RESPONSIVE LANDSCAPES

STRATEGIES FOR RESPONSIVE TECHNOLOGIES IN LANDSCAPE ARCHITECTURE

BRADLEY CANTRELL AND JUSTINE HOLZMAN

ROUTLEDGE

Responsive Landscapes

The sensing, processing, and visualizing that are currently in development within the environment boldly change the ways design and maintenance of landscapes are perceived and conceptualized. This is the first book to rationalize interactive architecture and responsive technologies through the lens of contemporary landscape architectural theory.

Responsive Landscapes frames a comprehensive view of design projects using responsive technologies and their relationship to landscape and environmental space. Divided into six insightful sections, the book frames the projects through the terms: elucidate, compress, displace, connect, ambient, and modify to present and construct a pragmatic framework in which to approach the integration of responsive technologies into landscape architecture.

Complete with international case studies, the book explores the various approaches taken to utilize responsive technologies in current professional practice. This will serve as a reference for professionals and academics looking to push the boundaries of landscape projects and seek inspiration for their design proposals.

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I would like to give personal thanks to my family, Susan, David, and Hannah. Thank you.—Brad

I would like to thank my parents Allan and Susan, whose lives are a creative endeavor, and my sister Shayne, who is a constant inspiration.—Justine

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Towards a robotic ecology

Jason Kelly Johnson and Nataly Gattegno
Future Cities Lab

Sensing, processing, visualizing, and feedback: These are the key processes that this volume hypothesizes are a new conceptual methodology for landscape and ecology in the coming era. Each process, referencing predominantly technical disciplines, suggests that the domain of emerging landscape practices will increasingly cross-over into fields such as computer science and robotics. In some ways this new methodology simply builds upon well-established disciplinary topics such as time, phasing, and entropy; however, in other ways this volume suggests something more radical: it forecasts an emerging world of *robotic ecologies*, where matter at all scales is programmable, parametric, networked, and laden with artificial intelligence.

Responsive Landscapes engages a latent territory that, to date, has remained largely underexplored within the discipline of Landscape Architecture. Authors Cantrell and Holzman predict an emerging paradigm shift—where biology, intelligent machines, and systems will begin to productively co-exist and co-evolve. By coupling this synthetic shift with the ubiquity of networked technologies and open-source resources, tomorrow's designers will be able to explore, design, and construct landscape prototypes that have in the past remained unapproachable. By experimenting across scales, for instance linking sensor-laden physical models to much larger and complex ecological simulations, the potential impact of these methodologies on landscape and infrastructure scale explorations is highly promising.

The authors argue for a conceptual shift from a more object-oriented understanding of technology as a mediator between systems to a more integrated and synthetic understanding of technology as the medium through which we can encode and amplify landscapes with intelligence and heuristic capacities. In other words, when landscapes get hybridized with responsive technologies, they will have the capacity to better process and respond to the variable and multi-scalar inputs from their environments. As the collected projects in this volume suggest, these sensing inputs and cybernetic capacities are now possible mediums to be experimentally mined for their spatial, material, and ecological potentials.

What would typically be described as 'form' is, in this methodology, defined as 'output': physical and digital manifestations perform in parallel and exchange real-time information across scales, contexts, and project types. The cross-disciplinary projects included in this volume provide a tantalizing sense of the texture and palette these outputs can produce. Far from passive visualizations of complex information, these tangible data-informed landscapes create visceral, immersive, and participatory human experiences. In the past, to allow for the sheer processing of large datasets, inputs were limited to two or three select parameters. With our increased capabilities to process large amounts of information, the authors believe that parallel models and simulations—what they call "hybridized" models operating simultaneously—could prove to be more effective models at the scale of landscape. Rather than argue for one large data processing model that encompasses climate change, hydrology, geology, flora, fauna, etc., the authors call for parallel virtual models that run concurrently to create a hybrid feedback loop for the evaluation of multiple possible design trajectories in real-time.

The virtualization and networking of the physical world also opens up the opportunity for communication and feedback with systems such as social networks and the "internet of things." At the scale of landscape, one could argue that "feedback" has typically been explored as a linear relationship between a landscape and its built environment: data about biological processes accumulated over long periods of time and in a more or less static context. What are the implications when these feedback loops are real-time, when contextual data is dynamic, and our algorithms allow us to evolve life-like characteristics and robotic ecologies? Several projects in this volume explore the opportunities for encoding behaviors such as unpredictability and randomness into landscape methods. By reconceptualizing the duration of landscape, this volume also posits that the concept of time must also be rethought. How do systems that we usually consider operating at the scale of days, months, years, seasons, or centuries respond to instantaneous dynamic inputs of information?

While the opportunities for this methodology are tremendous, they are clearly still being formed. Through essays and projects that cross scales and disciplines, the authors map out latent territories for landscape architecture to explore and give form in the coming years. Using terms such as "elucidate," "compress," "displace," "connect," "ambient," and "modify," they suggest a developing lexicon and conceptual framework ripe with possibilities. This raises questions such as: How will this framework transform the way we understand and design the robotic ecologies of the future? How will we construct and encode them? How will we interact with them? How will we navigate through them? And, perhaps the most challenging question, what pedagogical approaches will the discipline need to adopt to explore and engage these responsive landscapes to their fullest extent? Cantrell and Holzman, in the essays and projects collected here, suggest a methodology for the next generation of landscape designers. They call on students, designers, and educators to take ownership of these emerging methodologies and, most importantly, to engage them as design opportunities with mounting social, political, and ecological implications.

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Figure 01.01 Ecolibrium, *Kim Nguyen, Devin Boutte, Martin Moser, Joshua Brooks, Responsive Systems Studio, 2011*

INTRODUCTION

01

THE PARADIGM SHIFT

The last two decades have seen a range of experiments using responsive technologies focused on the interaction between environmental phenomena and architectural space. These experiments go beyond site or architectural controls that rely on efficiency and automation instead they are attempts to expand the application of responsive technologies. Novel and explorative work within this realm has emerged as installations or unique architectural features, often requiring collaborations across disciplinary boundaries and the hacking of accessible technologies. This text highlights a collection of projects experimenting with the application of responsive technologies and pulls forth methods specifically related to the indeterminacy and dynamics in contemporary landscape architecture. The application of responsive technologies in architecture has become technically advanced, but is ". . . in fact responding to the question posed in the 1960s by Cedric Price: What if a building or space could be constantly generated and regenerated?"[1] For landscape architects the act of response and regeneration is the basis of our profession and inherent to landscape as a medium. Therefore it is necessary to understand a framework for responsive technologies that speaks to the scale of the territory and acknowledges the interconnections of the many.

The advancement and availability of responsive technologies have increased accessibility to designers, prompting the development of new design methodologies that move beyond conventional methods of representation and implementation. The introduction of accessible software sets the stage for design culture to appropriate and advance software and hardware tools.[2] New methods focus on the expression or design of processes, logics, and protocols requiring design interventions to evolve throughout a project's lifespan. Evidenced by Usman Haque and Adam Somlai-Fischer's open-source research report, "Low Tech Sensors and Actuators for Artists and Architects,"[3] detailing the hacking and re-purposing of low-cost and widely available technologies embedded in toys and standard devices as a method for artists, architects, and designers to quickly and effectively prototype responsive and interactive urban installations that would otherwise require client support. In a similar manner ". . . during the 1980s GUI-based software quickly put the computer in the center of culture,"[4] the advent of visual programming is putting coding and scripting directly in the hands of designers. The coupling of Arduino IDE boards and kit-of-parts beginner robotic kits with software plugins to easily program unique methods of response have further hastened the pace of artists and designers prototyping innovative interactive solutions to urban scale problems.

Landscape architecture has seen a paradigm shift in the last two decades, requiring designers to respond to the dynamic and temporal qualities of landscape. This response examines the long-held view that landscape embraces an ephemeral medium constructed and maintained through generations. Landscape—a dynamic and temporal medium—is expressed through careful manipulation of vegetated, hydrological, and stratigraphic systems. Combining this shift with the increased accessibility of responsive technologies presents a new approach for challenging static design solutions. The ability to sense and respond to environmental phenomena invites new ways to understand, interpret, experience, and interact with the landscape.

This shift can be traced to several parallel events inherent to the discipline of Landscape Architecture and seeded by new paradigms in scientific thought particularly within ecology. A generational trend has emerged within landscape architecture that promotes a form of "distanced authorship,"[5] emphasizing natural processes such as succession, accretion, or passive remediation as agents for landscape design. In the essay, "Strategies of Indeterminacy in Recent Landscape Practice," Charles Waldheim uses the term "distanced authorship" to describe how the "privileging of landscape strategy and ecological process distances authorial control over urban form, while allowing for specificity and responsiveness to market conditions as well as the moral high-ground and rhetorical clarity of environmental determinism."[6] Autonomy within these systems has the potential to create scaffolds for designed landscapes, urbanism, or territorialization. This approach privileges the actions of biology and geology over manufactured static conditions and instead seeds these dynamic processes through an overarching ecological regime to shape designed conditions over time.

In the introduction to *Case: Downsview Park Toronto*, Julia Czerniak synthesizes this shift, traced from the international design competition for Parc de la Villette (1982/1983), towards "process" and "ecological frameworks," . . . reshaping landscape perceptions to value "processes of becoming," "frameworks over form," and performance.[7]

Bernard Tschumi's team proposal frames processes around a few key species and relies on processes of succession to build complexity over time, creating a known starting point and a maintenance regime that embraces flux. James Corner and Stan Allen's team proposal, titled "Emergent Ecologies," engages the concept of *emergence* as the combination of intentional and unintentional futures shaped by ecology and human intervention as an "engineered matrix" performing as a "living groundwork for new forms and combinations of life to emerge."[8] Corner and Allen boldly state, "we do not determine or predict outcomes; we simply guide or steer flows of matter and information."[9]

Continuing along this trajectory, in 2002 Field Operation's proposal for Fresh Kills in Staten Island highlighted phasing and indeterminacy as central agents in design. Fresh Kills is a brownfield landscape of significant scale requiring novel methods for performative uses of vegetation with minimal maintenance regimes. This approach bridges earlier projects redefining the discipline of Landscape Architecture that focused on post-industrial remediation, to expand the scope, scale, and potential for remediation and evolving landscapes. Field Operations uses a similar method of seeding vegetation within bands tied to the elevations of the landforms (landfills).

What emerges from the late 1990s in landscape architecture is over two decades of exploration that has focused on complexity, indeterminacy, and dynamic systems. This body of research is marked by texts such as *The Landscape Urbanism Reader*[10] edited by Charles Waldheim (2006); *Ecological Urbanism*[11] edited by Mohsen Mostafavi and Gareth Doherty (2010), key categories of which are "sense," "curate," "interact," and "measure"; and most recently *Projective Ecologies*[12] edited by Nina-Marie Lister and Chris Reed (2013), which draws together a reader of seminal essays contributing to this discourse around concepts of "dynamics," "succession," "emergence," and "adaptability." This direction for the discipline continues to evolve the concept of "distanced authorship"[13] through a series of practices that have fought to realize built works. Landscape Architecture is a discipline of making. Practitioners and academics have sought to employ a multitude of techniques to understand how landscapes evolve and interrelate. On one hand, the profession has engaged and developed workflow methodologies with state-of-the-art tools in computation to simulate, analyze, and spatialize huge datasets to understand complex ecological relationships. On the other, landscape architects have pushed this agenda through the traditional tools of drawing, modeling, and diagramming to describe these complex systems, essentially outlining the projective tools they need. At this moment, there are trajectories for new computational methods beginning to find traction tied to a lineage of representational methods interrogating time through drawing and photographic methods such as the static series, image sequence, and photographic recording methods. This mode of seeing and transforming through an increased faculty with computational tools brings forth a new project for landscape that is firmly seated in an evolving ecological framework—a framework which, through distanced authorship, intends to address landscape of larger scales with more complex ecological problems tied to settlement and industry.

An ecological framework for landscape architecture is one that is based on strategy, an approach to landscape inextricably tied to habitat, species, and culture. Kate Orff describes that her "intuitive leap towards landscape begins with imagining the life it carries: mammals, molluscs, protoplasm" when describing her re-reading of Rachel Carson's 1937 book, *Undersea*, for *Harvard Design Magazine*.[14] This attachment to ecology through the species and individuals is a relationship that landscape architects and other environmentally based disciplines state as inspiration. It is also a powerful mechanism that pulls the public into ecologically based projects. This sentiment, coupled with advances in ecological sciences and a mandate for landscape architectural practice to adopt a strategic mandate, is the framework landscape architects rely upon.[15] This evolving framework is perfectly suited as a basis for utilizing responsive technologies and computation in ecological systems.

The ability to implement new computational methodologies hinge around emerging technologies for sensing and responding to real-time conditions. Responsive technologies counter disturbances through self-regulating systems, apparent when, "the linear system disturbs the relation the self-regulating system was set up to maintain with its environment."[16] Responsive technologies play a pivotal role in our evolving relationship between constructed and evolved systems. Current models of machine/human interaction are quickly evolving to encompass more complex methods of simulated intelligence and nuanced response. Several technologies that change the landscape of responsive technologies are converging, including autonomous robotics, distributed intelligence, biotic/abiotic interfaces, and ubiquitous sensing networks. As early as the 1980s, Xerox PARC coined the term "ubiquitous computing," which imagined the evolution of the human computer interface to "[take] into account the natural and human environment and [allow] the computer to vanish into the background."[17] With this focus away from HCI as personal device and integration into the environment, these technologies

Figure 01.02 Synthetic territories diagram, Bradley Cantrell, 2011

fundamentally alter our perception of constructed systems and their nuanced relationships with ecological processes.

These technologies have been recognized within architecture for their potential to create flexible and adaptable (though not adaptive in the ways ecological systems have the capacity to evolve) spatial or social conditions. "While, arguably, architecture has always been responsive, encouraging interaction between a space and the people that use it, new technological developments are putting pressure on architecture to become more adaptable and intelligent."[18] The extent to which responsive technologies address the goals of contemporary landscape architectural theory remains an emerging field. *Responsive Landscapes* conceptualizes the connection between environmental phenomena and responsive technologies as a continuum in which landscape places a vital role. The sensing, processing, and visualizing we are currently developing within the environment boldly changes the ways we perceive and conceptualize the design and maintenance of landscape or environment. Both *Interactive Architecture*[19] by Michael Fox and Miles Kemp (2009), and *Responsive Environments*[20] by Lucy Bullivant (2006) have set precedents for the integration of responsive technologies in the field of architecture. *Interactive Architecture* highlights malleable systems and transformable morphologies, whereas *Responsive Environments* begins to point towards more nuanced relationships between architectural objects as mediators of space and interaction. *Responsive Landscapes* is the first work that attempts to rationalize interactive architecture and responsive technologies through the lens of contemporary landscape architectural theory. These new relationships suggest a series of networked and object-oriented relationships between designed devices, ecological entities, and regional influences. This shift calls for an expanded view that asks for ecological system abstraction, filtering, and embedded intelligence that drives feedback loops of sensing, processing, and visualizing. This process of feedback, sensing the environment, processing the sensed data, and visualizing the response is the core design focus in the development of responsive technologies.

NATURE?

A fundamental aspect to further understanding the role of responsive technologies as drivers of landscape scale manipulations is the often dualistic view of human/nature interactions that has shaped the discipline of Landscape Architecture. Our relationship with the natural environment can never be described simply. This dualism of clearly delineating objects and processes within the world as a product of nature or as a product of humanity has created a perceived separation of interaction. Over several decades, new understandings of ecology tied to ecological disturbance make it overtly apparent that we live in an environment constantly evolving in parallel to our interactions with it. While not under our control—these environments are synthetic expressions of both direct and indirect anthropogenic interaction with environmental processes. As the discipline attempts to shift formative conceptions of human/nature interactions and operate within an anthropogenic biosphere, designers are drawing from new definitions and re-conceptions of ecology, ecological thought, and geologic scale change from multiple disciplines including philosophy and the sciences.

Linda Weintraub's definition of "deep ecology":

> . . . [a] philosophy that envisions the universe as unified and interconnected and recognizes the inherent worth of all forms of life without regard for human utility and pleasure. As such, deep ecologists pursue metaphysical unification of humans and their surrounds, as opposed to relying on reason, to guide environmental reform.[21]

Understanding the environment human beings operate in, as a composite product of our interactions and a series of systems, allows for designers to operate as active agents within an assemblage of biotic and abiotic agents. As designers we can understand our role differently—if we are no longer in opposition to the operation of ecological systems we can assume the roles of curators and manipulators of processes.[22] Within this new mode of operation, designers are using and developing new tools to understand historic processes and future outcomes while working within a localized environment.

The environment we operate within can be seen as an anthropogenic product, where human beings are one of many contributors within an ecological system. While our scope is wider and our effects more prolific, our modes of construction and habitation are an integral (although at times disruptive) portion of the ecological systems in which we are situated.[23] Evidence of a new geologic period is easily found in the altered stratigraphy of cities, rapid population growth in response to synthetic nitrogen production, the homogenization of biodiversity across the globe by the domestication of plants and animals, mass species extinctions, and dramatic increases in atmospheric carbon. Ellis and Ramankutty identify 18 anthropogenic biomes through empirical analysis of global population, land use, and land cover, that reside outside of existing descriptions and representations of biome[24] systems as "ignor[ing] humans altogether or simplify[ing] human influence into, at most, four categories."[25] Their research offers a way to assess current conditions of the terrestrial biosphere by providing accurate models depicting the true immersion of human and ecological systems. Anthropogenic biomes elucidate a relationship defined by human systems with natural systems embedded within them.

The emerging philosophical fields of new materialism and object-oriented-ontology, are useful for situating the designer's role as curator or manipulator of processes—considering both biotic and abiotic factors as equally engaged in shaping environments. Jane Bennett, a new materialist and author of *Vibrant Matter: A Political Ontology of Things*, elaborates on a further hindrance to building an effective view of contemporary ecological systems predicated on the false assumption that non-human matter is inanimate—though arguably non-human agency is required for human intent and intervention to manifest—and considers the capacity of things as equal actants.[26] Bennett uses materiality as "a rubric . . . to horizontalize the relations between humans, biota and abiota," indicative of the potential for responsive procedures within the landscape to actively shape material driven landscape processes.[27] Speaking to the political capacity of agentic assemblages, she uses the example of worms, free to make unpredictable decisions in the face of different material situations given different types of soils and ground covers, that ultimately contribute to a larger ecosystem responding in real-time without an overall goal or pre-determined outcome. In this example, materials play a vital role in the function, performance, and shifting configurations of ecosystems—such that, "the figure of an intrinsically inanimate matter may be one of the impediments to the emergence of more ecological and more materially sustainable modes of production and consumption."[28]

Both new materialism and object-oriented ontology (though unique fields of philosophical thought) provide ways into process based approaches to landscape manipulations beyond human intentionality. The approaches aim to attach the manipulation of landscape over time to the importance of site specificity—design should be based on unique phenomena of location and site history. The current state of a landscape is not the final state; rather it is a moment within a larger history and context as site processes are ongoing. Thus, an ecological state is not defined by a pre- or post-condition, but is continuously acting and evolving. Site-specific sensed data can provide curated histories over time to extract knowledge of material-based processes in order to inform future histories. This approach allows for movement between scales of time and space, to identify processes associated with ecological imperatives.