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.

The effect of human inhabitation on the planet can be seen through different settlement and infrastructure cases. A common case is the infrastructural systems of the Mississippi River watershed, composed of over 80 rivers and tributaries. The watershed interfaces a myriad of urban, agricultural, logistic, and cultural sites from Lake Itasca in the north, the Allegheny River in the east and the Milk and Missouri rivers in the west. This sprawling watershed covers over 40 percent of the continental United States, approximately 1.2 million square miles with the Mississippi River itself running for nearly 2,550 miles.[29] It is within this massive region that human beings have slowly manipulated and altered the course, speed, and scope of the river system in an attempt to provide consistent outcomes for navigation and the protection of urban centers. These manipulations have taken the form of large-scale infrastructure such as the Old River Control Structure, the Bonnet Carré Spillway, and the extensive levee systems that channel the river and prevent the flooding of the landscapes outside of the river's main channel. There are also small-scale manipulations such as channel dredging, vegetation removal, and bank stabilization that are reoccurring and help to promote stability within this landscape.

The management of this river system provides a remarkable land-scape for human settlement or commerce and focuses primarily on the current condition with little regard for future scenarios.[30] The Mississippi River watershed used to function as a meandering water system, engaging a myriad of systems from the micro to the macro scales. The argument could even be made that this river system affects climate at a global scale and genetics at the molecular level, thus touching every level of earthbound relationships. This relationship is not only dynamic, but it is also symbiotic: as the river channel breaks, territory is flooded, mixing upstream sediments with latent backwaters. This ever-evolving relationship between local systems and continental shifts is the key to the health of our ecological systems. The Earth does not survive through sequestered zones where we quarantine systems and processes to produce singular desires.

A clearer example, as an engineered system in contrast with naturalized systems, is the Los Angeles River. The current form of the channel no longer resembles our understanding of the definition of "river." Our perception that rivers are the product of an upstream water source that is attempting to find lower ground is skewed as we are confronted with a looming concrete channel with very little water. There are no meandering waterways punctuated with clusters of plant material, seasonally filling and washing through the basin. Instead the river has been engineered to control an annual torrent of water that rushes down from the mountains and fills the channel before hastily rushing out to the mouth of the river in Long Beach. It is often quoted as being dead, devoid of the life that defines the geographic typology of "river."

This engineered solution is a marvel, providing a stability to downtown Los Angeles that was missing from a river that used to be wildly unpredictable.[31] Similar to other engineering solutions during this time period, the solution works on a single goal: to move water at near constant velocities from north of the city to the south during times of high rain or snow melt. This adherence to a single goal has pushed aside the multiplicity of systems like the Los Angeles River, forgetting that these are habitats, methods of recharging aquifers, cleansers, retreats, and many other imagined and unimagined forms that engage our world. This is a story that plays out across the globe as human beings engage with the world around them.

The greatest fault in these engineered systems is the lack of engagement with complexity, particularly the processes feeding into and extending from them. While it is easy to criticize these systems, they must be understood as novel landscapes, providing a key translation of the relationship between synthetic constructions and endemic ecologies. These indirect products of landscape intervention can often be seen as one-offs or, as David Fletcher describes the Los Angeles River, a "freakology," a way of defining the "churning soup of exotic and native vegetative communities" despite the highly industrialized and contaminated urban condition of the channelized river.[32] This is often a central criticism but these are apt descriptions that frame the product of the systems as something different, unusual, or even unnatural. Rather than difference, or uniqueness, the criticism should lay in the kitsch, or lack of complexity and heightened biological stress that typically parallels these moments. These novel relationships are important, particularly in an approach that creates a new series of connections to contextual systems as we are creating systems that are new and unique for their context.

While humans may have little direct access to certain environments, we are still within their sphere of influence. Landscape architecture has always inserted itself within the relationship between humans and "nature," but the implications of acknowledging the Anthropocene as the current geologic epoch for landscape architecture and design of the built environment offers a much more accurate depiction of the scope and potential for intervention within anthropogenic biomes. Studies reveal that human-dominated ecosystems make up a higher percentage of the Earth's terrestrial area in comparison to still "wild" ecosystems. Historical ecologists, proponents of an interdisciplinary research program rooted in cultural anthropology, argue that humans

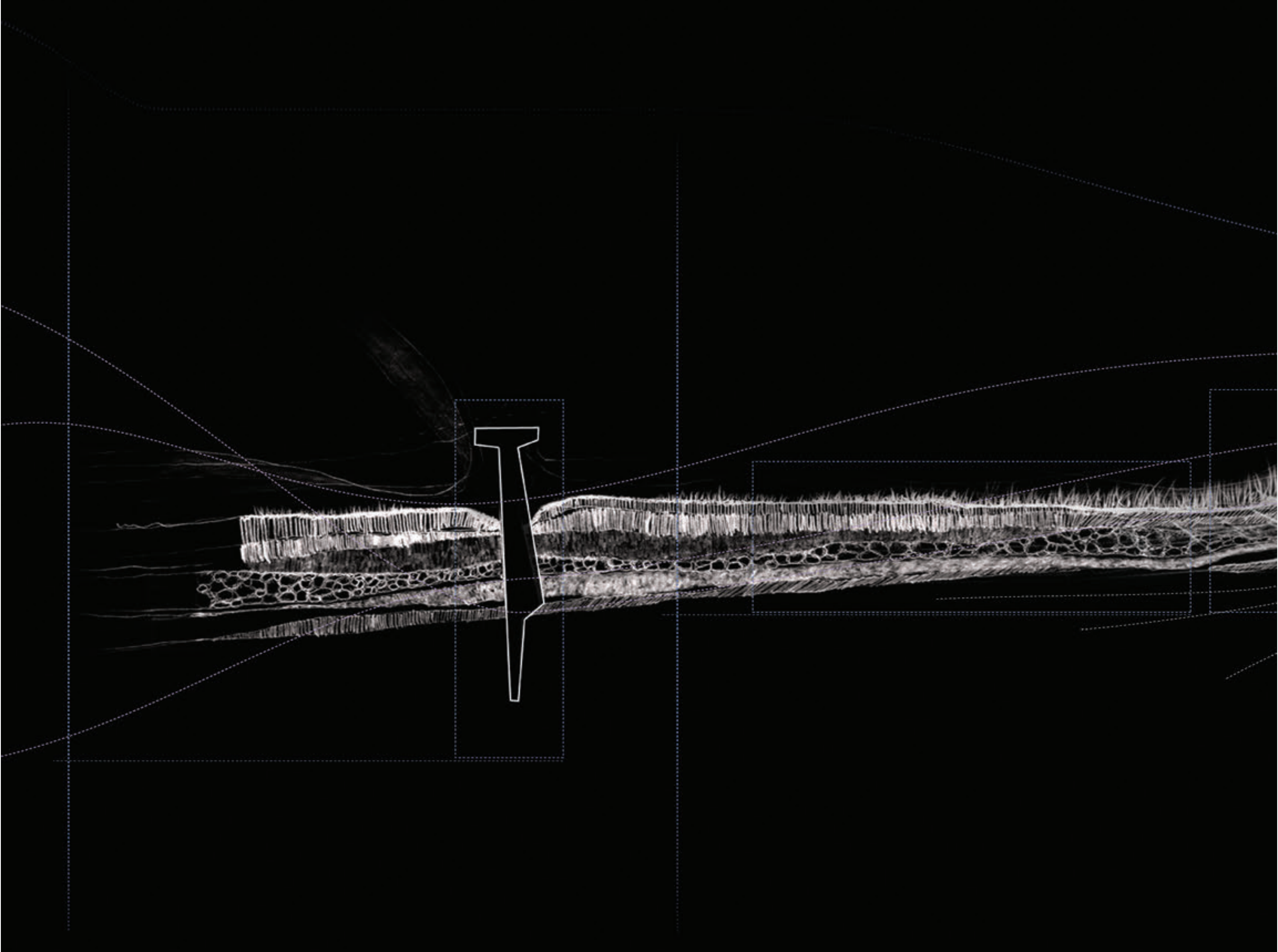
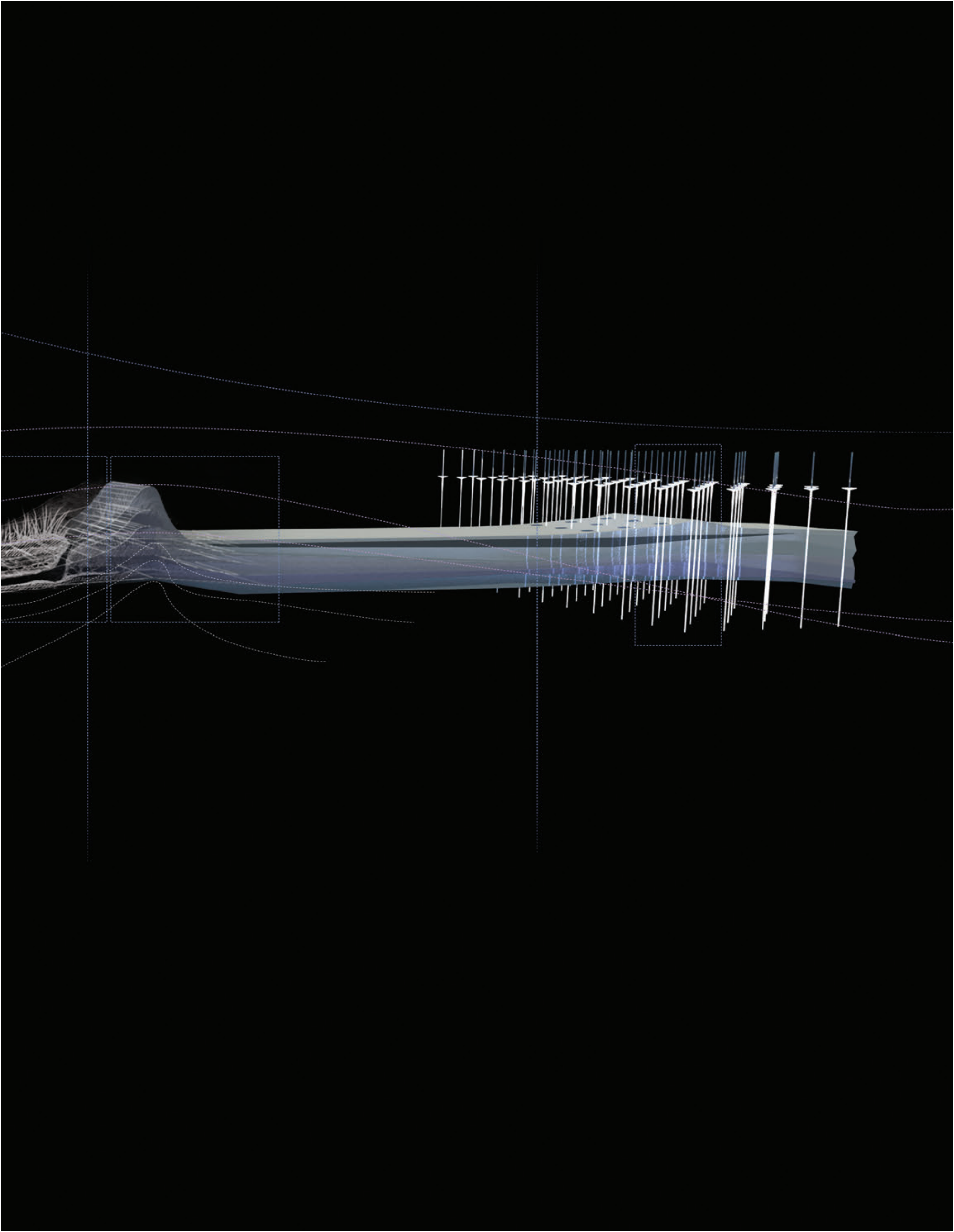


Figure 01.03 Cyborg Landscapes, *Bradley Cantrell, Kristi Cheramie, and Jeffrey Carney, 2010*



have shaped nearly every environment on Earth.[33] William Balée, historical ecology's primary advocate, notes even the supposed "pristine" forests of Amazonia encode a deep horticultural past in the presence of accessional species and in patches of Amazonian Dark Earth (ADE).[34]

Reconceptualizing our relationship with natural systems, our priorities must encompass human needs while balancing ecological fitness. To do this it requires a very difficult cognitive shift that does not separate human actions from non-human processes. We are required to confront complexity and diversity as driving principles in our relationships with natural systems and to develop equally complex computational relationships. It is through this lens, that we decenter humanity and clarify that we are not separate from "nature" but instead that we are "nature."[35] Speculating on the design methodologies and frameworks of responsive systems provides requires that we develop negotiations rather than controls. These negotiations require that humans are not placed in a mythical place of privilege but encapsulate the idea that concepts of ecological fitness and human comfort are equally considered.[36]

The device, machine, or object inherently influences the field in which it acts or resides. This form of instrumentality varies but can be framed as the ability of an object to influence the development of much larger and complex systems. Anthony Burke describes this networked condition as "Spatially indeterminate, temporally contingent, unstable, inclusive, and dynamic," in which network exhibits the "condition of paradoxical inclusion more aligned to quantum mechanics than the either/or of a discursive modernism."[37] This plays out in several different ways, as emergent behavior, interrupters, or through co-evolution. Instrumentality through emergence can be seen in a variety of biological systems, evolving from small changes in ecological systems that propagate into larger changes in systems. An example may be illustrated through the processes of commercial fishing and understanding the tools of this process as landscape instruments. These tools, fashioned to extract specific species of aquatic life, remove actors (fish, crabs, shellfish) from a large system and catalyze events that create changes along the food chain, within the water column, and may even affect climate. In a similar manner it is possible to describe interrupters as landscape instruments; this may be something similar to a dam, windbreak, or highway constructed to create a static condition within the landscape. This interruption in a larger system creates a series of effects that alter environments.

LOOKING FORWARD

This confluence of rapid technological development, an expanded view of humanity and the environment, and the influence of anthropogenic processes creates a tenuous state that requires an important shift in our conceptualization of responsive technologies. The landscapes that we can begin to imagine have the capacity to not only embed themselves within their context, but can also evolve with a life of their own, a synthesis between the biological, mechanical, and computational. There are several aspects that must be addressed in this regard, particularly in reference to our relationship to the design of systems that focus predominantly on control. Adam Greenfield asks:

> How might we use networked technologies to further the prerogatives so notably absent from the smart-city paradigm, particularly those having to do with solidarity, mutuality and collective action?[38]

This question, directed at how we design our cities, is our mandate for landscape systems at the city and territorial scales. In order to unpack this notion, it is critical that we understand the nature of our interactions: are they about embedding new forms of intelligence or do they simply imply a tightening of a feigned control over chaotic systems? This is a topic that is addressed not only in how we model and visualize these systems but also in how we use this information to create methods of maintenance, construction, and evolution. This requires a view of the devices and infrastructures that are implemented and also the communications and interactions that occur between these systems. "Following from Watts and Strogatz, a protocological architecture necessarily exists in the in-between space, the topological fold of both an empowering infrastructural ambience, and points of concentration that effectively organize that ambience."[39] This liminal space—or more aptly, the landscape itself—becomes the area of concern.

These forms of embedded intelligence must be confronted across scale and time, which are drastically shifted within this new paradigm. Scale is not only about relationships spatially, from site to territory, but also refers to the extents of the issues that designers are confronting at the global scale. The ability to address problems at the global scale requires more than monumental physical engineering; it requires a deft and evolving set of methods that fully adopt the complexity of ecological relationships. The scale of these issues also exists within a new temporal space. This space asks that landscapes are responsive to local processes as well as geologic shifts. These two scales of time were once out of our reach, but are slowly becoming clearer through simulations and models.

The projects outlined in this text are classified by their potentials for responsive design within the landscape and their effects, either perceptually or by direct manipulation. The case studies open up a focused discussion, framing the potentials for responsive technologies, that takes the installations beyond the role of landscape or architectural folly. The structure of the text responds to several modes that are specific to landscape methodologies, and organizes the case studies into actions expressed by the responsive system. A common series of threads are found through the projects, speaking to their direct relationship to the landscape by expressing each project's mode of response. These actions recognize the modes of behavior or modifications that phenomena are subjected to when converted to data or expressed through analog constructions. These responses focus on methods of clarity, interaction, connectivity, and augmentation that deliver both physical and virtual environments, expanding beyond installations to new relationships within the landscape. In the Foreword of *Alive: Advancements in adaptive architecture*, Carole Collet writes:

> In times where the very concept of 'nature' is questioned not only in its philosophical dimension, but in the core of its biological materiality, we need to reconsider the interrelations between architecture and nature.[40]

Moving forward from this cognitive shift, *Responsive Landscapes* frames a comprehensive view of interactive or responsive projects and their relationship to landscape or environmental space. *Responsive Landscapes* deconstructs a series of contemporary projects to develop a lexicon that defines new methods of constructing and framing responsive systems. Many of the projects are speculative and demonstrate a new methodology of working that moves beyond conventional methods of representation or perception. The complexity embedded in the design of responsive technologies requires iterative prototyping and computational development. This process of prototyping requires rigorous methods of making to tune sensing, feedback, and actuation. Each of the projects in *Responsive Landscapes* engages feedback or response as a method of modification, in a limited way, to understand the environment and to respond in calculated ways. While many of the selected projects are not specifically "landscapes," each engages landscape in important ways and develops a pragmatic framework to understand responsive methods in a new context.

NOTES

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