CYBERNETICS AND THE CONSTRUCTED ENVIRONMENT

Design Between Nature and Technology

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Chapter 9

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From Uncertainty to Opportunity

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From Uncertainty to Opportunity

"There is always a tension in landscape between the reality and autonomy of the nonhuman and its cultural construction, between the human impulse to wonder at the wild and the compulsion to use, manage, and control."[1] Working with living systems and materials, landscape architects must deal with unexpected outcomes, and the tension between control and uncertainty has been central to the work of landscape architecture. Meanwhile, this tension has been the basis for cybernetics, an interdisciplinary field that emerged in the United States in the 1940s when a group of postwar intellectuals, including engineers, mathematicians, anthropologists, and ecologists, converged on a new theoretical model based on systems thinking to understand control and communication between mechanical and biological systems. Landscape architecture and cybernetics should be viewed in tandem, and cross-pollination of thought could shed light on many pressing issues resulting from control and uncertainty, such as climate change.

However, it is only in recent years that scholars have begun to attend to the influence of cybernetics on landscape architecture. Landscape theorist Anita Berrizbeitia deployed concepts from second-order cybernetics such as "structural open" and "operational closure" to analyze the Downsview Park competition and illustrate how designers account for scales of undecidability with systems thinking.[2] Though her scope was limited to posthumanist Cary Wolfe's interpretation of cybernetics, Berrizbeitia's analysis showed potentially transformative outcomes in connecting the two fields.

Landscape scholar Margot Lystra builds specific connections between landscape disciplines and cybernetics within a broader conceptual framework.[3] Lystra argues that cybernetics concepts were instilled into the landscape

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discipline via ecological science and arts in the 1960s, and Ian McHarg and Lawrence Halprin were two prominent figures among those who established the link between cybernetics and modern landscape architecture.

Ecologist G. Evelyn Hutchinson had been a member of the early Macy Conferences on Cybernetics, and he became one of the pioneers in exploring the ramifications of cybernetic principles for ecological science. Hutchinson's student H. T. Odum integrated the notion of feedback and communication into ecological science, and his work depicted ecosystems as predictable and controllable. This deterministic view was favored by environmental designers in the mid-twentieth century, including McHarg, for it provided a sense of scientific causality with which to rationalize design decisions. Lystra argues that McHarg's adoption of "entropy" was evidence that cybernetics migrated via ecology into the landscape discipline.[4] Entropy describes the tendency of a system to move toward disorder and uncertainty when there is no energy input into the system. McHarg, Odum, and Norbert Wiener shared the same sentiment toward entropy; they viewed it as a threat to the integrity of the system, whether mechanical or biological, which they sought to control. Thus, managing entropy equals reducing uncertainty and controlling the system.

Lystra argues that, in contrast to McHarg, Halprin imported cybernetic ideas via the arts, specifically musical composition and choreography. Several arts and science collaborative events in the 1960s facilitated the migration of ideas, such as "9 Evenings: Theater and Engineering" in 1966. Lystra argues that "[a]rtists used cybernetic ideas in remarkably different ways than ecologists did: they found that cybernetic notions of indeterminacy offered methods for relinquishing, rather than increasing, control over their works. Many embraced chance as a catalyst for newly participatory and open-ended compositions."[5] In this movement, artists challenged the traditional notional systems that give precise instructions to performers, and they developed an "open scoring technique" that suggests only general intentions, and thus the resultant piece is partly dependent on the performers' choices. Open scoring was then imported to the landscape discipline by Lawrence Halprin through collaborations with his wife and partner, Anna Halprin, a choreographer and dancer.

Lystra's investigation opens a new avenue of research that takes cybernetics as a framework with which to examine key issues in the landscape discipline. Nevertheless, it is rather forced and too linear to map two distinct genealogies that demonstrate how cybernetic principles were introduced into landscape architecture.

First, as recognized by Lystra, cybernetics and systems thinking were simply "in the air" by the 1960s. The over-articulation of pathways gives a false impression that the migration of knowledge is a process of one person passing it to another, as if the issue of indeterminacy originated within the field of cybernetics, was mobilized by artists, and was finally imported to the landscape discipline by Lawrence Halprin. However, by the 1960s, Halprin had in fact already been involved in multiple community engagements in his professional work, and he had already explored scoring and notational systems to cope with the issues of uncertainty in design processes. Though the issue of control and uncertainty is at the center of cybernetics, the shift in how we understand uncertainty was more of an epistemological reflection in the 1960s across disciplines rather than a development specific to the field of cybernetics and then exported to other disciplines.

Second, like many others, Lystra's analysis starts with reasoning that positions landscape architecture as a passive receiver of ideas from other disciplines, overlooking the value of landscape architecture as a model that provides a new lens with which to examine the issue of indeterminacy. The inherent disciplinary hierarchy in many landscape theorists' analysis prevents us from recognizing the value of landscape as a transformative field of research via material practice. Indeed, despite designers' borrowing of terms from other disciplines, they did not thoroughly import the concepts; terms and ideas were often interpreted very differently. Halprin's description of his scores that "communicate but do not control" apparently plays on Wiener's book, titled *Cybernetics: or Control and Communication in the Animal and the Machine*. Halprin sought to distance his approach from Wiener's cybernetics, formalizing another way to articulate control and communication deeply rooted in the tradition of landscape architecture.

Finally, it is understandable that Lystra's analysis focuses on the 1960s, when landscape architecture was going through a paradigm shift; its key figures, such as McHarg and Halprin, have left enduring legacies and impacts on the discipline. However, this limited time frame essentially ignores the dramatic development of cybernetics after the late 1960s. The advancement of second-order cybernetics in the 1970s revolutionized the field itself and inspired many transformative concepts, such as autopoiesis and emergence, that altered how scholars understand and discuss the issue of uncertainty.

Because of the field's interdisciplinary nature, concepts in cybernetics and second-order cybernetics have been instilled into diverse fields, such as sociology, computer science, systems theory, ecology, and humanities, from all of which landscape architects have drawn inspiration. It is better to recognize that cybernetics and second-order cybernetics and their concerns have formed an undertone to intellectual life in the latter half of the twentieth century. Thus, genealogizing cybernetics to landscape architecture would be less useful than juxtaposing the two to construct connections between them. By analyzing how different concepts have been used to address the tension between control and uncertainty, modern landscape architecture could become a truly transformative model in contemporary environmental practice.

In her seminal work, *How We Became Posthuman*, N. Katherine Hayles has schematized the cybernetics movement into three waves of research, where the frontier of each wave has mobilized among different fields of study.[6] Three cybernetics waves can serve as an organizational and analytical framework for juxtaposing landscape design and cybernetics and highlighting how the tension between control and uncertainty was understood and addressed in each wave. Juxtaposing landscape design with cybernetics brings forth another crucial aspect that has been overlooked within the field of cybernetics—drawing and representation, which are important visual techniques for landscape architects to identify design possibilities and opportunities. Shifts in representational techniques in the landscape discipline reflect changes in how designers interpret and manage uncertainty.

The First Wave: Homeostasis and Entropy

Based on Claude Shannon's foundational work, which formalized information and communication, and inspired by wartime mechanical control systems such as servomechanisms and artillery targeting systems, Norbert Wiener revived the concept of cybernetics to develop a general theory of control and communication among not only mechanical but also biological systems, such as humans. The first wave of research speaks to the Macy Conferences on Cybernetics (1946–1953) that brought together influential postwar intellectuals, including mathematicians Norbert Wiener, Claude Shannon, and John von Neumann; anthropologists Gregory Bateson and Margaret Mead; neurophysiologist Warren McCulloch; physicist and philosopher Heinz von Foerster; psychiatrist W. Ross Ashby, and others from diverse fields. These conferences planted the interdisciplinary seed for the field of cybernetics, which, in turn, profoundly influenced sciences and humanities in the following decades.

The first wave focused on feedback mechanisms in self-regulating systems. Engineers sought to control complex systems through feedback, following the function $y = f(y)$, with output feeding back into the system as input. There are two types of feedback mechanisms: positive and negative. In negative feedback, an increase of y at time t will decrease y in $t+1$, and vice versa; thus, the result of the function will oscillate around an equilibrium. Negative feedback, such as in thermostats, is ubiquitous. If the room temperature exceeds a threshold, the air conditioner turns on; otherwise, it is off. As a result, the room temperature will oscillate around the target temperature. In contrast, positive feedback will produce runaway behavior in which the increase (or decrease) of y at time t will increase (or decrease) y in $t+1$. While negative feedback is the key to stability, positive feedback is responsible for growth and self-organization.

First-wave cybernetics favored negative feedback over positive feedback because the former could deliver controlled equilibrium, which was often associated with complexity. For Wiener, positive feedback was regarded as "disruptive and destructive, rather than as leading to complex stable structures."[7]

Entropy was a core concept in Wiener's reasoning. First developed in the field of thermodynamics and statistical mechanics, entropy describes the tendency of a thermodynamic system to move from order and organization toward disorder and chaos, as expressed through Boltzmann's function for statistical mechanics:

$$S = kBlog\Omega$$

where Ω represents the possible state of a system in a given time, S is the entropy, and k is the Boltzmann constant. Entropy S is in a logarithmic relationship with Ω, the number of possible system states. If a system possesses only one state, then the system is predictable because the probability for this state will always be 1, and thus entropy is 0 ($log1 = 0$). Conversely, for a complex system such as the universe, the number of possible states is infinite, and entropy reaches its maximum. In such case as the universe, since the possibility of the system being in a given state is so small, it becomes almost impossible to predict the system's behavior, and thus the system reaches maximum uncertainty. Claude Shannon similarly defines information in terms of the uncertainty of a system; we can decrease information entropy (or uncertainty) by eliminating certain possible states through observation. In this definition, Shannon constructed a direct relationship between observation and uncertainty; the information we receive from an observation equals the degree to which entropy or uncertainty is reduced in this round of observation. This conceptualization also built relationships between modeling and uncertainty. One can construct more complex models to represent the phenomena through observation, thus reducing uncertainty.

The second law of thermodynamics posits that if there were no energy input, the total entropy of an isolated system would increase over time, and probability would be evenly distributed across each state of the system. For example, if we pop a balloon full of oxygen, then the oxygen molecules will eventually blend within the surrounding air; the balloon acts as energy input that holds the isolated system in a low-entropy and highly ordered state; without the balloon, the system of air molecules would move to disorder (high entropy). For this reason, the term "heat death of the universe" entails that the universe will always move toward disorder, and entropy will reach its maximum level. The influence of the second law of thermodynamics on Wiener's reasoning is apparent here:

> As entropy increases, the universe, and all closed systems in the universe, tend naturally to deteriorate and lose their distinctiveness, to move from the least to the most probable state, from a state of organization and differentiation in which distinctions and forms exist, to a state of chaos and sameness.[8]

For Wiener, to control is to reduce uncertainty, or entropy, which is the tendency to move away from an organized state; the means for control is negative feedback. “It is my thesis that the physical functioning of the living individual and the operation of some of the newer communication machines are precisely parallel in their analogous attempts to control entropy through feedback.”[9] For Wiener, negentropy became a determining characteristic for life, because feedback is key to a negentropic system to “produce around it a local zone of organization in a world whose general tendency is to run down”.[10] This line of reasoning finally connected the idea of entropy to homeostasis, as argued by Wiener that “[t]he process by which we living beings resist the general stream of corruption and decay is known as *homeostasis*.”[11]

Entropy had a negative connotation in first-wave cybernetics, as did uncertainty; they existed on the same line with corruption, deterioration, and decay. Homeostasis was preferred, and control systems were a means to achieve observed stability. This reasoning could be easily extended to framing wild nature versus controlled landscapes. Wild nature represents uncertainty with high entropy, and technology is the means to bring order to wildness, producing homeostatic and habitable landscapes. In this view, landscape practices become a negentropic mechanism that fights against decay and deterioration. From this vantage, Ian McHarg’s ecologically inspired design methodology could be framed as a version of first-order cybernetics. McHarg used the concept of entropy extensively throughout his writing and contrasted entropy with ecological fitness.[12] The ecological science to which McHarg was exposed in the mid-twentieth century was dominated by Clements community ecology, which emphasizes ecological successions toward a climax community that is stable and desired. McHarg also emphasized succession and climax species. His design principles imply that environmental factors are determined; if we “design with nature,” the ecosystem will always follow a predetermined and predictable path toward the climax community, a homeostatic equilibrium.

Aside from the underlying ecological framework that favors stability over uncertainty, McHarg’s design methodology also ensured predictability in landscape design and “embraced the measurable and controllable aspects of landscape systems.”[12] He implemented a series of analytical strategies to reduce uncertainty in every aspect of landscape design. One of the most famous McHargian methods is the map overlay technique, known as “the ecological inventory” or “the layer cake.” This inventory allowed designers to observe landscape systems through a set of fixed lenses always in the same order: climate, geology, hydrology, soils, vegetation, and wildlife.[13] According to McHarg, this order was meant as a chain of deterministic reasoning, with the former variables predicting the latter. By knowing climate conditions and geology, one can comprehend the hydrological patterns of a place; then, with those three variables, one can predict patterns of soil and vegetation types.[14]

These landscape features will be drawn on individual maps and then overlaid atop each other to produce a composite map for suitability analysis. If one designed the landscape based on the suitability analysis, then the future of the landscape would be predictable, and thus uncertainty would be reduced.

Despite its inherent ecological determinism, the inventory reduced uncertainty in the creative process as well. McHarg essentially standardized the design process by attributing creative agency to "objective" and "scientific" procedures so that the same protocols could be practiced repeatedly on different sites and by different designers. Design outcomes depended solely on the different inputs fed into his "landscape designing machine," and the outcomes were comparable. Thus "design with nature" constructed a model of "nature" and allowed the initial variables, decided by the characteristics of different site conditions, to determine the designed landscape. The map overlay technique systematically reduced uncertainty by inventing an autonomous protocol independent of designers. Accompanying the systemic design method was a type of drawing technique that tried to eliminate ambiguity in representation. In the overlay maps, different landscape features were drawn with distinct boundaries without overlaps, and "the clarity of imagery implied that their information was absolute, reinforcing a notion that the viewer could be certain about the veracity of the visual data they observed."[15]

McHargian ecologically inspired landscape design managed uncertainty, from underpinning conceptual framework to design methodology and representational techniques. His legacy was not limited to the landscape profession. McHarg's map overlay technique directly influenced the later development of geographic information systems (GIS) and the founding of the Environmental Systems Research Institute (ESRI), which later became the largest geographic research and service provider in North America, playing an important role in standardizing organization and representation of geospatial information. The GIS is more than a piece of software; it is a system through which the environment can be reduced to spatial information that exhibits specific structures and organizations. Although GIS plays a vital role in today's environmental management discourse, which emphasizes adaptation and flexibility, the way in which the environment is structured as spatial information remains within the ecological paradigm that promotes stability through managing entropy and uncertainty.

First-order cybernetics is a model-making paradigm; it entails a sort of epistemological realism, where the object of study is independent of the human mind. With this conceptualization, "all our knowledge is mediated by our simplified representations—or models—of them, which necessarily ignore those aspects of the system which are irrelevant to the purposes for which the model is constructed."[16] In environmental practices undergirded by first-order cybernetics, there will always be models of the environment on which our decisions are made. In a way, the McHargian ecological inventory is a means to construct a model of the environment that predicts how the landscape could evolve and how design intervention could impact that evolution. Similarly, many present-day environmental practices, including adaptive management, rely on complex digital models to predict and simulate control strategies and evaluate their impacts, such as the South Florida Water Management Model used to devise watershed management strategies. In this conceptualization, uncertainty becomes the gap between the model and the modeled environment; uncertainty may be reduced via more complex models.

The Second Wave: The Irony of Relinquishing Control

Despite Wiener's original intention to develop a general control and communication theory across different systems, cybernetic principles quickly found their direct applications in the design of mechanical systems. The first wave of cybernetics gave rise to robotics, system engineering, computer science, artificial intelligence, and many other application-based fields, quickly drawing scholars' attention away from theory-based inquiries. In the meantime, cyberneticians, including Gregory Bateson, Margaret Mead, and Heinz von Foerster, felt the need to update cybernetics to focus on the issue of reflexivity and problematize the innocent observers of the first wave.

This concern over the observer mirrored a broader societal reflection on authorship, objectivity, and scientific truth in the twentieth century. In science, Thomas Kuhn's *The Structure of Scientific Revolutions* (1962) found its popularity beyond academics; so did the term "paradigm shift." Kuhn explored an alternative to the "great man" history of the scientific revolution, arguing that scientific knowledge was constructed by scientific communities based on their shared consensus regarding the underlying assumptions, techniques, and values reached by their members. In other words, individual excellence was questioned, and scientists and their unconscious minds became subjects of study.

Similarly, problematized authorship was a key issue in early twentieth-century works of art. Marcel Duchamp's readymade sculpture "Fountain" was one of the earliest avant-garde landmarks to challenge the role of artists in art production. A standard urinal, signed and dated "R. Mutt 1917" by Duchamp, was submitted to a jury-free exhibition of the Society of Independent Artists in April 1917. However, the Society's board of directors excluded Duchamp's submission based on the alleged indecency of the work. The tension between artists, art authority, and art critics posed questions about the authenticity of the works of art, and problematized authorship became one of the core issues in the later conceptual art movement. Conceptual artist Sol LeWitt argued that the idea was the most important aspect of art production, and the idea was the machine that produced art. In 1968, LeWitt began his wall drawing series, for which he only gave instructions on how to make drawings on the walls. These instructions were "scores" that choreographed his installation crews to produce art.

Similar concerns can be found in humanities as well. In "The Death of the Author" (1967), Roland Barthes questioned the role of authorship and argued that an author was not the creator of meaning in the text, but merely someone who meshed different texts. Once the author was gone, the text was truly liberated and overflowed with possible interpretations.[17] In the same vein, Michel Foucault questioned the issue of authorship with increased sophistication. More than activating readers by removing authors, authorship for Foucault can be understood through author function, which speaks to the need to pin a discourse to a person as a regulator of meaning. The author becomes an "ideological figure" implicated in our understanding of discourses.[18]

Many regarded Barthes and Foucault as key figures in the post-structuralism movement. Drawing ideas from linguist Ferdinand de Saussure's structural linguistics, structuralists deployed language as a model to analyze cultural products and society itself, prioritizing systematic inquiry to interpret their underlying structures. Whereas post-structuralists such as Barthes and Foucault have challenged the unquestioned linguistic model and have accepted that language is a flawed means of communication. Thus, reading through a text and deciphering the author's original intention is impossible and meaningless. Most importantly, for post-structuralists, this type of analysis, which focuses on interpreting the texts' underlying structure, ignores its rich possibilities. Thus, post-structuralism encourages us to reject any final meaning of a text and instead embrace the multiple meanings of cultural products. Post-structuralism began with a sense of reflexivity and problematized authorship but later found a broader implication in many fields, such as Jacque Derrida's deconstruction. In a way, post-structuralists embraced the uncertainty of the flawed linguistic system, and used it to their advantage to deconstruct the underlying binaries in the structures that give rise to cultural phenomena.

These examples demonstrate that in the mid-twentieth century, cybernetics was not the only field grappling with the issue of reflexivity. As argued by Cary Wolfe, at least two genealogies can be traced to the rise of posthumanism, one on the line of Foucault and post-structuralism and another on the route of second-order cybernetics.[19] From this perspective, second-order cybernetics essentially provides a systemic account for the issues of problematized authorship, presenting another model for posthumanist epistemology based on systems thinking.

Early cyberneticians such as Gregory Bateson realized that the issue of reflexivity is more than subjectivity in modeling but is, instead, an issue in the epistemological framework. Bateson predicted that "the problems posed by including the observer could be addressed only if a substantial reworking of realist epistemology was undertaken."[20] To resolve the issue of reflexivity requires a fundamental shift in the epistemological framework, and, as we have seen, constructivism was already discussed by the late 1960s. Cyberneticians were ready to embrace a more radical approach to the issue of reflexivity, one which was not properly addressed in the Macy Conferences era. In 1967, Margaret Mead, one of the key participants in the Macy Conferences, addressed the American Society for Cybernetics regarding the need for a recursive application of cybernetics on itself, treating the observer as a cybernetic system constructing models of another cybernetic system.

Early cyberneticians, including Mead, Bateson, and Heinz von Foerster, proposed a model of second-order cybernetics by drawing a larger box around the original feedback diagram (Figure 9.1). Nevertheless, this model was an intuitive leap until Chilean biologist Humberto Maturana's research on the frog's cortex provided empirical evidence for second-order cybernetics. According to Maturana, the frog's eye does not send a whole data package of the outside environment to the brain to interpret; instead, the environment triggers only a set of nervous system operations between the eye and the brain that produce a reality for the frog itself.[21] This finding inspired Maturana and Francisco Varela to coin the term "autopoiesis (self-production)" to describe this phenomenon. "The living organization is a circular organization which secures the production or maintenance of the components that specify it in such a manner that the product of their functioning is the very same organization that produces them."[22] Autopoiesis is essentially a version of radical constructivism claiming that knowledge is constructed through system operations to maintain the organization that constructs that knowledge.

In this highly reflexive framework, uncertainty becomes a notion which human systems invent to distinguish the conditions of known and unknown; uncertainty also plays a role in how we describe learning and time. Based on autopoiesis theory, a system, such as an observer, can only behave in the present by interacting with the descriptions that the system generates at

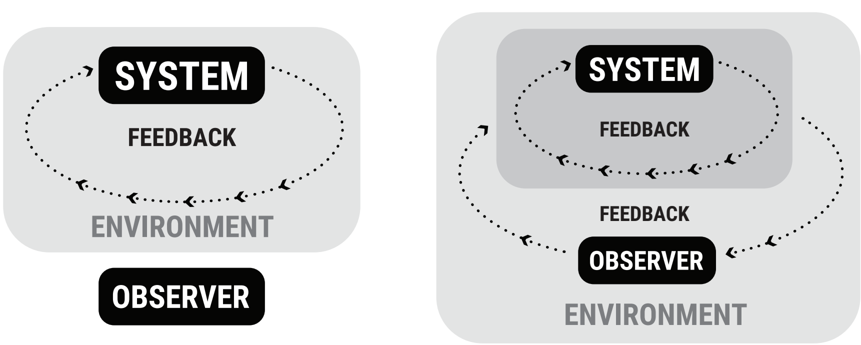

FIGURE 9.1 Feedback diagram. Illustration by the author.

this moment. Paradoxically, the observer could interact with a description generated in the past as if it were in the present. To resolve this paradox, the observer thus needs a notion of time—past, present, and future—to expand the domain of interactions. In autopoiesis, it is not because the notion of the future exists in the first place that uncertainty is on the horizon. Instead, it is because humans need a concomitant emotional state of anxiety when the observer interacts with a description for the first time, and the notion of uncertainty can provide that state of anxiety to maintain the system's organization. "Any experience without anxiety [or uncertainty] can be described as known, and thus serve as a basis for the functional notion of time."[23] In a sense, autopoiesis flips our conventional understanding of the relationship between uncertainty and future. Uncertainty becomes a notion to describe the unknown; consequently, reducing uncertainty becomes a description of learning.

Despite criticism of its self-referential language and potential solipsism, autopoiesis essentially problematized the observer and challenged the realist epistemology and objectivity in early cybernetics research. Radical constructivism found implications, especially in the posthumanist arguments. N. Katherine Hayles drew inspiration from autopoiesis and argued that those qualities, such as consciousness, intelligence, and free will, that helped those with the privilege to conceptualize themselves as liberal human subjects, were, in fact, epiphenomena of the system operation. Autopoietic theory "sees thinking as a secondary effect that arises when an autopoietic entity interacts with its own representations. Self-consciousness, a subset of thinking, is relegated to a purely linguistic effect."[24]

If we view the second wave of cybernetics as wrestling with authorship and challenging observers' authority, then we can identify many landscape counterparts in the second half of the twentieth century that questioned designers' intentions and authorship. Lawrence Halprin's score is one of them. Though Margot Lystra acutely defined Halprin's scoring method as a systemic approach informed by cybernetics, a caveat is that Halprin should be juxtaposed with specifically second-order cybernetics. In an interview, Halprin stated that his notion of scores emerged from a realization that if people were excluded from the design process, they would grow angry. Thus, he invented a system whereby all felt that they were shareholders, not only as clients but also as participants in the creative process.[25] Halprin offloads his authorial control to a system of scores, and the design outcome seems to become a byproduct of the system operation, independent of the designer's excellence. However, just as second-order cybernetics' use of a bigger box around the original system diagram created a meta-observer who hides behind a second-order cybernetics diagram, Halprin's scores essentially elevated designers to another plane of operation, to perform a sort of "distanced authorship."

Urbanist Charles Waldheim introduced the term "distanced authorship" when characterizing a body of landscape projects from the late 1980s to the early 2000s. "A variety of contemporary landscape practices evidently employ techniques of problematized authorship and contemporary discourse around landscape and urbanism is awash with claims of indeterminacy, open-endedness, self-regulation, and post-modern ecological models of autonomous emergence."[26] Waldheim argues for three categories of autonomous systems—computer algorithms (technical), activated users (cultural), and ecosystems. Yet, Waldheim's categorizations miss an underlying epistemological shift in landscape design. We should ask a different question: what is being designed? Since the 1980s, designers have grown interested in designing landscape systems rather than objects, programs, or forms. It is not that forms and programs are unnecessary, but they are no longer the fundamental components in how design projects are articulated and justified. Landscapes are envisaged as systems so that forms and programs become epiphenomena and concomitant effects in system operation. They matter only with regard to their functions and performances as components in the landscape systems. In a way, "distanced authorship" performs a type of second-order design: designing a system that designs. In this way, indeterminacy is achieved by instrumentalizing the self-production of the landscape systems that are imagined to be autopoietic living systems, and that exhibit a certain level of autonomy.

The quality of self-production can be illustrated through examining in tandem two competition projects by OMA: the first is the entry for the Parc de la Villette competition in 1982, and the second is the entry "Tree City" for the Downsview Park competition in 1999. In the Parc de la Villette, OMA's entry is considered a park of "culture" rather than "nature." The site was divided into a series of stripes of autonomous programs. The programs in different stripes "pollute" each other, making the park unstable and out of the designers' intended control.[27] These stripes are unstable because users, rather than authors, define their programs, whose characteristics are thus contingent on cultural practices over time.

Similarly, in the Downsview competition, OMA proposed a network of 1,000 paths, with vegetal clusters separated by vast undesignated areas, as a spatial framework to account for the park's future development. Many argue that OMA's "Tree City" exhibits some level of uncertainty, thus is open-ended. However, this flexibility is based on the self-production of the urban park as an autopoietic system. The project description resonates with autopoiesis theory, where the living systems operate to reproduce their organization:

> Tree City treats the park as if it is an adult soon capable of sustaining itself rather than a child in need of eternal care…We propose that capital

> generated from the park's appreciated land value be spent to manage the park's infrastructure and to support future development in an evolving cycle of implantation and speculation.[28]

Another way to understand self-produced flexibility is through the redefined system–environment relationship in autopoiesis theory. Since an autopoietic system interacts only with a representation constructed by itself, the outside environment is no longer accessible by the system. *Structural coupling* was introduced as a concept to describe interactions between systems. One of the contributions of autopoiesis theory is to distinguish structure from the organization—"the organization of a system as the set of relations between its components that define it as a system of a particular class, is a subset of the relations included in its structure."[29] The structure of a system can change without affecting its identity, as long as the organization of the system remains invariant. Structurally, a system is coupled with its environment and other systems; that is, there are pathways and relations between the system and its environment through which the system can exchange information, material, and energy flows. These pathways depend on the system's structure—how the system is wired concretely. When the system operates, it uses flows of information, material, and energy to reproduce its own organization so that it retains its identity. For this reason, autopoietic systems are said to be "structurally open" but "operationally closed."

In both of OMA's proposals, flexibility exists on the structural level. The stripes in the Parc de la Villette are structural so that they can be highly flexible—the forms, programs, functions, and performance within these stripes could be of any sort. As long as they exist within the park's organizational framework, the park's identity will not be jeopardized by changes on the structural level. Similarly, in "Tree City," the paths and vegetal clusters are not organizational components, so "clusters can acquire the form of precise, static, round shapes without the scheme losing any of its flexibility, complexity, or openness…What is inside the 'dots' responds to other criteria, independent from the park/environment organization."[30] The structure/organization difference thus creates two types of relationships between the site and its environment—structural and organizational. The park is structurally coupled with other urban systems so that it can be structurally flexible toward contingencies posed by these systems. Yet, the park is operationally closed to these external systems because it must retain the identity of a suburban Toronto park. As described by the designers, "[v]egetal clusters rather than new building complexes will provide the site's identity…Tree City assumes the park's suburban context to be its virtue. The locale offers an ideal opportunity to explore the unrealized promises of low-density metropolitan life."[31]

Once we take inspiration from autopoiesis and analyze "distanced authorship," we can find that forms, programs, and landscape objects, once the core of landscape practices, now become structures that are separated from the organizations of landscape projects. Anita Berrizbietia thus praised second-order cybernetics and autopoiesis framework, because through the structure/organization difference,

> we can conceptualize landscapes where there is space and time for process to unfold and for stable meanings to come forth… We have always known landscapes to perform multiple programmatic, functional, and metaphorical roles simultaneously, shifting from one system of signification to another, but only recently have we been able to articulate this complexity under a single framework.[32]

Though the ideas of flexibility and uncertainty might have been novel in the late 1990s and early 2000s, after nearly 20 years of development, these ideas have been tested in landscape practices. This new condition serves as a basis for us to reflect on autopoiesis and "strategies of indeterminacy" and ask whether they are truly indeterminate.

Structure/organization creates another level of stability, paradoxically achieved by amplifying structural flexibility. Is OMA's proposal flexible? On a structural level, yes. Is it truly open-ended and indeterminate? No, because the park is envisaged in such a way that information and material flowing into it are used to reproduce its organization and maintain its fixed identity as a suburban park. The paradox here reflects a shortcoming in the autopoiesis theory. As pointed out by Hayles, even though the implication of autopoiesis theory challenges observers' authorial control, it is still on the line of liberal humanism that re-inscribes a set of humanist values, including homeostasis.[33] The second wave of cybernetics raised questions about the observers but less about the conception of homeostasis that was central in the Macy Conferences era; homeostasis in first-order cybernetics persisted in the autopoiesis theory. Maturana and Varela stated clearly that "living systems are a subclass of the class of circular and homeostatic systems."[34] Autopoietic systems operate to maintain their equilibrium, and there remains little room to consider change and emergent behaviors. Structure/organization may resolve certain issues regarding system structural flexibility, but it becomes difficult to explain evolution and change; once the organization changes, the system becomes a different class. However, if a system operates to maintain the circularity that secures its organization, how could a system stop being one thing and become another, and how could evolution occur?

The individuation process is concurrent with the attribution of agency, and so is operational closure. Thus, autopoiesis should not prevent us from understanding the tendency for systems to assimilate, aggregate, and mobilize in a heterogeneous field. Drawing inspiration from ecological science, organizational closure at its best should be considered a local equilibrium, and autopoietic systems can move into another temporary stability. However, both of OMA's projects represent a strain of environmental practices that claim to be indeterminate on a structural level yet, in reality, re-inscribe the notions of stability, determinism, and homeostasis via organizational control. Not all "strategies of indeterminacy" are truly indeterminate. Ironically, autopoiesis theory results in another form of control regime that can only be revealed within a second-order cybernetics framework; it reinforces organizational control by relinquishing structural control.

The Third Wave: Emergence and Posthumanist Ecology

According to N. Katherine Hayles, "emergence" distinguishes the third wave of cybernetics research from the second wave. It became apparent that self-production in autopoiesis was insufficient to consider runaway behaviors and positive feedback loops that move the systems from equilibrium and toward unexpected directions. Hayles argues that the frontier of cybernetics research moved into the field of artificial life around the 1990s. One thread of autopoiesis arguments is the attempt to redefine life—all living systems are autopoietic systems, and any system, if it is autopoietic, can be said to be living.[35] Thus the third wave of cybernetics may be understood as an implication of this argument in the field of artificial life, drawing analogies between computer simulations and the life evolution.

In the 1990s, evolutionary biologist Thomas S. Ray developed a computer simulation called Tierra, in which programs were given simple rules to replicate themselves by copying bits in computer memory.[36] When the machine copied the code, the programs would flip the bits (1 and 0) so there were opportunities for mutations to give birth to a new "digital species." Tierra programs could evolve into ecosystems with various digital species and communities by repeating simple rules. The results might be completely different if the initial variables were slightly changed. These computer programs compete for CPU time and space in the computer memory; they are digital species in a computational universe. Based on the empirical evidence, Hayles made the stretch to argue that human consciousness, intelligence, thinking, and the idea of free will, as well as humanist concepts used to define human subjects, can be understood as emergent behaviors of random interactions of distributed systems.

Autopoiesis in the second wave of research has evolved into a posthumanist epistemology, which offers new ways to frame concepts such as agency, intelligence, evolution, and emergence. Within a posthumanist and emergence framework, autopoietic systems could employ their flexibility to expand and construct new pathways and form structural couplings with other systems. Emergence describes the process of forming these pathways between different systems. Only through this posthumanist framework can we begin to make sense of the value of a body of landscape practices since the 2000s that emphasize emergence and posthuman ecology.

James Corner, Stan Allen, and Nina-Marie Lister's entry "Emergent Ecologies" for the Downsview Park competition might be aligned with the third wave of cybernetics, which considers emergence. This entry is in a different paradigm from the other four finalists, including the above OMA's winning proposal "Tree City." For this reason, "Emergent Ecologies" holds a high value in the landscape disciplines, even though it lost the competition. The Downsview competition brief specifically asked the teams to consider a phasing strategy for developing the park over 15 years, in five-year increments, and accommodating future changes. The five finalists all addressed this request in one way or another. The phasing strategy distinguishes "Emergent Ecologies" from the other four finalists because it considers not only the time involved in developing the park but also how the park's development will continue in the future, after construction. For the other teams, including OMA, designing a park is the ultimate goal; there will always be an endpoint when the park is considered "built," and "phasing" is limited to a strategy of spreading out its construction over 15 years. This mindset might be due to the fact that these teams were led primarily by architects, with specific images of "landscape" and "urban park" in mind.

Landscape architect and theorist Kristina Hill was highly critical of OMA's proposal, and she pointed out that OMA's team "proposed the pastoral forms of traditional urban parks, but used a language of mimicry to describe them, calling the park a 'Tree City' that celebrates (and in formal terms, imitates) its suburban context of lanes and clusters of trees."[37] Berrizbeitia has issued similar criticism:

> the OMA scheme falls short of its promise…instead of seeing the broad array of possibilities afforded by their process, we see nature and urban life reduced to one vision, that of logolike landscapes frozen as stage sets of human and vegetal performances.[38]

For landscape architects, the question of "what landscape is" has always been at the core of the profession, and practitioners have pushed the boundary of landscape practices over the course of the twentieth century. By the late 1990s, landscape architects were accustomed to understanding landscapes through processes, and recognizing landscape design as a temporary intervention on a site with a history and future of its own. This realization led the "Emergent Ecologies" team to approach the Downsview site differently:

> We propose a carefully gauged framework…this framework will be mostly constructed (or 'seeded') within the first five years, its 'lifeline' drawing energy, life, matter and activity across the site. The park's identity will

> subsequently evolve and be re-shaped as users inscribe their own traces into its various surfaces and pathways over time.[39]

"Emergent Ecologies" interpreted the phasing requirement with a landscape sensibility. The designers did not treat park design as a kind of courageous adventure that imposes a "master plan"—an image of the pastoral suburban park found in major cities by the end of the twentieth century—on the site of Downsview in a 15-year timeline. Instead, the proposal treasured the first five-year window as a chance to intervene in an ongoing ecological process on the site of Downsview itself. Without designers, the Downsview site would still be a complex system that evolved and unfolded; the role of designers was to plant a seed that might or might not guide the Downsview site to assume a different trajectory into the future. As the team stated, "*We do not determine or predict outcomes;* we simply guide or steer flows of matter and information."[40] From this perspective, "Emergent Ecologies" possesses the highest indeterminacy among the five finalists, leaving the design truly open-ended. After the 15-year phasing program, "Emergent Ecologies" also considered the site's long-term potential. In other words, building a conceivable and stable suburban park was not the goal of its proposal; instead, the aim was to prepare the Downsview site for a territory full of potential. Its proposal leaves space to imagine a wild, vibrant place entirely different from a pastoral park. This sort of risk-taking spirit perhaps intimidated the Toronto jury, propelling it away from "Emergent Ecologies" in favor of OMA's "Tree City" as a less threatening proposal.

We can observe a sort of posthumanist ecological thinking that underpins the ethical framework of the proposal for "Emergent Ecologies." Even though all competition finalists addressed ecological dynamics in their own responses, only "Emergent Ecologies" recognized that ecological processes do not occur solely for human use. In other words, OMA's proposal is trapped in a humanist ecological framework that regards "nature" as resources that sustain a "low-density metropolitan life." In contrast, "Emergent Ecologies" could be understood as a posthumanist project that specifically renders a future park that can sustain more-than-human life forms. For the other entries, humans were still envisioned as a force outside the site's ecology. Yet, "Emergent Ecologies" regarded designers' interventions as an indispensable part of the site's ecosystem dynamics, so design strategies could influence its future evolution.

This level of realization can be explained through a posthumanist ecology that requires designers to cultivate a deep understanding of ecological science. As explained by Kristina Hill, ecological science since the late twentieth century has expanded its considerations in three different aspects. The first is the temporal expansion through which ecologists are willing to consider ecosystem dynamics on a geological time scale. The second is the expansion in spatial scale, where local ecological flows are part of broader ecosystem dynamics. The third is a more dynamic view of physical landscapes, as constantly shifting mosaics with different ecosystem types constantly emerging and disappearing.[41] When considered within a posthumanist framework, these updated understandings of ecology result in a series of implications, in terms of design activities. If we take the Downsview site as an example, the site's current condition and the proposed suburban park only matter on a human timescale. When considered on a geological timescale, any intervention becomes a transient phenomenon, like a drop of water in a river of evolving ecologies.

The posthumanist ecological framework also possesses ethical implications. The site is being made and remade with more-than-human species, among which a human is minuscule. From this perspective, design activity is no longer about envisioning a "master plan" and expecting changes, but instead about inserting designers' current limited understandings of the site into an ongoing process of co-production and co-evolution among more-than-human lives. With this reconfiguration of design comes an updated sense of responsibility. In a way, the designer's claim for "Emergent Ecologies," that "we do not determine or predict outcomes," is not about escape from responsibility. On the contrary, it suggests assuming more responsibility, by recognizing the limitations of designers' current ethical and epistemological frameworks that undergird and limit the proposed strategies, and expressing a willingness to step aside and give way to future interpretations of the site. From this vantage, beyond the open-ended strategies, the flexibility of "Emergent Ecologies" also lies in its ability to account for changes in ethical and epistemological considerations of future designers who will wish to insert their understandings of the site into the process of co-evolution.

Like the McHargian map overlay technique that uses defined boundaries to re-inscribe a sense of stability and reduce uncertainty, representation techniques in this wave of landscape design highlight the considerations of emergence and increased complexity over time. Representational techniques can be better illustrated by including another important landscape project of the 2000s, performed by Field Operations: the Freshkills Park design competition. The winning team proposed transforming a previous landfill on Staten Island into parkland. This time, the jury favored the proposal by Field Operations. The designers proposed a timeline to evolve the landfill into a park over 30 years through ecological emergence. Freshkills and Downsview should be viewed as seriation because they share not only the underlying design framework concerning emergent ecologies but also a similar representational technique. Unlike most "master planning" projects that feature a top-down view plan and perspectival rendering that freeze time, Freshkills and Downsview feature a series of site maps in a sequence, displaying increased ecological patches, habitats, and human activities over time.

Accompanying the map sequences are a series of abstract timeline diagrams portraying the emergence of wild animals and plant species, indicating enhanced biodiversity over time. The use of timelines de-emphasizes a single view of the project through one master plan; both projects represent the landscape as a process of emergence rather than a static conglomeration of objects, forms, and functions. Unlike the McHargian map overlays technique that reduces ambiguity, Field Operations' diagrams are abstract and open to interpretations. Especially in the case of Freshkills, the timelines consist of abstract dots rather than concrete forms. Yet it matters little what the dots represent; what matters are the increased quantity, type, and colors of these dots over time. These diagrams invite different interpretations about emergence and increased complexity.

In both their representational technique and underlying ecological framework, the Downsview and Freshkills entries led by Field Operations became early-2000s exemplars for a new paradigm of landscape design deeply rooted in cybernetics. Over the past two decades of practice and theory-development, the discipline of landscape architecture has developed a design framework in which strategies are articulated through process-based operations that aim to intervene in socio-cultural, technological, and ecological processes. The designs are said to be open-ended with emergent qualities unfolding over time. Most importantly, uncertainty is no longer viewed as a negative concept; instead, it becomes a source of emergence. At both Downsview and Freshkills, the sites possess rich possibilities to take on different trajectories *because* the future is uncertain.

Three Paradigms of the Cybernetic Environment

By juxtaposing the development of landscape practices with the evolution of cybernetics, we can see that the key concerns in each wave of cybernetics mirrored how designers consider the issue of control and uncertainty in landscape practices since the mid-twentieth century, when designers began to instill cybernetic principles into their design frameworks. These changes in considerations can be described by three paradigms of environmental practices undergirded by cybernetics (Figure 9.2).

The McHargian ecological design framework operates in first-order cybernetics. This type of environmental strategy seeks to maintain a homeostatic system by reducing entropy or uncertainty, which represents the model/environment differences. Its consequent reasoning is that the gap between the model and the modeled environment can be reduced by constructing more complex models through iterative system observation and monitoring, and thus uncertainty can be regulated. Several versions of adaptive management, which rely on model-making and digital simulations for decision-making, rest within this category.

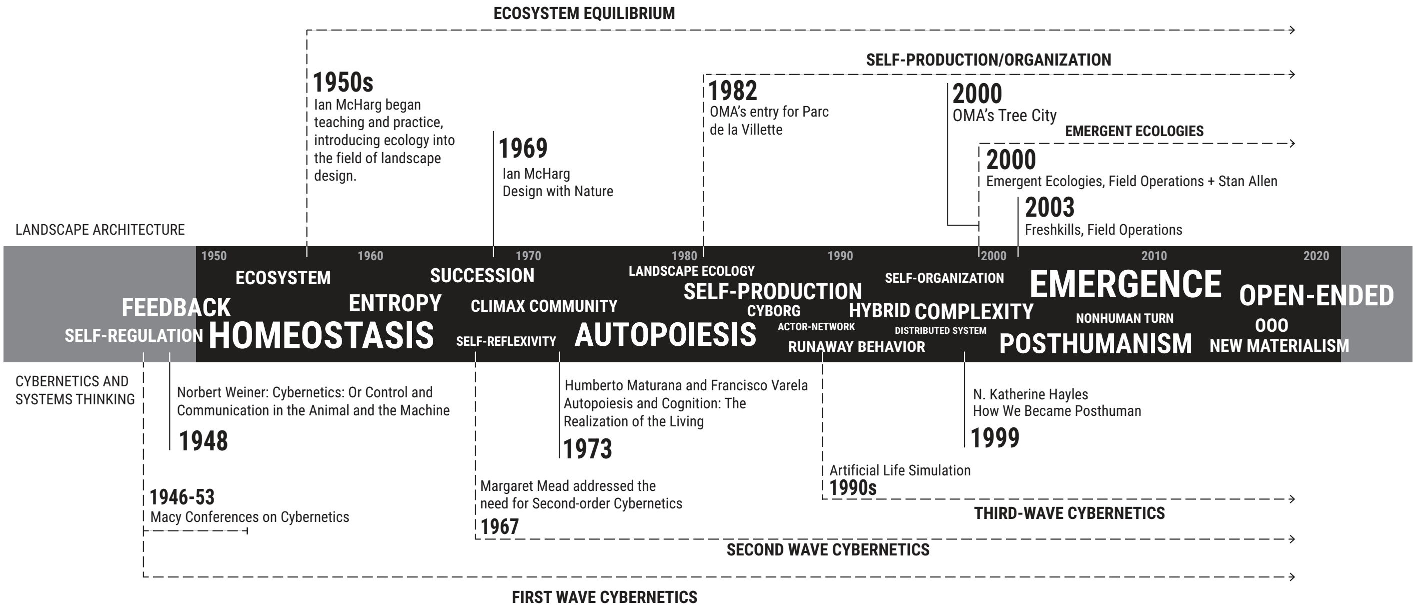

FIGURE 9.2 Landscape design and cybernetics. Illustration by the author.

The second paradigm speaks to Halprin's score and OMA's two park competitions in the 1980s and 1990s. Through problematizing authorship in design processes and emphasizing organization/structure differences, this type of practice articulates an overall homeostatic framework on the organizational level, within which flexibility is produced by distributed authors/users on the structural level of the system. Uncertainty is instrumentalized as material and information flow which park systems can use to reproduce their organization, thus maintaining their fixed identities. A new type of control regime is established on the organizational level by relinquishing control on the structural level.

The third paradigm includes the landscape practices exemplified by Downsview Park and the Freshkills entries led by Field Operations. This paradigm reflects the notion of homeostasis and favors emergent behaviors and posthumanist ecology.

Even though the three paradigms emerged in chronological order, the development cannot be described as two paradigm shifts because the last paradigm has not entirely overthrown and replaced its predecessors. For example, McHargian map overlay is still prevalent in today's landscape and ecological planning, and ecological fitness, in many cases, is still associated with stability and equilibrium.

Similarly, the second paradigm—structural flexibility within a homeostatic framework—has also been observed in recent environmental practices. Many contemporary urban design projects rely on programming and events as strategies to revitalize designed public spaces. For example, the Bentway, designed by Public Work, is an urban landscape project located beneath the Gardiner Expressway in Toronto. The project relies on the strategy of intentional programming to revitalize an undesired space under a mono-functional transportation infrastructure. The design was conceptualized around the expressway's columns, called "bents," that could form 55 "civic rooms" to be used either as a whole, as in a winter skating trail, or individually, with different events from farmers' markets to contemplative spaces. The designers consulted neighboring residents and potential users to develop a range of potential events which might be hosted in the Bentway, and the designers needed only to provide basic infrastructures to support these activities. The Bentway Conservancy was established as an agency to maintain the public space and, most importantly, organize and program events and activities throughout the year. The Bentway project uses the same strategy as in OMA's Park de la Villette design, and cultural practices and uncertainties are conceptualized as desired qualities under a fixed-system organization and identity that fit within a linear urban park typology.

After Hurricane Sandy hit the New York City region in 2012, the Rebuild by Design competition called for projects to address the issue of climate resilience through landscape strategies. Led by Bjarke Ingels Group (BIG), The BIG U proposal was one of the finalists. It proposed a protective system in Lower Manhattan to run from West 57th Street to the southern tip of Manhattan Island and then back up to East 42nd Street, forming a U-shape to shield Lower Manhattan. The U-shape comprises a series of flood infrastructures which could be used as public spaces for all sorts of activities, from jogging to practicing tai chi, as rendered by the architects. The Rebuild by Design competition specifically requested the teams to conduct community engagement in the design process. In a way, community feedback could be understood as uncertainty that undermines designers' intentions. From this perspective, the flexibility of the BIG U manifests in its ability to accommodate various inputs from stakeholders and community members and provide multitudes of activities to meet their needs. However, that flexibility is based on an aggressive and dominating organizational framework—the U-shaped protective system. In other words, in the BIG U, we observe a tactic similar to one practiced by OMA in the Park de la Villette and the Downsview competition: because the suggested programs and activities rest on the structural level, they can be of any type as long as the overall organization of the system remains invariant. Since the U-shape remains unchanged, it matters very little what sorts of activities can occur and in which forms the infrastructures are built. Community feedback poses uncertainties on the structural level, and they are instrumentalized in maintaining the identity of the BIG U through autopoietic self-production. In a way, community members are encouraged to accept the BIG U as a given constant, and thus community engagement should never pose any genuine challenge to those characteristics that give the project its identity; on the contrary, the more feedback generated, the more flexible the BIG U appears to be to accommodate uncertainties.

This can be observed in recent years, when the BIG U was implemented in the planning and design of several sections of flood infrastructure in Lower Manhattan, named the East Side Coastal Resilience (ESCR), Brooklyn Bridge Montgomery Coastal Resilience (BMCR), Lower Manhattan Coastal Resilience (LMCR), and Battery Park City Resilience (BPCR) Projects. The ESCR created the most controversy among these implementations when the demolishment of the existing East River Park began in December 2021 despite protests and objections from an activist group called "East River Park ACTION," which blamed the plan for being "destructive." The ACTION group critiqued the plan, calling it "ugly and cruel" and "environmentally destructive," yet the activists could not fundamentally challenge it because their objections remained structural rather than organizational. The aggressive and dominating U-shaped protective system remains an organizational framework.

The ESCR proposes deconstructing the existing East River Park to build a new park on an elevated flood infrastructure. The rendering of the park shows yet another conventional pictorial urban park programmed with fields and playgrounds—an elevated urban park on a flood wall is the least innovative approach for coastal adaptation. The BIG U fails to offer any room to imagine an alternative coastal landscape that sustains a new urban coastal ecosystem for a new type of lifestyle. The organization of the BIG U and its implementations is a homeostatic framework that seeks to maintain the status quo of Lower Manhattan—including its high-density financial center, which is, ironically, a fundamental part of the world's capitalist system which many would argue is responsible for climate change-induced extreme weather such as Hurricane Sandy. From this vantage, the Rebuild by Design competition and the resilient mindset create an ultimate organizational framework that promotes homeostasis and stability over change and uncertainty.

Notes

1 Spirn, "Constructing Nature: The Legacy of Frederick Law Olmsted," 113.
2 Berrizbeitia, "Scales of Undecidability."
3 Lystra, "McHarg's Entropy, Halprin's Chance."
4 Lystra.
5 Lystra, 77.
6 Hayles, *How We Became Posthuman*.
7 Heims, "Introduction to 'The Human Use of Human Beings,'" xv.
8 Wiener, *The Human Use Of Human Beings*, 12.
9 Wiener, 26.
10 Wiener, 34.
11 Wiener, 95.
12 Lystra, "McHarg's Entropy, Halprin's Chance." 75.
13 Spirn, "Ian McHarg, Landscape Architecture, and Environmentalism: Ideas and Methods in Context."
14 Spirn, 107.
15 Lystra, "McHarg's Entropy, Halprin's Chance," 76.
16 Heylighen and Joslyn, "Cybernetics and Second-Order Cybernetics," 3.
17 Barthes, "The Death of the Author."
18 Foucault, "Authorship."
19 Wolfe, What Is Posthumanism?
20 Hayles, *How We Became Posthuman*, 132.
21 Lettvin et al., "What the Frog's Eye Tells the Frog's Brain."
22 Maturana and Varela, *Autopoiesis and Cognition*, 48.
23 Maturana and Varela, 24.
24 Hayles, *How We Became Posthuman*, 149.
25 Halprin, *Lawrence Halprin on Design: RSVP Cycles*.
26 Waldheim, "Strategies of Indeterminacy in Recent Landscape Practice," 82.
27 OMA, "Parc de La Villette." https://www.oma.com/projects/parc-de-la-villette. Last accessed: April 29, 2024.
28 OMA, "Downsview Park." https://www.oma.com/projects/downsview-park. Last accessed: April 29, 2024.
29 Maturana and Varela, *Autopoiesis and Cognition*, xx.
30 Berrizbeitia, "Scales of Undecidability," 124.
31 OMA, "Downsview Park."
32 Berrizbeitia, "Scales of Undecidability," 124–25.
33 Hayles, *How We Became Posthuman*, 142.

34 Maturana and Varela, *Autopoiesis and Cognition*, 48.
35 Maturana and Varela, *Autopoiesis and Cognition*.
36 Ray, "An Approach to the Synthesis of Life."
37 Hill, "Urban Ecologies: Biodiversity and Urban Design," 99.
38 Berrizbeitia, "Scales of Undecidability," 125.
39 Czerniak, *Downsview Park Toronto*, 58.
40 Czerniak, 58. Emphasis added.
41 Hill, "Shifting Sites."

Bibliography

Barthes, Roland. "The Death of the Author." In *Image-Music-Text*, translated by Stephen Heath, 142–48. London: Fontana, 1977.

Berrizbeitia, Anita. "Scales of Undecidability." In *Downsview Park Toronto*, edited by Julia Czerniak, 117–25. CASE Series (Prestel Verlag). Munich; London: Prestel, 2001.

Czerniak, Julia, ed. *Downsview Park Toronto*. CASE Series (Prestel Verlag). Munich; London: Prestel, 2001.

Foucault, Michel. "Authorship: What Is an Author?" *Screen* 20, no. 1 (1979): 13–34.

Halprin, Lawrence. Lawrence Halprin on Design: RSVP Cycles, 2003. https://www.youtube.com/watch?v=QbIi966lOLs.

Hayles, Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago, IL: University of Chicago Press, 1999.

Heims, Steve J. "Introduction to 'The Human Use of Human Beings.'" In *The Human Use Of Human Beings: Cybernetics And Society*, New edition, xi–xxiii. New York: Da Capo Press, 1988.

Heylighen, Francis, and Cliff Joslyn. "Cybernetics and Second-Order Cybernetics." In *Encyclopedia of Physical Science and Technology*, 155–69. Amsterdam: Elsevier, 2003. https://doi.org/10.1016/B0–12–227410-5/00161-7.

Hill, Kristina. "Shifting Sites." In *Site Matters: Design Concepts, Histories, and Strategies*, edited by Carol Burns and Andrea Kahn, 131–55. New York: Routledge, 2015.

———. "Urban Ecologies: Biodiversity and Urban Design." In *Downsview Park Toronto*, edited by Julia Czerniak, 90–101. CASE Series (Prestel Verlag). Munich; London: Prestel, 2001.

Lettvin, J., H. Maturana, W. McCulloch, and W. Pitts. "What the Frog's Eye Tells the Frog's Brain." *Proceedings of the IRE* 47, no. 11 (November 1959): 1940–51. https://doi.org/10.1016/B0-12-227410-5/00161-7.

Lystra, Margot. "McHarg's Entropy, Halprin's Chance: Representations of Cybernetic Change in 1960s Landscape Architecture." *Studies in the History of Gardens & Designed Landscapes* 34, no. 1 (January 2, 2014): 71–84. https://doi.org/10.1080/14601176.2013.850313.

Maturana, H. R., and F. J. Varela. *Autopoiesis and Cognition: The Realization of the Living*. Boston Studies in the Philosophy and History of Science. Cham: Springer Netherlands, 1980. https://doi.org/10.1007/978-94-009-8947-4.

Ray, Thomas S. "An Approach to the Synthesis of Life." In *Artificial Life II: Santa Fe Institute Studies in the Sciences of Complexity*, edited by Christopher G. Langton, Charles Taylor, J. Doyne Farmer, and Steen Rasmussen, XI:371–408. Redwood City, CA: Addison-Wesley, 1991.

Spirn, Anne Whiston. "Constructing Nature: The Legacy of Frederick Law Olmsted." In *Uncommon Ground: Rethinking the Human Place in Nature*, edited by William Cronon, 1st ed., 91–113. New York; London: W. W. Norton & Company, 1996.

———. "Ian McHarg, Landscape Architecture, and Environmentalism: Ideas and Methods in Context." In *Environmentalism in Landscape Architecture*, edited by Michel Conan, 97–114. Washington, DC: Dumbarton Oaks, 2000.

Waldheim, Charles. "Strategies of Indeterminacy in Recent Landscape Practice." *Public*, no. 33 (2006): 81–86.

Wiener, Norbert. *The Human Use Of Human Beings: Cybernetics And Society*. New edition. New York: Da Capo Press, 1988.

Wolfe, Cary. *What Is Posthumanism?* Posthumanities Series. Minneapolis: University of Minnesota Press, 2010.