma	2		6.1
GeoJournal Library	2		1.9
Health Environments Research and Design Journal	2		2.6
International Journal of Design and Nature and Ecodynamics	2		0.8
International Journal of Wildland Fire	2		3.2
ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences	2	X	
ISPRS Journal of Photogrammetry and Remote Sensing	2	X	
Journal of Asian Architecture and Building Engineering	2		0.94
Journal of Environmental Protection and Ecology	2		0.5
Multimedia Tools and Applications	2		2.75
ORYX	2		2.69
Precision Conservation: Goespatial Techniques for Agricultural and Natural Resources Conservation	2		
Progress in Water Resources	2		4.51
Representing Landscapes: Digital	2		
Smart and Sustainable Built Environment	2		2.054
The Routledge Companion to Landscape Studies	2		
18th World IMACS Congress and MODSIM 2009 - International Congress on Modelling and Simulation: Interfacing Modelling and Simulation with Mathematical and Computational Sciences, Proceedings	3	X	
2006 International Technology and Innovation Conference (ITIC 2006)	3	X	
2008 IEEE Congress on Evolutionary Computation, CEC 2008	3	X	
2009 17th International Conference on Geoinformatics	3		
2009 First Asian Conference on Intelligent Information and Database Systems	3	X	
2009 Second International Conference on Intelligent Computation Technology and Automation	3	X	
2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce, AIMSEC 2011 - Proceedings	3	X	
2011 2nd International Conference on Intelligent Control and Information Processing	3	X	
2011 International Conference on Electric Technology and Civil Engineering (ICETCE)	3	X	
2011 International Conference on Electric Technology and Civil Engineering, ICETCE 2011 - Proceedings	3	X	
2011 International Conference on Remote Sensing, Environment and Transportation Engineering, RSETE 2011 - Proceedings	3	X	
2013 IEEE Congress on Evolutionary Computation	3	X	
2014 11th International Conference on Fuzzy Systems and Knowledge Discovery (FSKD)	3	X	
2015 38th International Conference on Telecommunications and Signal Processing (TSP)	3	X	
2015 IEEE International Parallel and Distributed Processing Symposium	3	X	

2017 ASABE Annual International Meeting	3		
2017 International Conference on Smart Cities, Automation & Intelligent Computing Systems (ICON-SONICS)	3		
2017 Winter Simulation Conference (WSC)	3	X	
2019 Systems and Information Engineering Design Symposium, SIEDS 2019	3	X	
2020 43rd International Convention on Information, Communication and Electronic Technology (MIPRO)	3	X	
2020 IEEE 2nd Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS)	3	X	
2020 IEEE Conference on Big Data and Analytics, ICBDA 2020	3	X	
2020 Systems and Information Engineering Design Symposium, SIEDS 2020	3	X	
2021 2nd International Conference on Intelligent Design (ICID)	3		
2021 5th Asian Conference on Artificial Intelligence Technology (ACAIT)	3	X	
2021 Annual Modeling and Simulation Conference (ANNSIM)	3	X	
2021 IEEE 16th International Conference on the Experience of Designing and Application of CAD Systems (CADSM)	3		
2021 IEEE Conference on Telecommunications, Optics and Computer Science (TOCS)	3	X	
2021 IEEE International Conference on Artificial Intelligence and Computer Applications (ICAICA)	3	X	
2021 IEEE International Conference on Data Science and Computer Application (ICDSCA)	3	X	
2021 International Conference on Networking Systems of AI (INSAI)	3	X	
2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS)	3	X	
24th Mediterranean Conference on Control and Automation, MED 2016	3	X	
5th International Conference on Responsive Manufacturing - Green Manufacturing (ICRM 2010)	3	X	
Acta Ecologica Sinica	3		1.4
Acta Horticulturae	3		0.26
Acta Oecologica	3		1.674
Advanced Engineering Informatics	3	X	
Advanced Materials Research	3	X	
Advances in Intelligent Systems and Computing	3	X	
African Journal of Wildlife Research	3		
Agriculturae Conspectus Scientificus	3		0.5
AIChE Journal	3	X	3.6
AIP Conference Proceedings	3		
Applied Ecology and Environmental Research	3		0.23
Applied Mechanics and Materials	3	X	0.7
Arabian Journal of Geosciences	3		
Arid Ecosystems	3		
ASABE - 5th National Decennial Irrigation Conference 2010, Held in Conjunction with Irrigation Show 2010	3		
Beijing Linye Daxue Xuebao/Journal of Beijing Forestry University	3		
BELGEO	3		
Biodiversity Science	3		0.85
Biofuels, Bioproducts and Biorefining	3		
Boletin Tecnico/Technical Bulletin	3		
Cehui Xuebao/Acta Geodaetica et Cartographica Sinica	3		
Chang'an Daxue Xuebao (Ziran Kexue Ban)/Journal of Chang'an University (Natural Science Edition)	3		

Chinese Journal of Ecology	3		0.29
Chongqing Jianzhu Daxue Xuebao/Journal of Chongqing Jianzhu University	3		
Circuit Bending, Breaking and Mending - Proceedings of the 16th International Conference on Computer-Aided Architectural Design Research in Asia, CAADRIA 2011	3	X	
Cluster Computing	3	X	
Communications in Computer and Information Science	3	X	0.57
Computational Intelligence and Neuroscience	3	X	
Computer Aided Chemical Engineering	3	X	
Computers and Chemical Engineering	3	X	
Current Opinion in Chemical Engineering	3	X	
Dela	3		0.16
Digital Soil Assessments and Beyond - Proceedings of the Fifth Global Workshop on Digital Soil Mapping	3		
Dili Xuebao/Acta Geographica Sinica	3		
E3S Web of Conferences	3		
Ekologia Bratislava	3		
Ekoloji	3		
Environmental and Engineering Geoscience	3		
Environmental Challenges	3		0.9
Environmental Engineering and Management Journal	3		
Environmental Fluid Mechanics	3		
Environmental Technology and Innovation	3		0.86
European Journal of Operational Research	3		5.33
Forestry Studies	3		
Fractals	3		
Fresenius Environmental Bulletin	3		
Geografisk Tidsskrift - Danish Journal of Geography	3		
GraphiCon 2005 - International Conference on Computer Graphics and Vision, Proceedings	3		
Green Energy and Technology	3		0.49
Huanjing Kexue Xuebao/Acta Scientiae Circumstantiae	3		
ICEMT 2010 - 2010 International Conference on Education and Management Technology, Proceedings	3		
IEEE Access	3		
IEEE Geoscience and Remote Sensing Letters	3		
IEEE Transactions on Intelligent Transportation Systems	3		
IEEE Transactions on Knowledge and Data Engineering	3		
IEEE Transactions on Pattern Analysis and Machine Intelligence	3		
IEEE Workshop on Applications of Computer Vision - Proceedings	3		
IEEE/ASME Transactions on Mechatronics	3		
IJCCI 2013 - Proceedings of the 5th International Joint Conference on Computational Intelligence	3		
Informatica (Slovenia)	3		
Intelligent and Informed - Proceedings of the 24th International Conference on Computer-Aided Architectural Design Research in Asia, CAADRIA 2019	3		

International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives	3		
International Conference of Young Professionals, GeoTerrace 2021	3		
International Conference on Intelligent User Interfaces, Proceedings IUI	3		
International Conference on Management and Service Science, MASS 2011	3		
International Journal of Applied Environmental Sciences	3		
International Journal of Biodiversity Science, Ecosystem Services and Management	3		
International Journal of Environmental Technology and Management	3		0.75
International Journal of Global Energy Issues	3		
International Journal of Molecular Sciences	3	X	
International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM	3		
IOP Conference Series: Earth and Environmental Science	3		
IOP Conference Series: Materials Science and Engineering	3		
Izvestiya, Vsesoyuznogo Geograficheskogo Obshchestva	3		
Journal of Architecture and Urbanism	3		
Journal of Cleaner Production	3		
Journal of Electical and Computer Engineering	3		
Journal of Environmental Accounting and Management	3		
Journal of Environmental Studies	3		
Journal of Geo-Information Science	3		
Journal of Information and Telecommunication	3		
Journal of Physics: Conference Series	3		
Journal of Railway Engineering Society	3		
Journal of Software	3		2.9
Journal of Taiwan Agricultural Engineering	3		
Journal of the American Society for Information Science and Technology	3		
Journal of Urban Planning and Development	3	X	
Jurnal Teknologi	3		0.8
Key Engineering Materials	3	X	
Landscape Architecture and Art	3		0.3
Lecture Notes in Civil Engineering	3	X	
Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	3		
Lecture Notes in Electrical Engineering	3		
Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST	3		
Lecture Notes on Data Engineering and Communications Technologies	3		
MATEC Web of Conferences	3		
Materials Science Forum	3	X	
Microprocessors and Microsystems	3	X	
Mine and Quarry	3	X	

Mitteilung - Deutsche Forschungsanstalt fuer Luft- und Raumfahrt	3	X	
MODSIM05 - International Congress on Modelling and Simulation: Advances and Applications for Management and Decision Making, Proceedings	3		
MODSIM07 - Land, Water and Environmental Management: Integrated Systems for Sustainability, Proceedings	3		
Naturschutz und Landschaftsplanung	3		
Nederlandse Geografische Studies	3		
Neural Processing Letters	3	X	
Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering	3		
Nongye Jixie Xuebao/Transactions of the Chinese Society for Agricultural Machinery	3		
Osterreichische Wasser- und Abfallwirtschaft	3		
PLEA 2011 - Architecture and Sustainable Development, Conference Proceedings of the 27th International Conference on Passive and Low Energy Architecture	3		
Pollack Periodica	3		
Postmodern Culture	3		
Procedia Engineering	3		1.88
Proceedings - 11th International Space Syntax Symposium, SSS 2017	3		
Proceedings - 2009 International Conference on Future Computer and Communication, ICFCC 2009	3		
Proceedings - 2010 3rd International Conference on Biomedical Engineering and Informatics, BMEI 2010	3		
Proceedings - 2020 International Conference on Computers, Information Processing and Advanced Education, CIPAE 2020	3		
Proceedings - 2020 International Conference on Intelligent Design, ICID 2020	3		
Proceedings - 2021 2nd International Conference on Education, Knowledge and Information Management, ICEKIM 2021	3		
Proceedings - 2021 International Symposium on Artificial Intelligence and its Application on Media, ISAIAM 2021	3		
Proceedings - 2nd International Symposium on Uncertainty Modeling and Analysis, ISUMA 1993	3		
Proceedings - 3rd International Conference on Intelligent Transportation, Big Data and Smart City, ICITBS 2018	3		
Proceedings - 7th International Congress on Environmental Modelling and Software: Bold Visions for Environmental Modeling, iEMSs 2014	3		
Proceedings - CIS Workshops 2007, 2007 International Conference on Computational Intelligence and Security Workshops	3		
Proceedings 2011 IEEE International Conference on Spatial Data Mining and Geographical Knowledge Services	3		
Proceedings of 33rd PLEA International Conference: Design to Thrive, PLEA 2017	3		
Proceedings of SPIE - The International Society for Optical Engineering	3		
Proceedings of the 2nd International Conference on Electronics and Sustainable Communication Systems, ICESC 2021	3		
Proceedings of the 3rd International Conference on Intelligent Communication Technologies and Virtual Mobile Networks, ICICV 2021	3		
Proceedings of the iEMSs 3rd Biennial Meeting," Summit on Environmental Modelling and Software"	3		
Proceedings of the International Conference on Education and Research in Computer Aided Architectural Design in Europe	3		
Proceedings of the International Conference on Electronics and Sustainable Communication Systems, ICESC 2020	3		

Proceedings of the International Conference on Industrial Engineering and Operations Management	3		
Proceedings of the National Conference on Artificial Intelligence	3		
Proceedings. 1998 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (Cat. No.98CB36231)	3		
Proceedings: DMS 2011 - 17th International Conference on Distributed Multimedia Systems	3		
Progress in Civil, Architectural and Hydraulic Engineering - Selected Papers of the 4th International Conference on Civil, Architectural and Hydraulic Engineering, ICCAHE 2015	3	X	
Public Recreation and Landscape Protection - With Sense Hand in Hand... Conference Proceeding	3		
Public Recreation and Landscape Protection - With Sense Hand in Hand? Conference Proceedings	3		
RA Revista de Arquitectura	3		
Rangelands	3		1.09
Research in Urbanism Series	3		
Scientific Programming	3		1
Security and Communication Networks	3	X	
Sel. Topics in Energy, Environ., Sustainable Dev. and Landscaping - 6th WSEAS Int. Conf. on Energy, Environ., Ecosystems and Sustainable Dev., EEESD'10, 3rd WSEAS Int. Conf. on Landsc. Archit., LA'10	3		
Sensors and Materials	3	X	0.75
Shengtai Xuebao	3		
Shengtai Xuebao/ Acta Ecologica Sinica	3		
Shenyang Gongye Daxue Xuebao/Journal of Shenyang University of Technology	3		
Smart Innovation, Systems and Technologies	3		
SMC'03 Conference Proceedings. 2003 IEEE International Conference on Systems, Man and Cybernetics. Conference Theme - System Security and Assurance (Cat. No.03CH37483)	3		
Socio-Economic Planning Sciences	3		4.9
Soft Computing	3		
Soil Research	3		
Solid Earth	3		
Springer Geography	3		
Springer Proceedings in Mathematics and Statistics	3		
Studies in Computational Intelligence	3		
Studies in Regional Science	3		0.1
Third International Workshop on Software Engineering for Secure Systems (SESS'07: ICSE Workshops 2007)	3		
Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/Journal of Tianjin University Science and Technology	3		
Tongji Daxue Xuebao/Journal of Tongji University	3		
Traitement du Signal	3		
Urbani Izziv (Ljubljana)	3		
USDA Forest Service - General Technical Report PNW	3		
Vestnik Moskovskogo Universiteta, Seriya 5: Geografiya	3		
Vietnam Journal of Computer Science	3		
Visual Communication	3		
Wastewater Treatment, Plant Dynamics and Management in Constructed and Natural Wetlands	3		

Wireless Communications and Mobile Computing	3
WIT Transactions on Ecology and the Environment	3
WIT Transactions on Information and Communication Technologies	3
World Applied Sciences Journal	3
World Automation Congress Proceedings	3
World Conference on Timber Engineering 2021, WCTE 2021	3
Xi'an Jianzhu Keji Daxue Xuebao/Journal of Xi'an University of Architecture and Technology	3
	31
	70
	209

Phillip Fernberg

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EDUCATION

2024 **Ph.D. in Landscape Architecture & Environmental Planning**, Utah State University (USU)
Dissertation: Artificial Intelligence in Landscape Architecture: A Survey of Theory, Culture, and Practice

2024 **Graduate Certificate in Anticipatory Intelligence**, Utah State University (USU)
Capstone: Securing the Future of the Great Salt Lake Basin

2019 **Master of Landscape Architecture**, Louisiana State University (LSU)
Thesis: Doi Moi DIY: Tactical Ruralism and Tangible Modeling in the Mekong Delta

2016 **Bachelor of Arts in Latin American Studies,** Brigham Young University (BYU)
Minors: Scandinavian Studies, Urban and Regional Planning

POSITIONS

2023 – present	**Director of Digital Innovation**, OJB Landscape Architecture
2020 – present	**Instructor**, Utah State University, Landscape Architecture & Env. Planning LAEP 2400: 3D Representation course (36 students) LAEP 1300: Digital Drafting (70 students in 3 sections)
2020 – present	**Research Assistant & Assistant Lab Manager**, Utah State University Senior Ph.D. student in VIVID Lab, manage work of 14 students on 3 projects
2016 – 2019	**Teaching Assistant & Co-Instructor**, Louisiana State University Co-taught Foundations Studio (36 students), History and Theory course
2016 – 2018	**Graduate Research Assistant**, Louisiana State University Background & archival research, Forks of The Road Slave Site
2016	**Student Intern**, U.S. Library of Congress—Hispanic Division Digitization & archives for Handbook of Latin American Studies (HLAS)
2015	**Student Instructor**, BYU Department of Humanities Designed curriculum and taught Swedish 101 course (6 students)
2015	**Lead Student Intern**, Fairtrasa International/Ballard Center for Social Impact Non-Profit Market Research for global agriculture social enterprise
2013 – 2015	**Research Consultant & Teaching Assistant**, BYU Harold B. Lee Library Taught research database fundamentals to hundreds of students at all levels
2014	**Teaching Assistant**, BYU Department of Humanities Grading, writing help, and teaching for Humanities of Latin America course

GRANTS & FUNDING

Grants Awarded

1. **Fernberg, P.** (2022-2023) LAF Fellowship for Innovation and Leadership
   AI-LA: A Framework for Artificial Intelligence in Landscape Architecture ($5,000) Landscape Architecture Foundation.
2. Chamberlain, B., Johnson, J., Taylor, J., Null, S. (2023-2024). Formalizing Threats and Linkages of Land and Water Use within the Great Salt Lake Basin. USU Institute for Land, Water Air Impact Grant ($15,000). **Served as unlisted co-author (only Faculty were listed on the award)**.
3. Chamberlain, B., Null, S., Chikamoto, Y. and Johnson, J. (2022-2023) Planning: SCC-CIVIC-PG Track A: Securing the Future of the Great Salt Lake Basin Through Effective Water and Land Use Partnerships. ($50,000) National Science Foundation. **Served as unlisted co-author (only Faculty were listed on the award)**.

Assistantships

1. Assessing Spatial Memory Gist and Situational Awareness in Complex Environments (2020 – 2023). Funding received by PI Brent Chamberlain and provided through graduate research assistantship ($26,000/year). U.S. Army Research Institute of the Behavioral and Social Sciences.
2. Robert Reich Memorial Assistantship (2018– 2019). High distinction assistantship endowed in the name of the landscape architecture school's founder (Tuition + $11,000/year). Louisiana State University.

Funding Not Awarded

1. Chamberlain, B., Taylor, J., Null, S., Chikamoto, Y., and Johnson, J. (2023-2024) FP: SCC-CIVIC-PG Track A: Securing the Future of the Great Salt Lake Basin. ($1,000,000) National Science Foundation. **Served as co-author (listed as personnel on the proposal)**.
2. Finalist for Open Study/Research Award to Norway (2019) from a competitive pool of national applicants ($25,000 + tuition & expenses). Fulbright U.S. Student Program.

AWARDS, NOMINATIONS, & FELLOWSHIPS

1. Scientific Excellence (top paper) for Publication in *Journal of Digital Landscape Architecture* (2023).
2. PhD Student of the Year, *USU Faculty of Landscape Architecture and Environmental Planning* (2023).
3. Fellowship for Innovation and Leadership (2022 – 2023), *The Landscape Architecture Foundation*. One of six chosen nationwide.
4. Scientific Excellence (top paper) for Publication in *Journal of Digital Landscape Architecture* (2022).
5. Doctoral Student Researcher of the Year Nominee, *Utah State University* (2022).
6. Graduate Student Teacher of the Year Nominee, *Utah State University* (2022).
7. Doctoral Student Researcher of the Year Nominee, *Utah State University* (2021).
8. Excellence in Teaching Award, *Robert Reich School of Landscape Architecture* (2019).
9. Academic Achievement and Leadership Award, *Robert Reich School of Landscape Architecture* (2019).
10. Graduate History and Theory Award, *Robert Reich School of Landscape Architecture* (2019)
11. Fulbright Award Alternate, *Fulbright Norway* (2019). Not awarded.
12. Robert Reich Memorial Assistantship, *Robert Reich School of Landscape Architecture* (2018-2019).
13. Olmsted Scholar, *Landscape Architecture Foundation* (2018).
14. Helen Reich Memorial Scholarship, *Robert Reich School of Landscape Architecture*, (2018).
15. Director's Award, *Robert Reich School of Landscape Architecture* (2018).
16. Landscape Architecture Endowment Award, *Robert Reich School of Landscape Architecture* (2017).
17. Bjarnasson Travel Award, *BYU Department of Humanities* (2014)

PUBLICATIONS

Refereed Articles

1. **Fernberg, P.** and Chamberlain, B. (2023) Artificial Intelligence in Landscape Architecture: A Literature Review. *Landscape Journal: Special Issue.*
2. **Fernberg, P.**, George, B., and Chamberlain, B. (2023) Producing 2D Asset Libraries with AI-powered Image Generators. *Journal of Digital Landscape Architecture.*
3. Chamberlain, B., Johnson, S., Spencer, C., Evans, D., **Fernberg, P.**, Tighe, E., LaFavers, M., Creem-Regehr, S., and Stefanucci, J. (2023) Visualizing and Clustering Eye Tracking within 3D Virtual Environments. *Journal of Digital Landscape Architecture.*
4. **Fernberg, P.**, Tighe, E., Saxon, M., Spencer, C., Johnson, S., Stefanucci, J., Creem-Regehr, S., & Chamberlain, B. (2022). Measuring Perception of Urban Design Elements in Virtual Environments Using Eye Tracking: Benefits and Challenges. *Journal of Digital Landscape Architecture*, 463-470.
5. **Fernberg, P.**, Sturla, P., & Chamberlain, B. (2021). Pursuing an AI Ontology for Landscape Architecture. *Journal of Digital Landscape Architecture*, 452-460.

Non-Academic Publications

1. **Fernberg, P.** (2023) "Here Is How Pinterest Affects Your Taste*," Landscape Architecture Magazine*.
2. **Fernberg, P.** (2022) "Russian Nuclear Threat Exposes Scoping Issues for Ukraine Post-Disaster Recovery," *USU Center for Anticipatory Intelligence*. Policy Brief for academic coursework.
3. **Fernberg, P.** (2022) **"**Things You Should Know about Artificial Intelligence and Design," *The Dirt (ASLA)*. Book Review. Recirculated in ArchDaily with a reach of >8 million social media followers.
4. **Fernberg, P.** & Chamberlain, B (2021) **"**i, Designer?" *Landscape Architecture Magazine*, *111*(8), 120-130. Reached >60,000 readers.

Book Chapters

1. (In Copy-Edit) Chamberlain, B. and **Fernberg, P.** (2023) Urban Data Visualization. Book Chapter. *Routledge Handbook of Urban Design Practice.*

Manuscripts in Review or in Process

1. (Copy-edit) George, B., Chamberlain, B., **Fernberg, P.**, and Gardner, P. (2024) Assessing the Value of Artificial Intelligence in Plant Selection. *Journal of Digital Landscape Architecture.*
2. (Copy-edit) **Fernberg, P.** and Zhang, Z. (2024) Problematizing AI Omnipresence in Landscape Architecture. *Journal of Digital Landscape Architecture.*
3. (In Process) **Fernberg, P.** (TBD) A Cultural Topography of Landscape Architecture in the Age of AI. *Venue TBD.*
4. (In Process) **Fernberg, P. et al.** (TBD) Recoupling Greenfield Development and Water Use in the Great Salt Lake Basin. *Landscape and Urban Planning (intended venue).*
5. (In Process) Braiden, H., George, B., **Fernberg, P.**, Chamberlain, B. (TBD) A Benchmark Survey of AI in Landscape Architecture Practice, *CSLA/ASLA/IFLA.*

CONFERENCE PRESENTATIONS

2023

1. Putting AI to Work: Practical Applications of AI in Landscape Architecture. (Co-Presenter) 2023 ASLA Conference on Landscape Architecture, October 2023. *Minneapolis, MN.*
2. Wicked Problems, Wicked Partnerships: Can AI help landscape architects to fulfill our ambitions? (Keynote Presenter) Michigan Chapter Conference on Landscape Architecture, October 2023. *Bay City, MI.*
3. Tech x Scale: Lessons from the Great Salt Lake Basin. (Keynote Presenter) Louisiana Chapter Conference on Landscape Architecture, August 2023. *New Orleans, LA*
4. Future Problems, Now: Landscape Architecture in the Age of AI. (Keynote Presenter) The Landscape Architecture Foundation (LAF) Symposium for Innovation and Leadership. June 2023. *Washington, D.C.*
5. Producing 2D Asset Libraries with AI-powered Image Generators. (Co-Presenter) Digital Landscape Architecture Conference. May 2022*. Campus Dessau, Hochschule Anhalt, Germany.*
6. Visualizing and Clustering Eye Tracking within 3D Virtual Environments. (Co-presenter) Digital Landscape Architecture Conference. May 2022*. Campus Dessau, Hochschule Anhalt, Germany.*
7. Entourage Automaton: Making 2D Visual Assets with AI Image Generators. (Co-presenter) Council of Educators in Landscape Architecture (CELA) Annual Conference. March 2023. *San Antonio, TX.*

2022

8. Detecting Spatial Gist While Locomoting in an Immersive Virtual Environment: The role of speed of travel and urban design (Co-presented as Poster) Psychonomics, November 2022. *Boston, MA.*
9. Measuring Perception of Urban Design Elements in Virtual Environments Using Eye Tracking: Benefits and Challenges (Co-presenter) Digital Landscape Architecture 2022. *Harvard GSD, Boston, MA.*
10. def designer(): AI and the Future of Landscape Architecture. (Lead Presenter) Council of Educators in Landscape Architecture. March 2022. *Albuquerque, NM.*

2021

11. New Metrics and Analytical Tools for Measuring Spatial Memory. (Co-presenter) International Conference on Spatial Cognition. September 2021. *Rome, Italy (Remote).*
12. Individual Differences in Spatial Memory for a Large-Scale Virtual Environment. (Co-presenter) In Symposium: Navigation and environment representation: personality and individual differences. International Conference on Spatial Cognition. September 2021. *Rome, Italy (Remote).*
13. 'Imageable' Numbers: Theory-Based Urban Design for Immersive Psychometrics Research. (Poster Presentation) Spatial Cognition 2020/1. August 2021. *Riga, Latvia (Presented Remotely)*.
14. Pursuing an AI Ontology for Landscape Architecture. (Co-presenter) Digital Landscape Architecture Conference. June 2021. R*emote Presentation.*
15. The effect of landmarks on learning the gist of spaces. (Co-presented as poster) 61st Annual Meeting of the Psychonomics Society*. Remote Presentation.*
16. Spatial Memory Gist: Assessing Imageability in Immersive Virtual Environments. (Lead Presenter) Council of Educators in Landscape Architecture. March, 2021. *Virtual Conference.*

OTHER INVITED PRESENTATIONS

1. Guest Panelist for Symposium on the Future of Cincinatti. University of Cincinatti Department of Urban Planning, January 2024. *Cincinatti, OH*
2. A Survey of AI Research in Landscape Architecture. Guest Lecture to University of Sheffield, UK. December, 2023. *Remote Presentation.*
3. Emerging Technology and the Built Environment: Threats and Opportunities. (Keynote Presenter). Philo Ventures Ideafest. March 2023. *Heber City, UT.*
4. State of the Archives: Presentation from LARS Committee to ASLA Chapter President's Council. November, 2019. *San Diego, CA*.

OTHER WORK EXPERIENCE

2021 – present	**Principal and Designer,** Philomath Landscape Lab	*Logan, UT*
2019 – 2020	**Designer**, RHAA Landscape Architects + Planners	*Mill Valley, CA*
2018	**Landscape Intern**, Design Workshop	*Aspen, CO*
2018	**Landscape Intern**, Kimley-Horn Associates	*Baltimore, MD*
2017	**Planning Intern**, Michael Baker International	*Salt Lake City, UT*
2015	**Team Lead/Student Volunteer**, BYU Planning	*Provo, UT*
2011 - 2013	**Assistant Cruise Director**, Princess Cruises	*Worldwide*
2008 – 2010	**Full-time Missionary**, Church of Jesus Christ of LDS	*Pocatello, ID*
2008	**Character Performer**, Walt Disney World	*Orlando, FL*

SERVICE & LEADERSHIP

Leadership

2022 – present	**Chair of the Board of Directors**, *Latter-Day Saint Earth Stewardship*
2019 – 2020	**LARS Committee Chair**, *ASLA*
2017 – 2018	**Community Outreach Coordinator**, *Student ASLA LSU*

Service

2023	**MLA Committee Member for Marika Li**, University of Guelph
2018 – 2022	**Library and Research Services (LARS) Committee**, *ASLA*
2016	**Volunteer**, Mormon *Helping Hands*, Baton Rouge Flood Recovery
2013	**Volunteer**, Corazon *Tijuana*, Family Christmas Party
2001 – present	**Various lay leadership roles**, *Church of Jesus Christ of Latter-Day Saints*

TECHNICAL SKILLS*

2D Representation: Photoshop (a), Illustrator (a), InDesign (a), After Effects (i), Hand drawing (i)
Photography, Video, & Editing: UAS (i), Film, Lightroom (b), Premiere Pro (b), iMovie (i)
CAD & 3D Modeling: AutoCAD (a), Rhino + Grasshopper (a), SketchUp (i), Lumion (i), Blender (i)
Information Systems: ESRI Suite (a), Grass GIS (a), QGIS (i)
Programming Languages: Python (i), R (b), Unity (i)
*a = advanced, i = intermediate, b = beginner

LANGUAGE PROFICIENCY

English (Native)
Spanish (a)
Swedish (a)
Portuguese (i)