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Forms of Ecology: Towards New Epistemological Binds between Landscape Architecture and Ecology

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FORMS OF ECOLOGY

Towards New Epistemological Binds between Landscape Architecture and Ecology

A dissertation presented

by

Pablo Pérez-Ramos

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Forms of Ecology

Towards New Epistemological Binds between Landscape Architecture and Ecology

Abstract

Forms of Ecology examines the main narratives through which ecology has come to the forefront of landscape architecture during the last two decades, criticizes their reductive implications for design, and proposes a series of alternative narratives of ecology that emphasize ideas of form, by which it fosters new relationships between ecology and landscape architecture as a way to bolster the agency of design as a cultural project.

The dissertation departs from a critique of the emphasis on the operative capacities of landscape brought about by ecology's move to the foreground of landscape architecture. Indeed, the last decades have witnessed a proliferation of ecologically-grounded landscape architecture discourses and built works that emphasize notions of *performance*—the capacity to carry out work—and *adaptation*—the capacity to accommodate change in order to endure. While performance and adaptation, as I shall show through the revision of several case studies, have been extremely fruitful ideas in expanding the field of landscape architecture and its modes of practice, they also entail limitations for design. Through performance, landscape architecture is often invoked as a problem-solving practice, invested in the production of systems to assist in the ecological project of environmental efficiency, and largely unaware of landscape formal associations, that is, landscape's possibility of being looked at and deciphered. I argue that adaptation, on the other hand, calls for landscape strategies that privilege ecological complexity and its process-based notions of indeterminacy, unpredictability, and open-endedness, which often restrain

landscape architecture's agency in favor of passive positions that relinquish the specification of design outcomes to external forces.

In order to overcome these limitations, the dissertation investigates the origins of these ecological views and their biased interpretations of system and process. In so doing, it draws a lineage of the core debates in the evolution of ecological theory during the twentieth century. Amply overlooked in contemporary landscape architecture, core to these debates were questions around the fundamental ecological entity—whether it is the biotic community or the individual organism—and the different modes of interaction that exist between them, as well as around the homeostatic and stochastic nature of environmental processes. The research looks back into the nineteenth century embryonic stages of ecological theory, where these ideas were not so neatly delineated but, instead, embedded within metaphysical and epistemological concepts of form.

In seeking to forge new relationships between ecology and landscape architecture, the dissertation applies the conceptual frameworks derived from these debates to the examination of a series of case studies that emphasize the legibility of the different modes of interaction established between designed landscapes and their environment and the different ways by which design deliberately speeds up or slows down the processes through which the environment is formed. In so doing, it contributes to the formulation of new epistemological binds between landscape architecture and ecology. Such an expanded field of reciprocity between design and science allows for a better understanding of the formative processes and interactions of designed landscapes and for an increase in landscape architecture's potential to articulate new forms of thought that both work on the environment and render it legible as a social construction.

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INTRODUCTION

Forms of Ecology

Introduction. Forms of Ecology

The purpose of this dissertation is to investigate the relationship between ecology and landscape architecture. It examines the main narratives through which ecology has come to the forefront of landscape architecture during the last two decades and criticizes their ultimately reductive implications for design. By looking at some of the key concepts in the theory and philosophy of the field, it proposes a set of counter-narratives of ecology that emphasizes ideas of form, by which it seeks to formulate new relationships between ecology and landscape architecture that bolster the agency of design as a cultural project.

Ecology has been at the forefront of landscape architecture theory and practice for almost five decades now. The growing influence of ecology on landscape architecture and the design fields in general is part of the larger move of ecology into positions of extraordinary social and cultural relevance with the rise of environmentalism in the late 1960s and 1970s. In order to scientifically endorse its emerging postulates, environmentalism aligned itself with some of the mid-twentieth century ecological axioms. In so doing, it eventually elevated ecology to the category of central theory in the interpretation of the environment and made it a fundamental technique for its control and protection.[1] Landscape architecture, motivated by the expansion of the environmentalist agenda, became progressively aware of ecology's principles and more experienced in some of its associated practices, in a phenomenon that extends to our days. Through its 1960s alliance with ecology, landscape architecture became a productive instrument of environmentalism, increasing its relevance and public visibility, and ending up a period of relative marginalization as a design field during the first half of the twentieth century.

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[1] Philosopher David Keller and ecologist Frank Golley argue that today ecology is something vaguely synonymous with "environmentalism." In their argumentation they note that in the *Environmental Ethics* journal, which has been a very influential one in the definition of the field, more than thirty papers were published between 1979 and 1996 with the words *ecology*, *ecological*, or *ecosystem* in the title, while only a small fraction of these actually touched even tangentially the question of ecology as a *scientific* field. David Keller and Frank Golley, "Ecology as a Science of Synthesis," in *The Philosophy of Ecology: From Science to Synthesis* (Athens: The University Of Georgia Press, 2000), 1-20.

With the impulse of environmentalism, ecology transcended its original bounds within the natural sciences, penetrating the social and cultural spheres and launching, in so doing, a process of almost indiscriminate expansion and convolution of its already comprehensive inaugural agenda—the study of the relationships of the organism to the environment.[2] When dealing with ecology, the design fields have been also far from providing a monolithic response as a single school of thought; instead, the ways in which design has mobilized ecology are quite diverse, ranging from an understanding of ecology as scientific mandate, metaphor for rhetorics, and intellectual justification. In this third category we normally find plainly formulaic modes of practice, which simply incorporate ecology as a buzzword to provide design with some sort of null ideological or aesthetic patina. Leaving those aside, more critical landscape architecture theories and practices have broadly exercised an understanding of ecology either as a source of guidelines towards specific scientific targets, or as inspiration for representational or experiential pursuits. After fifty years of ecologically-driven landscape architecture, it is possible to begin to organize these various design expressions into a genealogical structure. As part of this exercise, it is also possible to draw the lines that connect these manifestations with the concomitant shifts in the scientific theories of ecology, on the one hand, and, on the other, with the new cultural connotations that the very word "ecology" has incorporated over the years.

Quite schematically, this timeline of ecology in landscape architecture begins in the late 1960s and 1970s, in the midst of the rise of the environmentalist movement. In 1969, Ian McHarg published the now classic *Design with Nature*, which greatly contributed to a larger project of transformation of landscape architecture into a productive field essential to "solving" environmental "problems."[3] Through professional practice and education, McHarg introduced a design method that departed from the preparation of a comprehensive and systematized ecological inventory, which served as scientific base

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[2] As I will explain in chapter 1, ecology was first introduced as a branch of biology in 1866, when Ernst Haeckel, a German naturalist and fervent follower of Charles Darwin, defined it in his textbook *General Morphology of Organisms,* as the "science of the relations of the organism to the environment." Ernst Heinrich Philipp August Haeckel, *Generelle Morphologie Der Organismen. Allgemeine Grundzüge Der Organischen Formen-wissenschaft, Mechanisch Begründet Durch Die Von Charles Darwin Reformirte Descendenztheorie* (Berlin: G. Reimer, 1866), 286.

[3] Ian McHarg, *Design with Nature* (Garden City, N.Y.: Natural History Press, 1969).

for, first, the diagnosis of any given environmental situation, second, the identification of problems and opportunities, and, ultimately, the definition of a holistic strategy for development. McHarg's method aligned with a mechanistic approach to ecology based on the idea of the "ecosystem," where exhaustive analysis was the foundation for the control and directability of the environment. Overwhelmingly dominant in mid-twentieth century ecology, this mechanistic model was the same that environmentalism took as both the central theoretical apparatus that would offer the most competent frameworks for the interpretation of the environment and, consequently, as the applied science that would provide the adequate protocols for intervention.

In the 1980s and 1990s, a new generation of landscape architects drew upon previous experiences in the context of environmental art as a reaction to what they considered an overly deterministic ecological program in design. These authors critically rejected analytics and developed instead a largely phenomenological approach to the environment that privileged the experience of change, time, and motion, introducing, in doing so, a new vocabulary of process-based aesthetics in landscape architecture. With their new modes of expression, these practices were implicitly engaging new theories of ecology which, as a result of the rise of complexity in the larger scope of science, had begun to diminish the directional and balanced character of the mid-twentieth century concept of "ecosystem" in favor of ideas of "ecological succession" that emphasized a continuously changing and often ungovernable image of the environment.[4] In these projects, there was also an interest in addressing new post-environmentalist discourses which, also starting in the 1980s and coming mainly from the humanities, were critically questioning longtime-accepted dichotomies in contemporary culture, and suggesting, among other

[4] See Donald Worster, "The Ecology of Order and Chaos," *Environmental History Review* 14, no. 1/2 (April 1990), 1-18. I will elaborate on these notions with detail in chapter 3.

reconsiderations, the cancellation of the very notion of "nature" in environmental philosophy,[5] or new aesthetic interpretations of environment as *medium* rather than *otherness.*[6]

With the turn of the twenty-first century, a general shift often alluded to as "the projective" has taken place in the design fields. Its proponents generally claim that the cultural relevance of the design disciplines lies more in their capacity to have an impact on the material world and to engage the forces that shape it, than in their capacity to explain or represent it.[7] As part of the agenda of the projective, the relationship between landscape architecture and ecology has been largely reformulated.

On the one hand, the notion of "landscape performance"—the ability of landscapes to carry out work—has become pervasive in today's landscape architecture lexicon. The notion of "performance" not only constitutes an eloquent indication of the "projective shift" towards an understanding of design as an eminently material and instrumental practice but is also one of the most dominant expressions of the contemporary "problem-solving" agenda of landscape architecture. Under the rubric of sustainability, the twentieth century agenda of environmentalism has been projected into the early decades of the twenty-first, bringing a new attention to ecosystems through the notion of "ecosystem services"—the benefits humans get from properly working ecosystems.[8] As a result of this renovated mechanistic approach, it is easy to find in today's landscape architecture practice and education abundant references to ecological

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[5] In the early 1990s, Neil Evernden argued that the very act of giving a name to "nature" implied a dichotomy between the natural world and the human world. See Neil Evernden, *The Social Creation of Nature* (Baltimore, Johns Hopkins University, 1992). In more recent years, authors like Steve Vogel and Timothy Morton have claimed that the very notion of "nature" is obstructing the development of properly ecological forms of culture, philosophy, politics, and art. See Steven Vogel, "Against Nature", in *Thinking like a Mall* (Cambridge MA: The MIT Press, 2015), 1-31, and Timothy Morton, *Ecology without Nature* (Cambridge, MA: Harvard University Press, 2007).

[6] Arnold Berleant and his work on environmental engagement and aesthetics is seminal here. See Arnold Berleant, *The Aesthetics of Environment* (Philadelphia: Temple University Press, 1992), and Arnold Berleant, *Art and Engagement* (Philadelphia: Temple University Press, 1991).

[7] I will provide a more detailed revision of the debate around the question of the "the projective," also called the "post-critical," in chapter 2.

[8] Millennium Ecosystem Assessment, *Ecosystems and Human Well-being: Synthesis* (Washington, DC: Island Press, 2005).

engineering systems and techniques by virtue of their functional capacities—such as bio-swales, constructed wetlands, porous pavements, and so on—as well as unprecedented interest in quantifiable data and its computation into key indicators, which serve to measure landscape performance and certify the accomplishment of new "green" goals.

On the other hand, the ideas of complexity that favored the concept of succession in ecological theory during the 1980s have more recently intermingled with the opportunistic approach of projective design practices, yielding discourses of landscape architecture where ecology is mainly invoked to privilege notions of open-endedness, flexibility, emergence, resilience, and self-organization. Through these notions, the "adaptation" of landscapes—their capacity to accommodate change as the only way to endure—has also become a priority, and the process-based aesthetics of change, time, and motion that characterized the engagement of environmental discourses in landscape architecture during the 1980s and 1990s has given way to a more operational and projective approach to "process." By heavily drawing on the notion of ecological adaptation, "process" today emphasizes the provisional and the dynamic, often at the expense of the alleged permanence of forms. Finally, we are witnessing today how the newly incorporated digital technologies, with their capacity to model and simulate change over time, have become a very fruitful medium to derive insights about these eminently adaptive conceptions of process, which, paradoxically, once filtered by the processual logic of algorithms, yield design expressions that in many cases are less operational than purely formalistic.[9]

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By virtue of the sheer comprehensiveness and convolution of its subject matter—explicit in its first definition is the claim that ecology studies all of nature—ecology has been a very fecund field in both producing and supporting different ontic and epistemic frameworks around the concept of nature. So fecund has it been, in fact, that today ecology is not only used to *denote* a scientific discipline, but also to

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[9] Anita Berrizbeitia, "On the Limits of Process," in *New Geographies* 8 *Island*, ed. Daniel Daou and Pablo Pérez-Ramos (Cambridge, Mass.: Harvard University Press, 2016), 110-117.

connote a wide range of aesthetic and ideological narratives. Even through its stricter meaning as a formal scientific field that looks at the structure, evolution, and functioning of environmental relationships, ecology has cultivated different and often confronting models: both holistic and reductionist analytical approaches to the environment have yielded useful results; different theoretical models have assigned significantly different values—including zero—to the human factor in the equation of the environment; some have privileged equilibrium-based images of nature, while some others mainly see nature as a continuously adaptive condition. When it comes to the more expanded meaning of ecology as narrative, the prolificacy is such that the ecological idea is equally invoked today by both resourcist ideologies, according to which the environment is governable and can be controlled through scientific knowledge and technological formulas, and conservationist agendas, for which the environment needs to be protected in order to heal the damage caused by human depredation.

The dissertation claims that, despite the extreme pluralization of meanings, the influence that ecology exerts over the theory and practice of landscape architecture today is largely limited to two very different and well delineated vectors. One of these conveys an idea of ecology as a scientific imperative—ecology as a catalogue of technical formulas at the service of scientific targets—and the other deals with ecology as an aesthetic metaphor that serves to mobilize different interpretations of the environment. Both "ecologies" have certainly participated, as we have just seen, in the development of the theory and practice of landscape architecture during the last five decades. But the scientific targets and the environmental interpretations that these "ecologies" mobilize today in landscape architecture are quite specific and are generally derived from two major changes that the science of ecology experienced during the 1970s.

The first of these is the already mentioned entrance of ecology into the social and political spheres as a result of the rise of the environmental movement. After a few decades of formal scientific pursuit, the then dominant model was suddenly mobilized beyond the scope of the natural sciences as a framework that should provide the rational basis for intervention in the face of newly described environmental problems. Using the ecosystem as the central unit of ecological inquiry, it was suggested that, with the manipulation of ecosystems, the whole planet could be managed for improved efficiency—an idea that is still today firmly rooted in the collective imagination. Through the lens of this ecology, landscape architecture is primarily seen as a problem-solving practice and, as part of this vision, the operative capacities of the landscape are brought to the foreground: landscapes appear as material realities that carry out work and which, in properly doing so, contribute to the overall ecological project of environmental efficiency.

The second change is caused by a major revision in ecological theory promoted by the notion of complexity. Complexity emerged in the sciences at large as difficulties with modeling certain properties of certain systems became the norm, and when it was perceived that the behavior of such systems was not predictable apart from those properties. As complex systems began to be formally studied in the 1970s, ecosystems soon fell within their category, and the deterministic image of the environment drawn by mid-twentieth century ecology began to shift towards a probabilistic model, where the behavior of the environment was not directional anymore through the manipulation of its components. Ecosystems do not follow a single "strategy for development" whose achievement puts them in a closing state of balance;[10] instead, ecosystems unfold towards several different coherent future scenarios—which may or may not come about—through a non-linear process of evolution characterized by uncertainty.[11] This complex-systems ecology has privileged notions of indeterminacy, unpredictability, open-endedness, self-organization, and so on, through which, accordingly, landscapes are seen as conditions that can and must accommodate change in order to endure, and the provisional and the indeterminate are, consequently, emphasized in landscape architecture design.

While the first of these two images of ecology keeps calling for strategies aligned with principles of environmental control, the second one suggests that the intrinsic complexity of the environment is its

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[10] Eugene P. Odum, "The Strategy of Ecosystem Development," *Science* 164 (April 1969), 262-270.

[11] James J. Kay, "An Introduction to Systems Thinking," in *The Ecosystem Approach: Complexity, Uncertainty, and Management for Sustainability*, eds. David Waltner-Toews, James J. Kay, and Nina-Marie Lister (New York: Columbia University Press, 2008), 3-15.

most fundamental property and precisely the reason why governability is just a chimera. The technological neo-positivism of the "scientific imperative" of ecology clashes with the intrinsic nihilism of "ecological complexity." And although much of today's theory of scientific ecology is invested in the mediation between these two apparently conflicting models—so that new ecosystems' management is driven by more flexible and adaptive strategies—in the design fields both paths rarely cross, and when they do, the conundrum that seems to exist between them remains largely unspoken, or dealt without rigor.

The dissertation suggests that there is a strong correlation between this twofold influence of ecology and two of the still tacitly accepted yet most widely utilized expressions in today's vocabulary of landscape architecture: the already mentioned notions of "performance" and "adaptation." "Landscape performance" is generally designated as the capacity of landscapes to carry out work. The focus on sustainability and ecological services proper of the ecological imperative has bolstered the idea of the *performative* in landscape architecture, through which landscape is seen as the fundamental material substratum towards the consummation of an efficient model of environmental management. "Landscape adaptation," on the other hand, is normally used to allude to the capacity of landscapes to accommodate change. Following the imaginary of complexity as the most prevalent ecological metaphor today, notions of resilience and adaptation have become the norm in contemporary landscape architecture; the capacity of design to produce open-ended strategies of self-generation is almost incontestably praised as a fundamental asset in engaging the uncertainty that rules the world of complexity.

While the incorporation of these ecologies and their associated concepts of "performance" and "adaptation" has been extremely fruitful in expanding the field of landscape architecture and its modes of practice, it also entails reductive implications for design. The ecological imperative and the *performative*, on the one hand, exacerbate the techno-scientific dimensions of design; many ecological ideas are disaggregated into a series of problem-solving and quantifiable techniques, which landscape architecture has to put into practice in search of new models of efficient environmental management. The result is a strong emphasis in landscape's ability to work, and a subsequent lack of interest in landscape's formal associations, that is, the capacity of landscape to be looked at and deciphered. As a cultural metaphor, on the other hand, ecology is primarily used today to invoke notions of complexity. Through complexity and the *adaptive*, landscape architecture has been instrumentalized in the aestheticization of process-based notions of unpredictability, open-endedness, and indeterminacy in design, neglecting, as a consequence, alternative modes of formal expression that serve to communicate other ideologies and issues that remain at the core of the discipline.

Both the *performative* and the *adaptive* in landscape architecture pose problematic limitations for design. While the performative's focus on landscape's capacity of work puts the emphasis on technics and often ignores aesthetics in landscape architecture, the adaptive's engagement of notions of complexity presents, on the contrary, a strong aesthetic component. But one that is heavily invested in the exploration of the very specific formal languages of flows and processes that serve to naturalize notions of complexity, uncertainty, and provisionality. So, while the lack of aesthetic discourse in the performative limits the very possibility of design as a means for expression and communication, the adaptive's focus on provisionality and surprise not only limits the repertoire of aesthetic explorations to the fetishization of languages of flows—excluding the putatively top-down methods based on permanence and form—but also restrains design agency in favor of positions of passiveness that relinquish the specification of design outcomes to external and abstract forces.

* * *

From the consideration that ecology, despite the limitations of its current influence over landscape architecture, is still a very valid worldview by which some of today's urgent questions can be approached, the dissertation seeks to articulate alternative narratives of ecology as a way to both counterbalance the imaginaries that prevalent ideas of ecology have normalized in the design disciplines and to bolster the agency of landscape architecture as a cultural and cognitive project. In so doing, the dissertation examines the concepts of "system" and "process" for their key role in the theoretical development of the "ecological imperative" and the complexity approach to ecology, and also for their key role in the more recent emergence of the notions of "performance" and "adaptation" in landscape architecture. It is suggested that the ways in which contemporary landscape architecture deals with system and process is largely dependent on the ways in which ecological theory has managed those same concepts during the twentieth century. When alluded to in landscape architecture design, system often drags elements of the thermodynamic quest for efficiency and the mechanistic connotations of the ecological idea of the "ecosystem." Process, on the other hand, can hardly escape the mainstream ecological view as open-ended phenomenon, and, when it breaks into landscape architecture discourses, notions of provisionality, indeterminacy, and uncertainty normally take prominence.

In order to overcome these biased associations of system and process and to open up their potential for design, the dissertation revisits some of the ontological and epistemological debates that characterized the unfolding of ecological theory during the twentieth century. Preceding the ultimate dominance of the ecosystem since the 1960s, these debates, largely unnoticed in landscape architecture's engagement with ecology, touch upon questions of systemic interconnection and successional processes, by focusing on the ontological status of the primary ecological entity—whether it is the biotic community or the individual organism—and on the ultimate constitution of nature itself—whether there is a "balance of nature," or nature is inherently chaotic.

The dissertation also looks at the embryonic stages in the development of ecological theory, when these concepts were not so clearly delineated but, instead, intricately embedded within metaphysical and epistemological ideas of form. In this sense, it examines the work of nineteenth century proto-ecological authors, such as Alexander von Humboldt, Charles Darwin, and, before them, Johann Wolfgang von Goethe, to propose a series of ecological syntheses according to which it is through the interaction between things, and through their processes of becoming, that things are what they are—that things receive their *form*. Form becomes through these syntheses, as in Aristotelian metaphysics, the essence of things, and also an epistemological entry point through which the interrelatedness of things and their shared developmental processes can be apprehended.

Following these premises, rather than focusing on a mechanistic and techno-scientific notion of "system"—as most of twentieth century ecology and, through it, contemporary landscape architecture generally do—the dissertation puts the accent on a rather monistic notion of "system:" once freed from its "ecosystemic" connotations, notions of quantification and energetic efficiency recede and the idea of "system" focuses instead on the interdependence between seemingly disconnected elements, helping to constitute an idea of environment as a compound of interacting entities. In such an environment, every entity is an expression of its relationships with the rest, and therefore a synecdochic expression of the environment itself. A capacity that, of course, applies to entities that are the result of the practice of landscape architecture. In this sense, the dissertation examines landscape architecture projects concerned with the establishment of a spatial dialogue between the object of design and its environment, in which a more nuanced relationship between performance and legibility can be produced by means of the concepts of system and form.

Similarly, rather than focusing on notions of process that privilege ideas of instability, uncertainty, and emergence—as has been the case in ecological theory for the past decades and again, through it, in landscape architecture—the dissertation emphasizes a gradualist notion of "process." In opposition to the idea of environment proposed by complexity discourses, with its marked polarization between images of perpetual equilibrium and of sudden, unpredictable change, this gradualist notion of process suggests an environment that modulates between both extremes, an environment as an aggregate of processes that unfold at different temporalities and which, in their continuous unfolding, constitute the source of form and novelty. The dissertation focuses, in this sense, on landscape architecture strategies deliberately intended to speed up or slow down the processes through which the environment is formed. By looking at landscape projects, whose forms are specifically designed in order to render visible those processes of change—both those that entail a movement further from tension and towards higher equilibrium, and vice-versa—the cultural project of landscape architecture is bolstered through the expression of the friction existing between notions of environmental adaptation and design precision.

* * *

In seeking to bolster the agency of design as a critical project, this dissertation puts the accent on works of landscape architecture whose primary motivation is to be looked at and deciphered as representations of particular positions in regards to the different modes of interaction that exist between designed landscapes and their environment and the different ways by which design deliberately speeds up or slows down the processes through which the environment is formed. In so doing, it suggests an epistemological bind between landscape architecture and ecology. One that, on the one hand, provides landscape architecture with a new epistemological role, that of constructing new forms of thought that help to better understand ecological conceptions of the world and render them legible. And one that, on the other, allows landscape architecture design to be seen through the lens of ecology—for ecology is, as we have seen, an epistemological framework itself—so that the processes of becoming of designed landscapes as well as the interactions with their contexts can also be better understood.

If, following its original definition, ecology is the science of the relationships of the organism with its environment, the dissertation emphasizes an idea of landscape architecture as the medium through which those relationships can and must be represented. If, in the face of some of today's pressing challenges, the relevance of ecology can be explained by its capacity to articulate ideas of environment as an aggregate of processes that unfold independently to us, but whose ground and fate we inevitably share, the dissertation claims that landscape architecture must be the medium through which such narratives are given form. If that is one of today's most relevant projects for landscape architecture, then its practice cannot just be reduced to the satisfaction of ecological performance exigencies, nor to the indeterminacy of design in favor of notions of adaptation to the agency of external forces. Instead, landscape architecture needs to broaden its field of action by reconciling ecology's imperatives with the possibility of design to represent new modes of thinking about the environment as social construction, and to communicate those through the specificity and legibility of form.

Structure and Method of the Work

The work is structured in three parts: the first one covers the lineage of the relationship between ecology and landscape architecture, the second sets the basis for an alternative formulation of that relationship, and the third one supports and illustrates that reformulation with specific examples of landscape architecture (*Figure i.1*). The first part, consisting of the first two chapters, overviews the influence of ecology over landscape architecture, by accounting for the polysemic and comprehensive meaning that the term ecology has acquired in its short history, and provides a quick chronology of ecologically-driven landscape architecture design. The second part, consisting of the two following chapters, suggests a revision of ecology in order to propose a new relationship with design. It does so by, first, using proto-ecological positions of the nineteenth century as a way to examine the metaphysics of some of the main concepts in the development of the field and, second, through the consideration of some ontological and epistemological debates in ecological theory during the first half of the twentieth century that remain largely neglected in landscape theory. The third part, covering the last three chapters, discusses a series of landscape architecture projects and built works as examples that illustrate the ability of design forms to represent this expanded idea of ecology through three different dialectics: discreteness and continuity, transcendence and immanence, and tension and equilibrium.

More precisely, chapter 1 analyzes the wide range of ideas and definitions around the term "ecology," from its original inception in the late nineteenth century as a sub-discipline of biology to its maturation as a modern science in the mid-twentieth century and to the multiple semantic and ideological bifurcations that have invaded the field since the 1970s. Chapter 2 offers a revision of the different modes in which ecology has impregnated the field of landscape architecture since the rise of environmentalism in the 1960s and 1970s—mainly as a scientific imperative and as a metaphor for ideas of complexity—to then focus on the more specific narratives through which ecology has come to the forefront of landscape architecture during the last two decades—the performative and the adaptive. It also analyzes the very particular conceptions of "system" and "process" that these narratives have induced in landscape architecture theory and practice. Chapter 2 ends with a critique of the problematic implications of these narratives for landscape architecture.

Chapter 3 grounds these ideas into the ontological and epistemological debates around the structure and the evolution of nature that were central in the maturation of ecology during the twentieth century. These debates revolved around the issue of reductionism versus holism in the construction of ecological knowledge: whether ecological entities have "emergent" properties or the properties of ecological entities can be understood by the analysis of the parts; the question of homeostasis versus stochasticity in the evolution of nature—nature as an aggregate of processes that tends toward some state of balance, or one in a perpetual barrage of chaotic shifts; and the tension between essentialism and nominalism—whether ecological entities have ontological value or not. These debates in ecological theory will serve to expand the reductive conceptions of "system" and "process," which ecology has introduced in landscape architecture over the past two decades.

Chapter 4 seeks to build syntheses from these debates. By looking at the work of nineteenth century proto-ecological thinkers Alexander von Humboldt, Charles Darwin, and, before them, Johann Wolfgang von Goethe, chapter 4 proposes three major ecological syntheses: the synthesis of becoming, the synthesis of interaction, and the synthesis of conjunction. Through the first synthesis, the synthesis of becoming, process becomes a core principle in ecological thinking, but one that is less concerned with notions of unpredictability and more with the idea of formation. This first synthesis, with its accent on process and becoming, allows for a reading of the environment that is simultaneously solid and fluid, for what is perceived as stable is in fact just a phase in the long duration of a continuous process of change. Through the second, the synthesis of interaction, the notion of system also remains a fundamental principle of ecology, but one that is freed from its energy and efficiency connotations in order to put the accent, instead, on the interrelatedness between different entities. These notions of system and interaction allow us to think of entities as deriving their essence from a dual condition as both wholes in themselves—autonomous and independent—and as parts of larger wholes—engaged and interdependent. The last synthesis, the synthesis of conjunction, recapitulates the two previous ones by putting the accent on the idea of entity as expression of specific relations in a system of interactions, and the idea of form as expression of specific phases in a process of becoming. Through this synthesis of conjunction, entities and their forms are literally synecdoches of larger spatial and temporal orders, where the singular invokes the complex, and the one conjoins the many.

Finally, the third part, consisting of chapter 5, chapter 6 and, chapter 7, offers a series of landscape architecture works and projects as examples by which some of the ideas developed in the second part are grounded in design thinking. The title of each of these three chapters consists of the association of two antithetical concepts: "Discreteness and Continuity" in chapter 5, "Transcendence and Immanence" in chapter 6, and "Tension and Equilibrium" in chapter 7. These binary formulas refer, on the one hand, to alternative ontological categories that define the notion of environment but also serve to discuss, on the other, different formal operations by which landscape architecture unfolds a new agency as an epistemological project to approach such definitions. In accordance to the synthetic narrative of ecology proposed in the second part of the dissertation, each of the three chapters suggests a conceptual and formal synthesis of the antithetic binary of the title.

In chapter 5, a genealogy of design of botanic gardens between the sixteenth and the nineteenth centuries illustrates the epistemological bind that existed between landscape architecture and the different classification systems that existed in the natural sciences during the modern age, some of which interpreted species as discrete classes and some others as links in a continuous chain. Chapter 6 takes the question of transcendence and immanence to discuss different modes of both internal relationships in landscape architecture design projects and external relationships between projects and their environments. Chapter 7 uses the relationship between tension and equilibrium as a way to discuss different orders in landscape architecture through the engagement of energy and process.

PART 1

CHAPTER 1

The Polysemy and Comprehensiveness of Ecology

The Polysemy and Comprehensiveness of Ecology

The word "ecology" encompasses a wide range of ideas and definitions. A term coined in 1866 by the German naturalist Ernst Haeckel, it originally served to name a new branch of biology aimed at the study of the living organism in relationship to its environment.[1] Relatively dormant during the next fifty years, it began to develop a specific body of knowledge in the early decades of the twentieth century with the work of the American botanists Frederic Clements and Henry Gleason, who proposed two alternative interpretations of the structure and behavior of plant associations, and the British botanist Arthur Tansley, who emphasized the consideration of the abiotic components of the environment and introduced the concept of the "ecosystem."[2] It is generally considered that the moment where the field achieves a mature state as a modern scientific discipline is the publication in 1953 of Eugene Odum's *Fundamentals of Ecology*, the first textbook in ecology, where some of the previous and discordant theories were agglutinated.[3] During the years that followed the publication of the *Fundamentals*, Tansley's "ecosystem" gained preeminence, and the project of ecology evolved into the understanding of energy flows across and between ecosystems, which were largely analyzed as physical systems. With the rise of environmentalism in the late 1960s and early 1970s, this ecosystems ecology was heralded as the science that should not only study but also manage those ecosystems in order to alleviate the adverse effect of humans. As a result of the managerial mission it was assigned, the field gained great cultural relevance during the last quarter of the twentieth century, transcending the scope of the natural sciences and permeating the social sciences and the humanities, including the design fields. Entering the twenty-first century, the meaning of ecology has expanded and been convoluted further, and the term is broadly used today as a metaphor that, by virtue of a notion of environment as an integral web, refers to any complex and dynamic set of interrelations.

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[1] Ernst Heinrich Philipp August Haeckel, *Generelle Morphologie Der Organismen. Allgemeine Grundzüge Der Organischen Formen-wissenschaft, Mechanisch Begründet Durch Die Von Charles Darwin Reformirte Descendenztheorie* (Berlin: G. Reimer, 1866), 286.

[2] Arthur G. Tansley, "The Use and Abuse of Vegetational Concepts and Terms," *Ecology* 16, no. 3 (July 1935), 284-307.

[3] Eugene P. Odum, *Fundamentals of Ecology* (Philadelphia: Saunders, 1953).

In this sketchy timeline there are implicit at least three different connotations of ecology: ecology as an incipient branch of biology, ecology as a modern scientific discipline, and ecology as a cultural metaphor. The pervasiveness of the term, which impregnates any imaginable field of knowledge, including the design fields, the sheer amplitude of the signified in all of its possible acceptations—be it the relationships between organism and environment, the understanding and management of energy flows, or the image of an integral web—and the frequent and often conscious lack of precision in the meaning intended in each case, are some of the reasons that explain the confusion surrounding the use of ecology. Not by chance, ecology is equally invoked today by both environmentalists and neoliberals in order to sustain very different—if not frontally opposed—ideological agendas.

The design fields do not escape the intrinsic contradictions of ecology. The term has permeated the design vocabulary, especially during the last two decades, and has become particularly ubiquitous in landscape architecture and urbanism. Motivated by different discourses around the notion of environment, and invested in the very *production* of large scale and complex environments, landscape architects and urbanists have become increasingly knowledgeable and experienced in ecological principles and practices, certainly expanding, in so doing, the agency and disciplinary relevance of the design fields. We see, at the same time, that the term ecology is deployed in irreconcilable ways: at times it calls for techno-scientific strategies aligned with principles of environmental control, and other times it suggests that the complexity of the environment escapes any possibility of control and that design should instead accept uncertainty.

These contradictions now inherent in the word "ecology" arise from the semantic bifurcations that the term has experienced in its relative short history. In order to set the base for discussion of the relationships between ecology and landscape architecture, this chapter elaborates on the three connotations of ecology just mentioned and their associated intellectual projects. In so doing, it dedicates a few lines to the inception of ecology as a scientific field that, in studying the organism in relationship to its environment, aimed at covering a gap between other nineteenth century branches of biology, such as physiology, botany, and zoology. Then it turns to the idea of ecology as a mature modern science primarily invested in the understanding and management of various energy flows across the environment to then finish by discussing the emergence of various cultural narratives that emerged around the term ecology during the last third of the twentieth century. I will conclude with a brief discussion on what is often referred to as "ecological thinking," that is, the idea of ecology as ontological and epistemological framework whose image of the world is mainly characterized by an emphasis on notions of interconnectedness and evolution.

The Inception of a Branch of Biology

As with any other branch of knowledge, ecology was established as a formal scientific discipline at the time the term was coined to define a specific area of study. This happened in 1866, when Ernst Haeckel, a German naturalist and fervent follower of Charles Darwin, introduced the word in his textbook *General Morphology of Organisms* (*Figure 1.1*) and defined it as the "science of the relations of the organism to the environment."[4] More precisely, in Haeckel's text we read:

> By ecology, we mean the whole science of the relations of the organism to the environment including, in the broad sense, all the "conditions of existence." These are partly organic, partly inorganic in nature; both (…) are of the greatest significance for the form of organisms, for they force them to become adapted.[5]

The reference to the subject matter—literally, the relations of the organism to the environment—is explicit, but also explicitly extensive and complex. Haeckel considers that ecology should be invested in the study of *all* environmental conditions, both organic and inorganic, that have an influence over life on earth. He continues and explains what he means by these:

> Among the inorganic conditions of existence to which every organism must adapt itself belong, first of all, the physical and chemical properties of its habitat, the climate (light, warmth, atmospheric conditions of humidity and electricity), the inorganic nutrients, nature of the water and of the soil etc.

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[4] Ernst Heinrich Philipp August Haeckel, *Generelle Morphologie Der Organismen. Allgemeine Grundzüge Der Organischen Formen-wissenschaft, Mechanisch Begründet Durch Die Von Charles Darwin Reformirte Descendenztheorie* (Berlin: G. Reimer, 1866), 286.

[5] Haeckel, *Generelle Morphologie Der Organismen*. English translation in Robert C. Stauffer, "Haeckel, Darwin and Ecology," *The Quarterly Review of Biology* 32, no. 2 (1957): 138–144, 140.

> As organic conditions of existence we consider the entire relations of the organism to all other organisms with which it comes into contact, and of which most contribute either to its advantage or its harm.[6]

Haeckel refers to the relations between the organic and inorganic conditions of existence by making several allusions to biology. More particularly, he speaks about physiology, a biological science that he considered "incomplete" because of its limited focus on the relationships of the different parts of the organism to each other and to the whole.[7] Physiology had almost exclusively investigated, in other words, the internal relationships of the organism, and had neglected, on the contrary, external relationships. For Haeckel this was problematic; it was not possible to understand the organism independently from its processes of formation, which, in line with Darwin's recent and groundbreaking theory of evolution, were governed by the adaptive relationships of the organism to its medium.

With his definition, Haeckel also tries to create some disciplinary distance with the fields of botany and zoology. These, contrary to physiology, had certainly been devoted to the scientific study of external relationships between organisms but with a focus on the formulation of taxonomic logics through which formal similarities and disparities among different organisms could be studied. But again, the understanding of the developmental associations between organism was left aside. For a passionate supporter of Darwin's ideas, these cause-effect relationships between organisms were of critical importance in the understanding of life, for they ultimately forced organisms to adapt and evolve, and yet they were not being systematically studied.[8] With ecology, Haeckel was trying to use Darwin's theories of natural selection and evolution to cover the gap he had identified between the different branches of biology, and, in so doing, called for a shift of attention from the reductionist work in the laboratory to a more holistic study of organisms in their environment.

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[6] Ibid.

[7] Ibid., 141.

[8] Haeckel's emphasis in the connection between the new field of ecology and Darwin's evolutionary theory was made explicit in the full title of the book in which the word "ecology" first appeared: *Generelle Morphologie Der Organismen. Allgemeine Grundzüge Der Organischen Formen-wissenschaft, Mechanisch Begründet Durch Die Von Charles Darwin Reformirte Descendenztheorie.*

Of course, the turn towards the study of organisms in their "natural" setting not only implied the study of their relations with other organisms—the biotic components of the environment—but also relations with inorganic—abiotic conditions. By inorganic conditions, Haeckel referred to the combined physical and chemical properties of the environment, that is, its geological structure, its hydrology, the atmospheric and climatic processes involved in its formation, light, solar radiation, air quality, etc. By not only including the study of the morphology of organisms as it derived from their adaptive relations to other organisms, but also the study of all environmental abiotic conditions as factors that also exerted profound transforming action in the evolution of organisms, Haeckel was suggesting that the project of ecology was essentially a project of synthesis, for the subject matter of ecology was the totality of nature. A few lines below his first definition of the field, he writes that:

> all the infinitely complicated relations in which each organism occurs in relation to the environment […] the steady reciprocal action between it and all the organic and inorganic conditions of existence […] are the necessary effects of existing matter with its inalienable properties and their continual motion in time and space. Thus the theory of evolution explains the housekeeping relations of organisms mechanistically as the necessary consequences of effectual causes and so forms the monistic groundwork of ecology.[9]

Following the lineage of German Romanticism—which had had a significant impact on the natural sciences during the first half of the nineteenth century—Haeckel defended the idea of a unified and organic Nature.[10] In accordance with his beliefs, he introduced ecology as a monistic ontology where the notion of life would not admit the disaggregation of the different components of the environment, but would rely, instead, on the holistic comprehension of the intricate network of cause-effect interactions between these components.

Since the very first lines written on the meaning of the new field, the subject matter of ecology has been the totality of nature. The comprehensiveness and complexity that the idea of ecology invokes today was infused in the field since its very inception. With this innovative internalization of all biotic and abiotic conditions of the environment in the study of the single organism, Haeckel drastically expanded the scope

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[9] Stauffer, "Haeckel, Darwin and Ecology," 141.

[10] In 1905 Haeckel founded the so-called Monist League, created to disseminate a monistic view of the world.

of the biological sciences from their original confinement within the physical boundaries of the living being to the totality of nature, opening the door to a wide range of scientific and thought experiments that would unfold in the decades to follow.

The Maturation into a Modern Science

In coining the neologism "ecology" in his *General Morphology of Organisms*, Haeckel combined the Greek words *oikos*, generally interpreted as "house," and *logia*, or "study of." Besides "study of", *logos* can also be interpreted as "ultimate truth"—the answer, origin, root of things, reason, computation, reckoning, explanation, rule, principle, law.[11] A closer look to the signifieds of *oikos* reveals that the "house" is not only the built house, but "any dwelling place," "domicile or planet."[12] Drawing on these etymological elaborations, and in clear accordance with Haeckel's monistic beliefs, Keller and Golley have suggested that the meaning of ecology is something close to the "scientific study of the earthly dwelling place or home."[13] With such etymological roots, it was clear that Haeckel's ecology was eager to branch out into multiple intellectual speculations and appropriations, as it has been the case until now. Of these various associations, in this section, I want to put the emphasis on two, both of which appeared very early in the development of ecology and eventually played a fundamental role in the maturation of ecology as a modern science in the mid-twentieth century; one is the inevitable etymological association with the domain of "economy"; and the other deals with the engagement of the very human condition into the scope of ecology.

So early is the association of "ecology" with "economy" that Haeckel made a parallelism between both in the very same paragraphs of his 1866 *General Morphology* volume, where he elaborates on the definition

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11 Henry G. Liddell and Robert Scott, *A Greek-English Lexicon* (Oxford: Clarendon Press, 1968), 1057-1059, quoted in David Keller and Frank Golley, "Ecology as a Science of Synthesis," in *The Philosophy of Ecology: From Science to Synthesis* (Athens: The University Of Georgia Press, 2000), 9.

12 Ibid., 8-9.

13 Ibid., 9.

of his neologism.[14] Of course, both terms share the *oikos*' etymological root, which means, again, "household." The second part of "economy," *nomos*, is generally translated as the "management of."[15] In 1869, on a lecture at the University of Jena where he offered one of the most widely quoted definitions of ecology, Haeckel again equated "ecology" and "economy":

> By ecology we mean the body of knowledge concerning the economy of nature—the investigation of the total relations of the animal both to its inorganic and to its organic environment; including, above all, its friendly and inimical relations with those animals and plants with which it comes directly or indirectly into contact—in a word, ecology is the study of all those complex interrelations referred to by Darwin as the conditions of the struggle for existence.[16]

In establishing this correlation, he consciously linked ecology to an already existing lineage of thinking around the concept of the "economy of nature." Before Haeckel, Darwin himself and even Linnaeus, more than a century earlier, had used the notion of the "economy of nature" to discuss ideas on species' propagation, preservation, and destruction, as different managerial mechanisms to preserve stability and equilibrium in nature. If we follow, again, the etymological interpretation of *oikos* as the household in the earthly sense, then the notion of the "economy of nature" suggests that the whole planet could be seen as one single managerial unit, explicable through its internal associations, operations and maintenance regimes, an image that, as I shall show in the next section, parallels quite neatly those that the environmental movement put at the core of its postulates one hundred years later.

A second important association of the embryonic field of ecology was the one proposed in the first decade of the twentieth century by Ellen Swallow Richards.[17] An American chemist preoccupied with the environmental problems that she recognized as a result of modern industrialization and technology, Richards was the first to explicitly identify "the human being" with "the organism" that Haeckel put at the

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[14] "Physiology has largely neglected the relations of the organism to the environment, the place each organism takes in the household of nature, in the economy of all nature, and has abandoned the gathering of the relevant facts to an uncritical "natural history." In Haeckel, *Generelle Morphologie Der Organismen*. English translation in Stauffer, "Haeckel, Darwin and Ecology," 141.

[15] Stauffer, "Haeckel, Darwin and Ecology," 141.

[16] Ibid.

[17] Ellen Swallow Richards, *Sanitation in Daily Life* (Boston: Whitcomb and Barrows, 1910 [1907]).

core of ecology's first definition. She considered that the environment was the combined result of the non-anthropic action of climatic forces and human activity, which had great transformative power in the biophysical environment over which it was superimposed. With "human ecology," which she defined in 1910 as "the study of the surroundings of human beings in the effect they produce in the life of men,"[18] Richards put the human condition at the center of the equation of ecology, opening a whole new set of paths of development in ecological theory that would allow the new field to penetrate the spheres of the social sciences and the humanities.

These two early associations, first with the domain of economy and then with the human condition, largely set the base for some of the most important and long running debates that have characterized the brief intellectual history of ecology. The connection between ecology and economy opened the question of the disciplinary character that ecology should adopt: was it called to be a theoretical science essentially engaged in the understanding and explanation of the relationships between organisms and environment, or an applied science that could serve to manage the conditions of the environment? Human ecology, on the other hand, opened the field to the question of the inclusion versus the exclusion of the human factor in the equation of the environment, triggering a wide and new set of moral reverberations: what is the position of man in regards to the environment? Is it possible to know the environment prior to the effects of human agency? Is man responsible for the evolution of the environment? What should guide human agency in the management and transformation of the environment?

With these questions already on the agenda, the first decades of the twentieth century saw the beginning of a process of maturation of ecology that also pushed in some other fronts. Generally, these were years of transition from a sort of descriptive to a more analytical form of scientific natural history, and many biologists focused on the development of physiographic analysis methods and mathematical models for

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[18] Swallow Richards, *Sanitation in Daily Life*, v. Quoted in Carolyn Merchant, *The Columbia Guide to American Environmental History* (Columbia University Press: New York, 2002), 163.

the study of populations.[19] These were also years in which both holistic and reductionist approaches to the environment began to gain traction, delineating the “organismic” and “individualistic” positions that would eventually lead a very vivid ontic and epistemic debate on the structure and evolution of nature during the central decades of the twentieth century.[20] Some other biologists did put at the fore the economic and human dimensions suggested by Haeckel and Richards, and contributed decidedly in the establishment of an economic approach to ecology by working on the identification of functional connections in the environment. One of the scientists that laid the foundations of this economic lineage was the British zoologist Charles Elton who, by describing in 1927 the notion of the “food chain,” turned food into an essential capital moving across the natural order and assigned new roles of producers and consumers to different organisms.[21] Even more important was the contribution of the British botanist Arthur Tansley, who introduced in 1935 a new concept that would eventually become central in ecological theory: the ecosystem.[22] With the ecosystem, Tansley translated Elton’s *food* into *energy*, a rightly quantifiable physical property that, once incorporated into ecology, enabled a vision of the environment characterized by flows of energy moving across ecosystems. This vision, largely reliant on the concepts of “system” and “energy” as derived from physics and thermodynamics, engaged ecology with the tradition of mechanical materialism in the sciences, and became dominant among a whole generation of ecologists during the second half of the twentieth century.

It was in 1953 that ecology saw the publication of *Fundamentals of Ecology*, ecology’s first textbook, authored by the American biologist Eugene Odum. The whole book was organized around Tansley’s concept of the ecosystem. In *Fundamentals of Ecology*, the ecosystem was defined as “any unit that

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[19] Sharon Kingsland, “Conveying the Intellectual Challenge of Ecology: An Historical Perspective,” in *Frontiers in Ecology and the Environment* 2, no. 7 (2004): 367–374.

[20] A full section in chapter 3 will serve to elaborate on the debate in ecological theory between “organismic” and “individualistic” approaches to the environment, championed, respectively, by Frederic Clements and Henry Gleason.

[21] Charles Elton, *Animal Ecology* (London: Sidgwick and Jackson, 1927).

[22] Arthur G. Tansley, “The Use and Abuse of Vegetational Terms and Concepts,” *Ecology* No. 16 v. 3 (1935), 284-307.

includes all of the organisms (i.e., the "community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (i.e., exchange of materials between living and nonliving parts) within the system."[23] The ecosystem had already proven to be effective in articulating the premises of the economic lineage of ecology, but in the hands of Odum it also served to overcome the ontic and epistemic discussions around the "organismic" versus "individualistic" models of the environment that had polarized ecological theory during the 1940s and 1950s. In the years that followed the publication of *Fundamentals*, Eugene, in collaboration with his brother Howard T. Odum, elevated the ecosystem to the condition of the most prominent ecological ontology—the fundamental unit the environment is made of.[24] Around the concept of the ecosystem, a whole new and highly mechanistic model of environment was constructed, which basically saw the world as an economic system of flows of energy, matter, and information moving between and across ecosystems. So convinced were the Odum brothers of the power of this systems approach to ecology that they began to project it over almost any imaginable ecological entity, from the single cell to the tree, from the organism to the compound of living creatures, from the city to the region, to the totality of the planet (*Figure 1.2*).

And not only this approach was seen as extraordinarily relevant for its prolificacy in studying these energy-based functional connections between environmental components at all levels, but also, and even more importantly, for the applied science potential it offered in the development of a management apparatus through which the energetic inefficiencies found in the mechanic system of nature could be fixed and improved. This self-proclaimed "New Ecology" is generally seen as the culmination of the process of maturation of ecology as modern science. If ecology was to be called a real science, then its knowledge should be explicable by physical principles.[25] The ecosystem and its dependence on the notion of energy allowed ecology to root itself in the tradition of physical materialism proper to the "hard

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[23] Eugene P. Odum, *Fundamentals of Ecology* (Philadelphia: W.B. Saunders, 1971), 8.

[24] Ibid.

[25] Frank B. Golley, *A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts* (New Haven: Yale University Press, 1993), 34.

sciences," and the quantification of energy offered reliable scientific analysis and great potential for correction and control.

Not by chance, the New Ecology was the first broadly accepted theory of ecology among the scientific community, and the overwhelmingly dominant model for the interpretation and management of the environment in the late 1960s and the 1970s, that is, by the time of the rise of environmentalism (*Figure 1.3*). Initiated in the 1960s as a marginal campaign primarily focused on the idea of nature's preservation against the negative impact of humans, environmentalism eventually turned into a central narrative which, drawing heavily on some of the dominant principles and ideas of the New Ecology, developed a worldview in which humans took part of a large web of ecosystems, which they had the capacity to alter for both good and bad. While ecology offered environmentalism the scientific endorsement it needed to ground and promote its arguments, environmentalism heralded ecology, in turn, as an applied science that should not only study the environment but also control and preserve it. Through its perfect alliance with the environmental movement, ecology transcended by far its original definition as a scientific discipline invested in the study of the relationships of the organism to the environment, and unfolded into two alternative and largely contradictory grand narratives that are still very present today: the managerial narrative, by which the environment is governable to almost heroic extremes through scientific knowledge and technological formulas, and the conservationist, where the environment must be protected in order to alleviate the adverse effects of human agency.

This double narrative constitutes the climax of a process of internalization of the two early associations of ecology with the domain economy and the human condition. If the project of "economy" was the management of the household, the emphasis on the mapping and quantification of energy was the formula the Odumiam systems ecology conceived to arrive at an image of environment as both governable and protectable. This implied a redefinition of the notion of the "economy of nature," where the discussion was not so much anymore about the propagation, preservation, and destruction of *species*—as it had been with Darwin a century earlier—but about the propagation, preservation, and destruction of *energy*.[26] And at the same time, both the managerial and the conservationist narratives seemed to irremissibly engage the human condition; on the one hand, the environment was a resource with potential for optimization through human direction and control and, on the other, human appropriation of nature had resulted in extremely harmful effects on the environment that could only be alleviated with drastic changes in human activity patterns.

The full internalization of the human condition and its agency into the equation of ecology opened, therefore, a whole new field of moral and existential questions. If ecology accepted, as Richards had suggested, that humans were one of ecology's organisms, then, in line with ecology's original definition, the study and the definition of the conditions of human life, as well as the interpretation of how human action participates in the very production of those conditions, also became part of the program of ecology. The modernization of ecology implied, paradoxically, its irruption into areas of inquiry that were far beyond its modern science project as a discipline primarily invested in the understanding of the relationships between organisms and the environment; the understanding those relationships seemed to inevitably lead to their affirmation, suppression, and manipulation, to the benefit of some organisms and to the detriment of some others.

The Pluralization of Environmental Narratives

With the new managerial and human dimensions it acquired during the 1970s, ecology transcended the scope of the natural sciences and permeated the social sciences and the humanities. The growing comprehensiveness of the subject matter, and the moral reverberations derived from this shift were paralleled by a larger phenomenon of cultural pluralization through which many of the inherited

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[26] The lineage of ideas around the notion of the "economy of nature" has richly propagated during the twentieth century, where the phrase and its managerial associations have been continuously redefined in different ways and for multiple reasons, often turning ecology into an accessory division of economy. As it becomes clear from the very title, Donald Worster's seminal *Nature's Economy* uses this notion as the organizing thread of the whole book. Donald Worster, *Nature's Economy* (San Francisco: Sierra Club Books, 1977).

paradigms of modernity were put into question. As a result, during the past four decades or so, ecology has confronted a series of ontological and epistemological puzzles that remain unresolved. The present section focuses on some of the ideas behind these theoretical challenges, the first being the very possibility of demarcating ecology's particular subject matter—the totality of nature—and the definition of that particular subject matter—what we mean by "nature." It also looks at the problematization of the concept of nature that underlie the two meta-narratives that resulted from ecology's alliance with environmentalism—managerial and conservationist—despite their very different—and even oppositional—attitudes towards it, and reviews some of the more recent discourses that, in recognizing the environmental gridlock, suggest the need to obliterate the very concept of nature.

As already mentioned, Ernst Haeckel's introduction of ecology offered, as it is necessary with any branch of knowledge, a definition of a particular subject matter—all environmental conditions, both organic and inorganic, that have an influence over life on earth.[27] Such an enunciation pointed towards an extremely broad and complex signified. In looking at the relations of the organism with other organisms and with virtually any environmental physicochemical condition that could have an impact on its adaptive evolution, Haeckel suggested that ecology studies all of nature. So, if ecology's subject of study is the totality of nature, then the very definition of "nature" becomes a crucial question.

One of the central concepts in the history of philosophy, "nature" remains today a subject of speculation and discussion that is approached from many different angles, from science to politics, from conservation to aesthetics. As Raymond Williams warns, "Nature is perhaps the most complex word in the language," and, of course, a full analysis of the polysemy of the word and the complexity of the concept of nature are far beyond the ambition of this dissertation.[28] It is necessary, however, to revisit some aspects of its definition that are particularly relevant for the discussion about the possibility of establishing a project for ecology.

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[27] Haeckel, *Generelle Morphologie Der Organismen*. English translation in Stauffer, "Haeckel, Darwin and Ecology," 140.

[28] Raymond Williams, *Keywords* (New York: Oxford University Press, 1986), 219.

A first and relevant distinction is the one suggested precisely by Raymond Williams, when he refers to nature as either "the inherent force which directs the world or humans beings or both," versus "the material world itself."[29] This distinction touches the core of a long metaphysical discussion on the idea of reality as essentially a process, versus the idea of reality as substance. This discussion, whose roots in the history of Western philosophy go as deep as to the Pre-Socratic encounter between Heraclitus and Parmenides' positions, has had significant reverberations in late twentieth century ecology with the emergence of complexity theory, which has reformulated the question in terms of nature as a composite essentially in balance, versus more process-oriented interpretations of nature as primarily characterized by chaotic flux.[30] Complexity emerged in the sciences at large as difficulties with modeling the behavior of certain systems became the norm, and when it was perceived that the behavior of such systems was not predictable apart from those properties. As complex systems began to be formally studied in the 1970s, the deterministic image of mid-twentieth century ecology, where nature's ecosystems followed a developmental strategy towards a closing state of balance,[31] soon gave way to images of nature characterized by process-based notions of continuous adaptation, open-endedness, and self-generation.

Both notions, the "balance of nature" and "nature in flux," depart from an assumption whose questioning is the main purpose of a second distinction, which is essentially epistemological. It differentiates between an idea of nature as a compound of structures and processes that exists independently of human cognition and therefore is objectively comprehensible—as in scientific realism—versus an idea of nature as a socially determined representation that is projected over an abstract setting—as in social constructivism. By making this distinction, the constructivist stance argues that even realist approaches that claim

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[29] Ibid.

[30] See, for example, David Keller and Frank Golley, "Community, Niche, Diversity, and Stability," in their edited volume *The Philosophy of Ecology: From Science to Synthesis* (Athens: University of Georgia Press, 2000), 101–10; Donald Worster, "The Ecology of Order and Chaos," *Environmental History Review* 14, nos. 1–2, 1989 Conference Papers, Part 2 (Spring–Summer, 1990): 1–18; and Nina-Marie Lister, "Sustainable Large Parks: Ecological Design or Designer Ecology?" in *Large* Parks, eds. George Hargreaves and Julia Czerniak (New York: Princeton Architectural Press, 2008), 35–58.

[31] Eugene P. Odum, "The Strategy of Ecosystem Development," *Science* 164 (18 April 1969).

objective knowledge about nature are in fact nothing but socially and culturally biased interpretations.[32] As environmental philosopher Neil Evernden put it, “The entity which we take for granted as an objective reality has, in fact, a complex origin of social creation.”[33] Seminal in this sense is also the work of environmental historian William Cronon around the notion of *wilderness*. Departing from a widely accepted definition of wilderness as something close to “the last remaining place where civilization, that all too human disease, has not fully infected the earth,”[34] Cronon argues that wilderness, far from being a pristine place on earth that stands in opposition to those contaminated by humanity, is a social construction, as much as its alleged role in solving civilization’s pressures over the environment.

A third critical differentiation in nature’s meaning, an ontic one that derives from this epistemic confrontation between realism and constructivism, is the one that focuses on the question of the human inclusion as part of nature versus the human exclusion from it. From this angle, we find an interpretation that sees nature as something separate from humans, an outside world to us; the other discusses nature as an all-inclusive compound, which the conscious human organism is just a part of. According to the first position, nature is everything that exists and that is not artificial; according to the second one, nature is everything that exists—including the artificial—and that is not supranatural.[35]

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[32] From an innumerable list of works where the notion of nature as social construction has been discussed, I want to point to Raymond Williams, “Ideas of Nature,” in his edited volume *Problems in Materialism and Culture* (London: Verso, 1980), to William Cronon, “Introduction: in Search of Nature” and “The Trouble with Wilderness; or, Getting Back to the Wrong Nature,” both chapters of his edited volume *Uncommon Ground: Rethinking the Human Place in Nature* (New York: W. W. Norton, 1996), to Neil Evernden, *The Social Creation of Nature* (Baltimore: Johns Hopkins University Press, 1992).

[33] Neil Evernden, *The Social Creation of Nature*, 109.

[34] William Cronon, “The Trouble with Wilderness,” 69.

[35] To note the primacy of this question in discussions about the meaning of nature, I want to mention three very different references here. Frederick Ferré has taken this distinction as the primordial one in *Philosophy of Technology* (Englewood Cliffs, N.J.: Prentice Hall, 1988), Arnold Berleant has also expanded this polarized distinction about the relation of humans and nature across a big range of stages in “Environment as a Challenge to Aesthetics,” in *The Aesthetics of Environment* (Philadelphia: Temple University Press, 1992), 1-14, and Raymond Williams puts the inclusion or exclusion of the human condition in regards to nature also in two of the three definitions of the word that he proposes in *Keywords*, 219.

Although all of these three differentiations have been implicitly or explicitly tackled in the history of ecological theory, and the dissertation will be also looking at each of them with detail, at this point it is important to focus on the last one for its relevance in recent developments in the field of eco-criticism. Many voices have been critical of the currently pervasive and too often unconscious preference towards the idea of nature as separate from humans, and of the key role that environmentalism itself has played in the fixation of that cultural bias. With the rise of environmentalism, as already noted, ecology was heralded as a framework that should not only explain the relationships between organism and the environment but also guide our interactions as human organisms with the environment. Eventually, two alternative master narratives around this relationship were produced, one inspired by optimist positivism, the managerial narrative, according to which nature is governable and can be controlled through scientific knowledge and technological formulas; and another one associated with pessimist catastrophism, the conservationist narrative, according to which nature must be protected in order to be healed from the damage inflicted by humans. Despite the apparently different and even opposing attitudes of both narratives—one argues for nature's exploitation, the other for its protection—they both share the idea of an external nature separate from humans—an alien entity that humans have either to exploit or protect. Interestingly, although the rise of environmentalism did transform ecology by favoring, as Richards had suggested in the early twentieth century, the idea that human agency was part of the subject matter of ecology, it also accentuated an understanding of human agency as essentially external to nature. As the environmental philosopher Steven Vogel has recently argued, for environmentalism, "Environmental protection means the protection of nature, and environmental harm means harm to nature."[36]

From the position that many environmental problems have been nothing but exacerbated since they were first described, an increasing number of authors have been arguing for a couple of decades now that it is precisely this external model of nature what lies at the core of our inability to produce an effective counter-narrative of ecology. In trying to break this gridlock, they proclaim the need to dismiss the very concept of "nature" in ecological theory and environmental philosophy. In the words of the British

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[36] Steven Vogel, "Against Nature", in *Thinking like a Mall* (Cambridge MA: The MIT Press, 2015), 1.

philosopher and theorist of ecology Timothy Morton, “Strange as it may sound, the idea of nature is getting in the way of properly ecological forms of culture, philosophy, politics, and art.”[37] Authors that advocate for “the end of nature” do so in an attempt to cancel the dichotomy inherent to a form of nature that excludes the human. The metaphysical natural/artificial dualism constitutes an outdated and misleading idea, which obstructs a more coherent and integrated view of the world where everything has been virtually transformed by human agency.[38] In order to respond to the real and pressing problems posed by human action on the environment, we must not rely on the power of nature or wilderness, to go back to Cronon, as a proxy to alleviate to civilization’s pressures on the environment—for nature and wilderness are themselves constructions of civilization. We must find, instead, a less *natural* and more *built* definition of environment.[39]

The pluralization of narratives around ecology's subject matter has expanded and convoluted the meaning of ecology itself far beyond Haeckel's original definition, and beyond the definition implicit in the project of Odum's New Ecology. As a result, the term “ecology” *denotes* today, on the one hand, the *science* of ecology, with a legacy of more than a hundred years of scientists formally practicing ecology, with its specialized body of knowledge, its own literature, educational programs, scientific journals, and so on. But ecology serves to also *connote*, on the other hand, a *cosmovision*, a worldview which, I shall emphasize, in trying to synthesize the multiple debates surrounding the philosophy of field since its inception, puts the accent on the concept of interaction and evolution. The only possible project for a field of knowledge explicitly invested in the study of all of *nature*, it can be argued, is one of *synthesis*.

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[37] Timothy Morton, *Ecology without Nature* (Cambridge, MA: Harvard University Press, 2007), 1. A few years earlier, Neil Evernden also argued that the very act of giving a name to nature implied a dichotomy between the natural world and the human world. Neil Evernden, *The Social Creation of Nature* (Baltimore, Johns Hopkins University, 1992).

[38] The Slovenian philosopher Salavoj Zizek, following Morton’s *Ecology without Nature*, writes that “what we need is an ecology without nature: the ultimate obstacle to protecting nature is the very notion of nature itself.” Slavoj Zizek, *In Defense of Lost Causes* (London: Verso, 2009), 445.

[39] Cronon, “The Trouble with Wilderness,” 69. In the introductory chapter of *Thinking like a Mall,* Steven Vogel asks for an new role for “environmental philosophy after the end of nature,” and wonders whether this is the time of think instead of “an environmentalism of the built environment.” Steven Vogel, “Against Nature,” in *Thinking like a Mall* (Cambridge MA: The MIT Press, 2015), 1-31.

The Synthesis into a General Ontological and Epistemological Framework

During its short history, ecology has been subject to debates emerging from the strict scope of scientific ecology, from other external scientific sources, and from sources beyond science. A very schematic genealogy that presented the debates organized in accordance to these three nested spheres of influence would begin with the "organismic" versus "individualistic" controversy around the structure and evolution of the environment during the 1940s and 1950s, and then would be followed by the integrative approach of Eugene and Howard T. Odum in the 1960s. The Odums expanded the scope of ecology by drawing explicit connections with energetics and economics, and their plain acceptance of the ecosystem as the central concept in the understanding of the environment offered ecology a new interdisciplinary role as a general systems science.[40] The emergence of chaos and complexity theory in the 1970s found in this system-based model of ecology a very fertile ground. With its emphasis on cybernetics and non-linear dynamics, complexity transformed ecology into a complex systems science and new notions of behavioral adaptation came to the fore to detriment of ecosystemic balance. Almost concurrently, ecology burst into the political and social spheres as part of the rise of environmentalism. Since the 1980s, new efforts towards the development of alternative ecological discourses began to be made by the social sciences and the humanities, mainly directed to examine the role of scientific ecology in regards to the environmental challenges that were being described since the 1960s and 1970s. These efforts have included not only the already mentioned reconsideration of the very notion of "nature" in contemporary environmental philosophy,[41] but also the project for a renewal of political ecology as part of a re-evaluation of modernity,[42] the integration of Marxism in contemporary ecological discourses,[43] psychoanalytical

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[40] See, for example, Eugene Odum, "The Emergence of Ecology as a New Integrative Discipline," in *Science* 195, no. 4284 (March 1977), 1289-93.

[41] I have already alluded to the work of Timothy Morton and Steven Vogel in this front.

[42] Bruno Latour stands out as one of the most important authors in the development of this project, for which he has found the work of his mentor, Michel Series, particularly inspiring. See, for example, Bruno Latour, *Politics of Nature: How to Bring the Sciences into Democracy*, trans. Catherine Porter (Cambridge, Mass.: Harvard University Press, 2004), and Michel Serres, *Le Contract Naturel* (Paris: François Bourin, 1990).

[43] Deserves special mention, in this sense, John Bellamy Foster, "Marx's Theory of Metabolic Rift," *American Journal of Sociology* 105, no. 2 (1999): 366–405.

explorations of human subjectivity as a "third ecology,"[44] new aesthetic interpretations of environment as *medium* and not as *otherness*.[45]

The comprehensiveness of ecology's subject matter, and the complexity of the notions involved in its definition—nature, environment, organism, and so on—explain the wide array of connotations that ecology has been able to produce and, at the same time, the divergences existing amongst them. Interestingly enough, as philosopher David Keller and ecologist Frank Golley have noted in the introduction to *The Philosophy of Ecology*, scientific and humanistic approaches to the field are often in open confrontation.[46] While the science of ecology implies, still today, a relative perpetuation of the mechanistic models derived from the paradigm of modernity, most post-environmentalist and non-scientific ecological discourses of the last years rise as part of a fundamental contestation to those frameworks—determinism and scientific realism are just social constructions.

A terminological pluralization of ecology has run parallel to the conceptual one. The last four decades have witnessed the extraordinary proliferation of a wide range of fields that use the term "ecology" as either adjective or substantive, from social ecology, human ecology, political ecology, landscape ecology, urban ecology, industrial ecology, and critical ecology, to ecological economics, ecological urbanism, ecological engineering, ecological philosophy, and so on. To these fields, one can add ecology's own internal differentiators—population, behavioral, systems, and evolutionary ecology, to name a few—and modifiers—such as deep, romantic, radical, dark, industrial, and projective.[47] As the term proliferates,

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[44] Félix Guattari, *The Three Ecologies*, trans. Ian Pindar and Paul Sutton (New York: Bloomsbury Academic, 2014 [1989]), and the influence of Gregory Bateson, *Steps to An Ecology of Mind* (New York: Ballantine Books, 1972).

[45] Arnold Berleant and his work on environmental engagement and aesthetics is seminal here. See Arnold Berleant, *The Aesthetics of Environment* (Philadelphia: Temple University Press, 1992), and Arnold Berleant, *Art and Engagement* (Philadelphia: Temple University Press, 1991).

[46] David Keller and Frank Golley, "Ecology as a Science of Synthesis," in *The Philosophy of Ecology: From Science to Synthesis* (Athens: The University Of Georgia Press, 2000), 1-20.

[47] See Daniel Daou and Pablo Pérez-Ramos, "The World According to Ecology," exhibition at the Harvard Graduate School of Design, Student Forum Wall, December 2015.

some have argued, it faces the risk of entering the absurdity of a magnificent truism, where the possibility of meaning everything belies the evacuation of meaning, and turns ecology into an empty rhetoric.[48]

Despite the intrinsic disparities and the disciplinary promiscuity of contemporary ecology, all these ecologies, as mentioned before, are internalized in the ecological *cosmovision*. Sometimes denoted through the vague notion of "ecological thinking," this ecological cosmovision is a general epistemological and ontological framework, a way of thinking about the world that, in trying to build a synthesis of ecology's pluralization, emphasizes notions of interaction and evolution among things.[49] Grounded on previous models such as monism and process metaphysics,[50] it can be argued that the "ecological thinking" framework has not been strictly inaugurated by ecology itself but that, rather, it is through "ecology" that we designate in our current culture and imagination a cosmovision that emphasizes interaction and evolution.

In fact, both interconnected and evolutionary worldviews can be traced in the genealogy of Western thinking all the way back to the Pre-Socratics. However, there are important influences from the scientific panorama of the early and mid-nineteenth century, where the science of ecology was conceived. One of the phrases that more clearly catches this monistic idea of interaction, and where many authors have situated the beginnings of ecological thinking, is Alexander von Humboldt's famous aphorism "Alles is Wechselwirkung,"[51] which he wrote in 1803 during his research expedition across Central and South

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[48] Christopher Hight, "Designing Ecologies," in *Projective* Ecologies, eds. Chris Reed and Nina-Marie-Lister (Barcelona: Actar, 2014), 84-105.

[49] Keller and Golley, *The Philosophy of Ecology*, 2. See also Sanford Kwinter, "Neuroecology: Notes Toward a Synthesis," in *The Psychopatologies of Cognitive Capitalism: Part Two*, ed. Warren Neidich (Berlin: Archive Books, 2013), 315.

[50] Holism and process metaphysics and their influence on ecology will be developed in greater detail in chapters 3 and 4.

[51] Alexander von Humboldt, *Reise Auf Dem Rio Magdalena, Durch Die Anden und Mexico*, vol. 1, ed. and trans. Margot Faak (Berlin: Akademie Verlag, 1986), 358. Originally published in von Humboldt's Travel Diary of August 1803, while at the Valley of Mexico.

America, and which is normally translated into English as "Everything is interconnected."[52] This phrase definitely resonates with Haeckel's 1866 vision of ecology and has also been very literally echoed by some other influential "ecological thinkers" of the twentieth century, such as John Muir, who wrote, in 1911, "When we try to pick out anything by itself, we find it hitched to everything else in the Universe,"[53] or Barry Commoner, who proposed that "Everything is connected to everything else" as the first of his informal laws of ecology in the 1970s.[54] When it comes to the evolutionary aspect of the ecological cosmovision, the most important source remains Charles Darwin's *On the Origin of Species*,[55] published in 1859, only seven years before Haeckel's *General Morphology of Organisms*. Humboldt's work and expeditions were widely admired by contemporary scientists, including the British geologist Charles Lyell, whose influence on Darwin was above anyone else's.[56] Lyell's 1830 *Principles of Geology* had also served to reinforce James Hutton's concept of uniformitarianism—the idea that the Earth as it exists today is the result of slow-moving forces that have been acting for a very long period of time, and which still operate today. This gradualist vision contributed greatly to Darwin's own notion of evolution; if natural selection has happened in the past and is still happening today, it needs to be happening slowly, in small increments, rather than through large leaps or jumps.[57]

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[52] Kwinter prefers to translate Humboldt's sentence as "All is *interaction*." Kwinter, "Neuroecology," 315. Emphasis in original.

[53] John Muir, *My First Summer in the Sierra* (Boston: Houghton Mifflin Company, 1911), 211.

[54] Barry Commoner, *The Closing Circle: Nature, Man, and Technology* (New York: Knopf, 1971), XXX.

[55] The full title of Charles Darwin's groundbreaking book was *On the Origin of Species, by Means of Natural Selection, or The Preservation of Favored Race in the Struggle for Life* (London: John Murray, 1859).

[56] For a detail account of the influences that nineteenth century science had over Charles Darwin's work, see Donald Worster, "The Education of a Scientist," in *Nature's Economy* (San Francisco: Sierra Club Books: 1977), 130-144.

[57] This notion of gradualism that Darwin borrowed from Lyell's approach to geology, was also present in Johann von Goethe's idea of metamorphosis, as I shall show later in chapter 4. Goethe's metamorphosis has been discussed as another critical component of "ecological thinking" by Sanford Kwinter, "Neuroecology," 315.

The development of these syntheses constitutes the central theme of part 2, made of chapters 3 and 4. But in order to elaborate on these ideas with a more clear understanding of their relevance for landscape architecture, chapter 2 will review first the current relationship between some of these ecological narratives and landscape architecture, to then put the accent on those through which ecology has come to the very forefront of landscape architecture during the last two decades and problematize their implications for design.

CHAPTER 2

Performance and Adaptation in Landscape Architecture

Performance and Adaptation in Landscape Architecture

The comprehensiveness and complexity of ecology has been both seductive and problematic for landscape architecture. As seen in chapter 1, during the relatively short history of the field, ecology's original project has diverted into an extraordinary pluralization of narratives that were developed, first, within the scope of the life sciences, then, within the larger scope of the natural and social sciences—with inputs from physics, thermodynamics, and economics—and eventually, especially during the last four decades, in the humanities. There is some sort of before-and-after in this process of pluralization, which coincides with the moment in which ecology stops being a field invested in the scientific study of the relationships of organisms and environment and, in the face of new environmental concerns, becomes a fundamental technical apparatus for environmental control and protection. Through its alliance with environmentalism in the late 1960s and the 1970s, ecology suddenly moved into positions of extraordinary social and cultural relevance. Motivated by this expansion of the field, landscape architects became progressively aware of ecology's principles and techniques. The phenomenon of ecological influence over landscape architecture has extended until now, to the point where it can be said that ecology is central today for both the theory and practice of landscape architecture. Such proximity between ecology and landscape architecture is far from being incongruent, for in both fields the concept of environment becomes absolutely central; if ecology is the science that studies relations in the environment, landscape architecture is, in its broadest sense, the design field that deals with the *transformation* and *production* of environments. The environment, be it 'natural' or built, is the canvas, medium, and subject of landscape architecture.[1]

In chapter 2, I shall begin with an overview of the different modes by which ecology has impregnated the field of landscape architecture since the rise of environmentalism in the 1960s and 1970s—mainly as a scientific imperative and as a metaphor for ideas of complexity—and then focus more specifically on the narratives by which ecology has come to the forefront of landscape architecture during the last two

[1] I borrow this expression from Elizabeth K. Meyer, "The Post-Earth Day Conundrum: Translating Environmental Values into Landscape Design," in *Environmentalism in Landscape Architecture*, ed. Michel Conan (Washington D.C.: Dumbarton Oaks Research Library and Collection, 2000), 187-244.

decades. These narratives, emerging from a larger theoretical shift in the design fields that I shall refer to as a "shift from *form* to *performance* and *adaptation*," have certainly brought to the fore of landscape architecture theory the notions of landscape *performance* and landscape *adaptation*, that is, the idea that landscapes have great capacity to both carry out work and accommodate change. As I shall explain in the last section of the chapter, these narratives, as well as the very specific and ecologically-grounded conceptions of "system" and "process" they incorporate, have been extremely fruitful in expanding the field of landscape architecture and its modes of practice but also entail reductive implications for design.

The Roots of Ecology in Landscape Architecture: Ecological Planning and Environmental Engagement

Ecology is today one of the main drivers in landscape architecture theory and practice. This is the result of a process of growing influence of ecology over landscape architecture and the design fields in general, which was inaugurated during the late 1960s and the early 1970s with the rise of environmentalism. During the course of the last five decades, the associated practices and discourses that ecology has induced in landscape architecture have been far from representing a uniform approach, like a single school of thought. Instead, a diverse spectrum of attitudes towards environmental questions has been developed, ranging from projects and approaches that stimulate naturalistic aesthetics to others that put the emphasis on human agency and environmental disturbance, from projects that support rather scientific practices of ecological restoration to others that are less concerned with material outcomes than they are with rhetoric ones. So powerful has the influence of ecology been on the design fields that these decades have witnessed an immense proliferation of plainly formulaic modes of practice where ecology is called in as a mere intellectual justification. Still today, ecology is very often fields used in all the design simply as a buzzword aimed at providing design with all kinds of generic ideological and/or aesthetic patinas. Besides these trivializations, among the critical practices of landscape architecture that have familiarized themselves with ecology's theory and techniques, it is possible to observe some sort of oscillation between two primary categories: ecology understood as scientific mandate, versus ecology as rhetoric metaphor. In the first one we include design approaches that draw upon ecology as a source of guidelines towards the accomplishment of specific scientific goals, normally derived from the managerial and conservationist missions ecology assumed as part of its affiliation to the environmentalist cause. In the second one, we find those that engage one or more of the different scientific theories of ecology, or any of their derived non-scientific associations, as inspiration for representational or experiential pursuits.

After five decades of ecologically-driven landscape architecture, it is possible to begin to organize these various design expressions into a genealogical structure, which can also incorporate the lines that connect these manifestations with the concomitant shifts in the scientific theories of ecology, on the one hand, and, on the other, with the new cultural connotations that the very word "ecology" has assumed over the years.

Quite schematically, this timeline of ecology in landscape architecture begins in the late 1960s and 1970s, in the midst of the rise of the environmentalist movement. If the publication of Rachel Carlson's *Silent Spring* in 1962 and the celebration of the first *Earth Day* in April of 1970 are often regarded as the two milestones that mark the beginning and the end, respectively, of the period in which the environmental movement was established, the event that marks the beginning of a new era of ecological influence over landscape architecture is the publication of Ian McHarg's now classic *Design with Nature* in 1969.[2] The appearance of the book was the culmination of years of work as part of an ambitious program of transformations in the curriculum of landscape architecture at the University of Pennsylvania, where McHarg had been teaching since the mid-1950s. Through teaching, professional practice, and publication, McHarg launched a process through which landscape architects became increasingly aware of ecology's scientific principles and experience in ecological practices.[3] Among the many influential personalities he invited to lecture in his famous course "Man and Environment," were the Odum brothers, whose work on

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[2] Ian McHarg, *Design with Nature* (Garden City, N.Y.: Natural History Press, 1969).

[3] For a thorough account of the role of Ian McHarg in shaping the teaching and practice of landscape architecture as an instrumental discipline of environmentalism see Anne Whiston Spirn, "Ian McHarg, Landscape Architecture, and Environmentalism: Ideas and Methods in Context," in *Environmentalism in Landscape Architecture*, ed. Michel Conan (Washington, D.C.: Dumbarton Oaks Research Library and Collection, 2000), 97-114.

ecosystems ecology during the 1950s and 1960s had become, as we have seen, the overwhelmingly dominant paradigm of ecological theory and the model that offered environmentalism the allegedly "natural" principles it needed to scientifically endorse its postulates. McHarg gave these principles immense value as fundamental rules in the development of his environmental design approach. In one of his most quoted articles, "An Ecological Method for Landscape Architecture," published in 1965, McHarg proposed that with the arrival of ecology, "the caprice and arbitrariness of 'clever' designs can be dismissed forever," for, he continued, "ecology offers emancipation to landscape architecture."[4] Following his positivist belief in the potential of ecological science as a vehicle to cancel design's arbitrariness, he developed an exhaustive design method that departed from the preparation of a comprehensive and systematized ecological inventory, which served as scientific base for, first, the diagnosis of any given environmental situation, second, the identification of problems and opportunities, and, ultimately, the definition of a holistic strategy for development. McHarg's linear decision-making process reached its peak with the analytical exercise he did for the Potomac River Basin on the East Coast of the United States. The method began with the confection of an ecological inventory that, through an exhaustive exercise of mapping—what he called the "layer-cakes"—served to assess a wide range of environmental conditions—bedrock geology, wildlife, mineral resources, physiography, slopes, soils, hydrology and so on (*Figure 2.1*). Relying heavily on quantitative principles and spatial analysis, the information derived from the ecological inventory was inserted into matrixes—the so-called "suitability diagrams," which would serve to cross different layers of information and compute, in line with the rise of cybernetics and information theory of those years, the degree of compatibility or conflict existing between them (*Figure 2.2*). The method used pre-established natural and social requirements as well as the information received from the ecological inventory as inputs to evaluate potential conflicts and consequences, and offer, as the output, a holistic strategy that determined the most adequate modes of land development for each area (*Figure 2.3*). McHarg's strict analytical method of ecological landscape architecture triggered a phenomenon through which the field eventually gained unprecedented cultural relevance and public visibility as an instrument of environmentalism and shaper of environmental

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[4] Ian McHarg, "An Ecological Method for Landscape Architecture," *Landscape Architecture* 57, no. 2 (1967), 105.

policies, and set the base of a lineage of landscape architecture that, ever since, has taken ecology as a scientific imperative. As he very assertively stated in the opening sentences of another article, "Ecology and Design," published in 1997, almost thirty years later than *Design with Nature*:

> I am unabashedly committed to the imperative *design with nature*, or ecological design and planning. Indeed, I conceive of non-ecological design as either capricious, arbitrary, or idiosyncratic, and it is certainly irrelevant …. There is no doubt about my attitude toward this topic. I invented ecological planning during the early 1960s and became an advocate of ecological design thereafter. This was explicit in *Design with Nature*; it was not only an explanation, but also a command.[5]

McHarg's impulse had an enormous impact in landscape architecture and generated, before the end of the decade of 1970, a counterbalancing reaction to what was perceived as an excessive dependence on scientific analysis.[6] This position, with Peter Walker often seen as the main proponent, suggested that the path opened by McHarg basically reduced landscape architecture's appearance to the category of design "by-product" of a scientifically driven method based on ecological principles.[7] Landscape architecture should not be so dependent on external criteria, which ultimately could lead to a limitation of the field's autonomy as a cultural practice with specific discourses. Walker proposed, instead, a return to languages and codes specific to landscape architecture. Landscape architecture forms should be as open to speculation, exploration, innovation, as they were in the arts.

The practices of landscape architecture that emerged in the 1980s, such as Michael van Valkenburgh and George Hargreaves', found a disciplinary context characterized by some sort of a schism that offered no satisfying response to the integration of some of the values recently described by the environmentalist agenda into landscape architecture. There was a lineage of ecological landscape design and planning that tackled the new environmental questions by means of a well-structured but often too deterministic

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5 Ian McHarg, "Ecology and Design", in *Ecological Design and Planning*, ed. George F. Thompson and Frederick R. Steiner (New York: John Wiley, 1997), 321-332, 321.

6 For an excellent account of these tensions in the years that followed the rise of environmentalism in landscape architecture, see Meyer, "Post-Earth Day Conundrum."

7 Peter Walker is often seen as the main proponent of an alternative and art driven approach to landscape architecture during the 1970s and the 1980s. For a detailed explanation of Peter Walker's position towards the relationship of landscape architecture and art, see "A Personal Approach to Design," in *Peter Walker: Landscape as Art* (Tokyo: Process Architecture, 1989).

decision-making method, which showed no interest in exploring what formal languages could serve to express the challenges that the new environmental mindset posed to the inherited system of values. And there was an emerging counter-reaction in favor of design's autonomy, whose proponents actively sought to make specific aspects of the landscape discursively and aesthetically compelling but did so through the use of formal languages and codes that did not necessarily engage the new environmental awareness.

This late twentieth century generation of landscape architects aimed at finding a way out of this split—often discussed as a schism between "scientists" and "artists"—by deriving ideas, on the one hand, from some of the experiments that had been made during the preceding years in the context of environmental art, earth art, land art, and site art, and by looking, on the other, at phenomenology and other aesthetic theories that put the accent on the perception of time as an internalized experience.[8] As Elizabeth Meyer explains, what these designers learnt from artists like Robert Smithson, Michael Heizer, and Robert Irwin was that it was possible to approach the environment in ways that were not strictly analytical.[9] Instead of arriving, as McHarg did, at holistic solutions by previously reducing the environment to a set of layers where each condition is shown separately, environmental artists worked *synecdochally*, that is, by locally intervening on specific phenomena that were comprehensible to the human experience, in order to make legible through those interventions the larger scales and longer durations of other phenomena that participated in the production of such specific experiences. The range of conditions that these landscape architecture projects sought to interfere with, as well as a the range of environmental phenomena that they aimed to reveal, was very wide. Among the paradigmatic projects of this approach were Michael van Valkenburgh's *Ice Wall* series (1988-1990), which examined the transient condition of landscape by means of the different ambiences produced by the different combinations of various physical conditions—density, temperature, transparency, light reflection, material state—of a layer of ice formed on the surface

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[8] For a general overview of the impact of environmental art in landscape architecture as part of the various environmental trends that unfolded during the twentieth century, see Catherine Howett, "Ecological Values in Twentieth-Century Landscape Design: A History and Hermeneutics," in *Landscape Journal* 17, Special Issue (January 1998), 80-98. For a more detailed account of the pluralization of design approaches to the engagement of environmental question during the 1970s and 1980s, see also Meyer, "Post-Earth Day Conundrum."

[9] Meyer, "Post-Earth Day Conundrum," 197.

of a chain fence (*Figure 2.4*). We also include Georges Hargreaves' work, very specially *Candlestick Point Cultural Park* (1985-1993), where a conventionally manicured green lawn on the waterfront was set up in order to frame a roughly finished and slightly sloped, tapered terrace that, flanked by two narrow channels, served to dramatize the tidal fluctuation in the San Francisco Bay area (*Figure 2.5*). Similarly, Richard Haag's *Bloedel Reserve* (1979), in Washington State, offers a sequence of four disparate gardens that are simply created by editing out the purposeless condition of a disturbed forest (*Figure 2.6*). Outside of the United States, Georges Descombes' *The Swiss Way* (1987), an intervention comprising several sections of pathways around the Lake Uri in Switzerland, shows a similar attitude, where discrete and carefully targeted operations aim at disturbing specific moments as a way to better understand the processes involved in the formation of the site (*Figure 2.7*).

What all these projects have in common is an intentional separation from analytics in favor of an emphasis on rhetorics. They constitute critical reactions to one or more of the assumptions of the ecology that McHarg's design approach had taken as its reference model. McHarg's method was developed during the years in which the Odumian New Ecology was practically uncontested. Having taken a concept derived from the mechanistic tradition of the physical sciences—the ecosystem—as the fundamental ecological unit, the New Ecology favored an understanding of the environment as a grand and intricate machine, functioning according to the deterministic laws of physics, whose components could be at least momentarily disengaged for adequate scientific analysis. Ecosystems were analyzable, measurable, quantifiable, optimizable, dis-aggregable, evaluable, and the environmental whole that resulted from their aggregation was an external entity subject to human control. This modernly mechanistic and heroic version of ecology has been perpetuated, in significant ways, by the paradigm of sustainability, and is the one that underlies, still today, the ecological imperative in landscape architecture.

But, as discussed in chapter 1, mainly since the 1980s, different post-environmentalist ecological discourses rose in the humanities as an examination of the most prevalent interpretations of environment offered by this mid-twentieth century model. These were years of pluralization in the connotations and narratives of ecology and, not surprisingly, landscape architecture engaged ecology as a metaphor in more subtle ways. Both narratives and landscape architecture practices were less interested in ecology as a source of guidelines towards the accomplishment of specific goals of environmental governability, than in ecology as an inspiration for triggering new perceptual and intellectual associations through which new notions of environment could be enacted.

Among the relevant figures in the development of these narratives are Frederick Steiner and Anne Whiston Spirn, both of which had been students of McHarg at the University of Pennsylvania, and whose work, while still infused with influence from their mentor, also incorporated discourses clearly committed to the expansion of the field of conceptual associations between landscape architecture and emerging ideas around the notion of environment.[10] Spirn, who in 1986 was recruited to succeed McHarg as chair of the Department of Landscape Architecture at Penn with the mandate of extending its legacy and renewing its commitment to landscape design and theory, became a key voice during the 1980s and 1990s in advancing and keeping track of the incorporation of new layers of meaning and aesthetic experience to the received environmentalist agenda. It is particularly relevant, in this sense, the special issue of *Landscape Journal* she edited in 1988, which, under the title "Nature, Form, and Meaning," put at the fore not only the empirical but also the metaphysical connotations of a landscape architecture explicitly engaged in environmental questions. In her own article in the volume, "The Poetics of City and Nature: Towards a New Aesthetic for Urban Design" she declared:

> This is an aesthetic that celebrates motion and change, that encompasses dynamic processes, rather than static objects, and that embraces multiple, rather than singular, visions. This is not a timeless aesthetic, but one that recognizes both the flow of passing time and the singularity of the moment in time, that demands both continuity and revolution. This aesthetic engages all the

[10] It is remarkable, as a continuation of some of McHarg's science driven tenets, Frederick R. Steiner, *The Living Landscape: an Ecological Approach to Landscape Planning* (New York: McGraw-Hill, 1991). Steiner also edited, in 1997 along with George F. Thompson, *Ecological Design and Planning* (New York: John Wiley, 1997), a very influential volume, some of whose articles have been required readings in landscape architecture education ever since, which put together the voices of McHarg himself and some of his contemporaries with those of a new generation of young landscape architecture practitioners and scholars. Deserve mention, in this regard, Elizabeth Meyer, "The Expanded Field of Landscape Architecture," 45-79, and James Corner, "Ecology and Landscape as Agents of Creativity," 80-108, both in *Ecological Design and Planning*, George F. Thompson and Frederick R. Steiner (New York: John Wiley, 1997).

> senses, not just sight, but sound, smell, touch and taste, as well. This aesthetic includes both the making of things and places and the sensing, using, and contemplating of them.[11]

We see how, along these lines, Michael van Valkenburgh's *Ice Wall* projects, also of 1988, sought to induce an aesthetic experience through the combination of environmental phenomena, which are not understood here as extractable into a set of distinct layers but rather as an irreducible conjunction. The experience of the perceiver is given preferential attention, in line with the then prevalent aesthetic theories, but also in line with specific criticism against the external idea of environment that derived from ecological ideals of control. In this sense, the *Ice Walls* can be read through Arnold Berleant's notion of environmental engagement, where the immersion of mind and body into the environment allowed no further distinction between the self and the surrounding, where environment was then understood as *medium* and not as *otherness*.[12] We see as well how some aspects of Georges Hargreaves' work can be read in line with the post-environmentalist efforts to question inherited notions of nature. In *Byxbee Park* (1988-1992), for example, a recreational space built on a post-industrial site in Palo Alto, the design approach does not rely on the power of an idealized notion of nature—or wilderness, to go back to Cronon—as a way to alleviate our industrial pressure and reclaim disturbed environments.[13] Instead of proposing a new pastoralist mantle that would allegedly better suit its new recreational program, the project seeks to reveal—or, at least, to not conceal—the disturbed condition of the site by highlighting its contingencies and leaving evident traces of the past.

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[11] Anne Whiston Spirn, "The Poetics of City and Nature: Toward a New Aesthetic for Urban Design," in *Landscape Journal* 7, no. 2 (Fall 1988), 108. In this same volume we find another important article around ideas of form in landscape architecture, Laurie Olin's, "Form, Meaning, and Expression in Landscape Architecture," 149-168.

[12] See Arnold Berleant, *The Aesthetics of Environment* (Philadelphia: Temple University Press, 1992), and Arnold Berleant, *Art and Engagement* (Philadelphia: Temple University Press, 1991).

[13] I have already alluded to the work of Neil Evernden and William Cronon in highlighting the social creation of some "naturalized" ideas of "nature." In Neil Evernden, *The Social Creation of Nature* (Baltimore: Johns Hopkins University Press, 1992) and William Cronon, "The Trouble with Wilderness; or, Getting Back to the Wrong Nature" in *Uncommon Ground: Rethinking the Human Place in Nature*, ed. William Cronon (New York: W. W. Norton, 1996). I have also mentioned the more recent work of other authors like Timothy Morton and Steven Vogel, who propose the cancellation of the very notion of nature in environmental philosophy. See Timothy Morton, *Ecology without Nature* (Cambridge, MA: Harvard University Press, 2007), and Steven Vogel, "Against Nature", in *Thinking like a Mall* (Cambridge MA: The MIT Press, 2015).

The relaxation of notions of environmental control that these non-scientific ecological discourses and landscape architecture practices argued for in the construction of new images of environment found its counterpart also in scientific ecology and the sciences at large. The determinism of mid-twentieth century ecology began to shift towards a more probabilistic model where the behavior of the environment was not directional anymore through the manipulation of its components. This chaotic image of the environment was the manifestation of what came to be called complexity science, a set of theories that emerge mainly during the 1970s. Drawing upon the study of self-organization in physics, chaos theory in mathematics, adaptation in biology, and spontaneous order in the social sciences, complexity brought an emphasis on evolution and processes of succession in ecological theory that began to undermine the value of the ecosystem.[14] The projects already mentioned, van Valkenburgh's *Ice Wall* series, Hargreaves' *Candlestick Point*, and Haag's *Bloedel Reserve*, embody different aesthetic expressions of notions of chance that lie at the core of the complexity paradigm in science. The *Ice Wall*, with its ambience effects induced by the spontaneous formation and accretion of layers of ice, *Candlestick Point*, with its terraces of abrupt juxtaposition between the manicured and the unfinished, and the *Bloedel Reserve*, with its careful editing of an essentially successional landscape of ecological opportunism, all constitute rhetorical expressions of the passing of time, of the processual and emergent dynamics of the environment.

These practices were particularly interested, therefore, in developing new formal languages that served to bridge the gap between an emerging system of environmental values and the project of landscape architecture as an autonomous and discursive field. In so doing, they expanded the ecological program of landscape architecture, from being an instrument of environmental planning to being an agent in the construction of new cultural images of environment, and contributing, in this sense, to the pluralization of environmental narratives that followed the entrance of ecology into the sphere of the humanities. As I shall show in the the next sections, despite these exploratory and speculative efforts, the influence of

[14] As Donald Worster documents in the already mentioned article "The Ecology of Order and Chaos," the 1980s saw a decline in the importance of the concept of the ecosystem, and even some authors of important ecology textbooks which remained relatively loyal to the ecosystem, such as Robert Leo Smith, eventually recognized a shift from an "ecosystem approach" to an "evolutionary approach." Worster, "The Ecology of Order and Chaos," 8.

ecology over the theory and practice of landscape architecture remains today largely limited to two different and well delineated vectors: the ecological imperative and the metaphors of complexity.

Landscape and Performance: The Ecological Imperative in Landscape Architecture

As I suggested in the introduction, there is a strong correlation between the twofold influence of ecology explained in the previous section—scientific imperative and aesthetic metaphor—and two of the still tacitly accepted yet most widely utilized expressions in the vocabulary of landscape architecture during the last two decades: the notions of "performance" and "adaptation." As I mentioned, "landscape performance" generally designates the capacity of landscapes to carry out work. The focus on sustainability and ecological services that typify the ecological imperative today has bolstered the idea of the *performative* in landscape architecture, through which landscape is seen as the fundamental material substratum towards the consummation of an efficient model of environmental management. "Landscape adaptation," on the other hand, is normally used to allude to the capacity of landscapes to accommodate change. Following the imaginary of complexity as the most widely accepted ecological metaphor today, notions of resilience and adaptation have become the norm in contemporary landscape architecture: the capacity of design to produce open-ended strategies of self-generation is almost incontestably praised as a fundamental asset in adaptively engaging the uncertainty that rules the world of complexity.

By the notion of *performance* I refer, again, to "the capacity to carry-out work." Of the set of definitions that the Merriam-Webster dictionary offers, I want to focus on these three: *performance* is, as in *deed*, "the execution of an action," as in *implementation,* "the fulfillment of a claim, promise or request," and, as in *efficiency*, "the ability to perform."[15] Today we frequently read and hear that landscapes *perform*. What landscape performance denotes, then, is that landscapes can certainly execute actions or procedures, that they can fulfill commands, and that, in so doing, they may run with different degrees of efficiency. In sum, landscapes have the ability to do work.

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[15] "Performance," Merrian-Webster Online Dictionary, accessed July 1, 2017, https://www.merriam-webster.com/dictionary/performance.

Although *performance* is not a new term in the lexicon of landscape architecture, there has been a recent increase in the use of the word which coincides with an expansion in meaning. Before the 1990s, the notion of performance in landscape architecture was closer to the widely common acceptance of the term as public presentation, exhibition, or representation of a role in the *performing* arts.[16] These arts normally involve the movement of artists' bodies—or the use of voices—in contrast to the visual arts, where artists generally produce static objects. The percolation of this meaning of performance into landscape architecture was usually associated with the medium's continual state of transformation as a result of the passing of nature's processes, the change induced by hydrological and seasonal cycles—even socio-economic shifts—as well as with the relationship between the landscape and a human body in motion. There were also phenomenological connotations associated with the perception of time as an aesthetic experience. The work of Lawrence Halprin in the 1960s and 1970s is prototypical in this sense, aiming at giving shape to new ways of environmental engagement.[17] His methods and influences—ranging from choreographers to ecologists—show a clear connection with this idea of performance as a temporal engagement between a body's movement and environment. Even his vocabulary, as when the word *performance* itself participates in his famous *RSVP Cycles'* acronym, or when we read about the eco-score, which is borrowed from the performing arts and plainly projected over the environment, demonstrates his search for new modes of relationship based on ideas of expression, motion, and change.[18]

Towards the end of the 1990s, there was a general turn in the design fields from linguistics to materialism, through which the notion of *performance* in design incorporated new operative connotations. The late

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16 This meaning of the term is also among the ones addressed by the Merrian-Webster Online Dictionary, which defines *performance* also as "the action of representing a character in a play" and as "public presentation or exhibition." Ibid.

17 For a general account of Halprin's interest in human body and landscape engagement see Meyer, "Post-Earth Day Conundrum." For more detailed information about Halprin's interest in movement and design see Lawrence Halprin, *Freeways* (New York: Reinhold, 1966), and Lawrence Halprin, *The RSVP Cycles: Creative Processes in the Human Environment* (New York: George Brazilier, 1969).

18 Halprin, *The RSVP Cycles*.

twentieth century postmodern interest in signs and language gave way in the late 1990s early 2000s to a new fascination with material organizations and operations. This turn, which has been the subject of theoretical analysis during the last decade as part of the so called "post-critical" debate in the design fields,[19] was partly induced by the work of Gilles Deleuze and Felix Guattari in their double volume *Capitalism and Schizophrenia*. One of the tacit maxims of this theoretical turn in the design fields, extracted from Deleuze and Guattari's *The Anti-Oedipus*, was the shift of attention from the question of what things mean to the question of how things work.[20] The influence of Deleuze and Guattari is very clear for example in Stan Allen's 1999 book, *Points and Lines: Diagrams and Projects for the City*, which compiled a set of essays that in the following years contributed very significantly to this materialist shift and the "post-critical" discourse in general. In one of these essays, "Infrastructural Urbanism," Allen praises "architecture's powerful instrumentality,"[21] which goes beyond critique and actually has the capacity to transform reality. He provides a notion of:

> architecture as a *material* practice—as an activity that works in and among the world of things, and not exclusively with meaning and image. It is an architecture dedicated to concrete proposal and realistic strategies of implementation and not distanced commentary or critique.[22]

And a few lines below, while discussing the discipline's technical capacity to deal with infrastructural questions that are less related to discursiveness and more attached to physicality, he argues that:

> rethinking infrastructure is only one aspect of a larger move away from a representation model, one of the many implications of architecture understood as a *material practice*. Material practices (ecology or engineering for example) are concerned with the behavior of large scale assemblages over time. They do not work primarily with images or meaning, or even with objects, but with *performance*: energy inputs and outputs, the calibration of force and resistance.[23]

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[19] A good overview of the different positions and actors involved in the discussion can be found in George Baird, "'Criticality' and Its Discontents," *Harvard Design Magazine* 21 (Fall/Winter 2004): 16-21.

[20] Gilles Deleuze and Felix Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*, trans. Robert Hurley, Mark Seem and Helen R. Lane (Minneapolis: University of Minnesota Press, 1983), 109.

[21] Stan Allen, "Infrastructural Urbanism," in *Points and Lines: Diagrams and Projects for the City* (New York: Princeton Architectural Press: 1999), 50.

[22] Ibid., 52. Emphasis in original.

[23] Ibid. Emphases in original.

Besides the significant explicit mention to *ecology* in this statement, which I will discuss later, I want to point out now that the way *performance* is being used in Allen echoes the above mentioned engagement with notions of time, movement and change, but also incorporates new connotations that deal with the instrumental and the operational. Allusions to *energy*, *forces* and *resistances* imply that to praise performance in design is to praise the executive capacity of design outcomes. As Allen himself remarks, in a way that clearly resonates with Deleuze and Guattari, "They [material practices] are less concerned with what things look like and more concerned with what they can do."[24]

These materialist propositions are among the originators of a prevalent discourse in design that for almost two decades now has argued in favor of the performance of things—how things work, what they do—and in detriment to not only meaning—what things mean—but also to *appearance*—how they look. Some landscape theorists immediately began to explore similar performative dimensions in landscape architecture design. Julia Czerniak, for example, marked a sort of "schism" in landscape architecture that is very much present today, by precisely taking the dichotomy between *performance* and *appearance* as the central question of analysis in her introductory essay to the *Case: Downsview Park Toronto* volume she edited in 2001.[25] Czerniak's piece, simply titled "Appearance, Performance: Landscape at Downsview," is the first of a set of contributions that analyze the five finalist proposals for the Parc Downsview Park's competition—Stan Allen himself being one of them, in collaboration with landscape architect James Corner and ecologist Nina-Maria Lister. The competition was held in 1999 to select a design for a 320-acre military base in Toronto, Canada, and was organized with the ambition to prompt a discussion of the role of large urban parks in the turn of the twenty-first century and, more generally, of the role of the discipline of landscape architecture.

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[24] Ibid., 53.

[25] Julia Czerniak, "Appearance, Performance: Landscape at Downsview," in *CASE: Downsview Park Toronto, CASE Series* (Munich; New York; Cambridge, Mass.: Prestel; Harvard University, Graduate School of Design, 2001).

In her article, Czerniak frames the discussion around the shift of attention of the five finalist proposals, in accordance with the competition brief, towards the "invention of infrastructural and administrative frameworks, their engagement with complex processes, and their formulation of modes of practice involving landscape, architecture and the city." [26] Czerniak's discussion of "frameworks" in Downsview clearly echoes "infrastructures," as Allen had discussed them a couple of years earlier in *Points and Lines*—in fact, Allen found in the Downsview competition a very fertile ground to explore in a more practical manner many of the questions he had speculated with in his writing. It also helps tie some of these discourses to a lineage of architecture and landscape architecture practices of the 1980s and 1990s, such as George Hargreaves', West 8's, or Rem Koolhaas', which had been working on projects whose large scales incorporated inevitably infrastructural implications and the participation of other professional agents such as civil engineers. The scale of Downsview was therefore tackled through infrastructural approaches that foregrounded the *performative* capacities of landscape through the notion of the framework; the framework—against the more rigid connotations of form—is discussed as open, dynamic, organizational, infrastructural, and as a promoter of ideas of provisionality, indeterminacy, impermanence, and open-endedness—ideas associated with complexity and process-oriented thinking, whose impact over design has been also extraordinary during the last years, and which I want to discuss with detail in the next section through the notion of *adaptation*.

Landscape and Adaptation: Ecological Complexity and Landscape Architecture

By *adaptation* I refer to "the capacity to accommodate change." Again, looking at the Merriam-Webster dictionary, we read that *adaptation* is both the result and the process of being *adapted*,[27] and that *adapt* is "to make fit (as for a new use) often by modification."[28] One of the definitions of *adaptation* is in fact formulated through the notions of the organism and the environment, marking a strong link with ecology;

[26] Czerniak, "Appearance, Performance," 14.

[27] "Adaptation," Merrian-Webster Online Dictionary, accessed July 5, 2017, https://www.merriam-webster.com/dictionary/adaptation.

[28] "Adapt," Merrian-Webster Online Dictionary, accessed July 1, 2017, https://www.merriam-webster.com/dictionary/adapt.

adaptation is "adjustment to environmental conditions: such as: (a) adjustment of a sense organ to the intensity or quality of stimulation; (b) modification of an organism or its parts that makes it more fit for existence under the conditions of its environment."[29] With these premises in mind, therefore, a landscape that *adapts* is a landscape that is able to accommodate particular changes, which will serve specific functions that will ultimately make it more responsive to its environment and/or more likely to endure.

Adaptation is the means towards perpetuation, and therefore it entails *time* and *process*. Adaptation has been lately surrounded by a myriad of associated concepts, such as the open-ended, the indeterminate, the aleatory, the dynamic, and so on, which have also come to the forefront of landscape architecture and the design fields at large during the last two decades. These are concepts that relate to process philosophy, which have received a good deal of attention in the formal sciences, the natural sciences, and the social sciences, as a result of the development of complexity theory. Quite roughly, complexity is the interdisciplinary domain that investigates systems whose structure and behavior at the macro level are often unpredictable and inexplicable through the properties of the parts.[30] Established, as I have already mentioned, in the 1970s, and having drawn contributions from many different fields, including mathematics, physics, biology, and economics, complexity and its derived concepts have also been a subject of interest in the design disciplines since the 1990s, and, as with performance, they have become commonplace in recent design theory through post-critical discourse. One of the most remarkable manifesto-like essays of the past two decades that has aimed at bolstering notions of adaptation in the design fields, is the one that landscape architect James Corner wrote to preface Charles Waldheim's influential *The Landscape Urbanism Reader* volume of 2006. Corner, another important actor in the post-critical debate and, significantly, a partner of Stan Allen in the Downsview Park competition, offers a piece called "Terra Fluxus,"[31] whose title is already an unambiguous statement in favor of more "liquid"

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[29] "Adaptation," Merrian-Webster Online Dictionary.

[30] A detailed explanation of complexity theory and of complex adaptive systems will be presented later in chapter 3. A key volume in the development of complexity theory is Ilya Prigogine and Isabelle Stengers, *Order out of Chaos: Man's New Dialogue with Nature* (New York: Bantam Books: 1984 [1978]).

[31] James Corner, "Terra Fluxus," in *The Landscape Urbanism Reader*, ed. Charles Waldheim (New York: Princeton Architectural Press, 2006), 21-34.

conceptions of landscape as the medium where different design fields operate.[32] The bulk of the article is a defense of four provisional design principles. When promoting the first of these, according to which processes of urbanization are more determinant in the shaping of urban relationships than the spatial forms offered by the designers, Corner discusses the necessity of new tools of representation that allows a reading of:

> the entire metropolis as a living arena of processes and exchanges over time, allowing new forces and relationships to prepare the ground for new activities and patterns of occupancy. The designation *terra firma* (firm, not changing: fixed and definitive) gives way in favor of the shifting processes coursing through and across the urban field: *terra fluxus*.[33]

In their promulgation of dynamism and process-based design, Corner and other participants in the "post-critical" discussion reject stasis and, through it, design methods or products based on ideas of form and composition—by virtue of their allegedly passive implications; process better engages the dynamic, opportunistic and risk-taking basis of their position. In another passage of "Terra Fluxus," he writes that:

> unlike architecture, which consumes the potential of a site in order to project, urban infrastructure sows the seeds of future possibility, staging the ground for both uncertainty and promise. This preparation of surfaces for future appropriation differs from merely formal interest in single surface construction. It is much more strategic, emphasizing means over ends and operational logic over compositional design.[34]

Corner's claim in favor of the adaptive surface as opportunity for the uncertain and the operational, in detriment to form as restriction of possibilities, echoes the already mentioned arguments in favor of performance that we read in Stan Allen's "Infrastructural Urbanism" and in Julia Czerniak's examination of the Downsview competition, and reiterates, very literally in fact, the shift of attention from how things look to how things work, promulgated by Allen.[35]

It also echoes another article that was equally significant to the theoretical development of landscape urbanism, Alex Wall's "Programming the Urban Surface," published in the *Recovering Landscape*

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[32] Some authors have used the "liquid" metaphor to signify the gamut of concepts around these notions of complexity—the adaptive, the open-ended, the indeterminate, the aleatory, the dynamic, the uncertain, and so on. See Zygmunt Bauman, *Liquid Life* (Cambridge, UK: Polity Press, 2005).

[33] Corner, "Terra Fluxus," 30.

[34] Ibid., 31.

[35] Allen, "Infrastructural Urbanism," 51.

volume that Corner himself edited in 1999.[36] In it, Wall writes that in contemporary urbanization, cities are not historical cores surrounded by modern expansions surrounded in turn by the countryside anymore, but rather polycentric regional metropolises served by multilayered logistical and informational networks, and that, in these circumstances, "operationally, if not experientially, the infrastructures and flows of material have become more significant than static political and spatial boundaries."[37] In what he calls a picture of urbanism that is dynamic and temporal, "the emphasis shifts here from *form* of urban space to *process* of urbanization, processes that network across vast regional—if not global—surfaces."[38] He describes this shift as a change of paradigm from viewing cities in formal terms to viewing them in dynamic terms. In addition, he regards urban typologies as useless and insignificant in comparison to the infrastructural and to the ambiguous and polymorphous constitution of contemporary urban spaces, which, referencing Delueze and Guattari, he equates to a rhizome. In the rejection of types, there exists an implicit rejection of meaning, as derived from the structuralist use of typological thinking in postmodernism, and in the welcoming of the diffuse, there is an explicit acceptance of the *rhizome*.[39]

Drawing from the same sources as Stan Allen, Wall uses Deleuze and Guattari's metaphor of the rhizome to claim a new notion of *flexibility* and *multi-functionality* in design thinking that dovetails with performance and adaptation.[40] Deleuze and Guattari describe the rhizome as an image of thought that follows a principle of connection and heterogeneity, according to which "any point of a rhizome can be connected to anything other, and must be,"[41] unlike hierarchical and ordering structures like trees. The rhizome does not have a beginning nor an end, is always in the middle, from which it grows, and is "an

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36 Alex Wall, "Programming the Urban Surface," in *Recovering Landscape: Essays in Contemporary Landscape Architecture*, ed. James Corner (New York: Princeton Architectural Press, 1999), 233-250.

37 Alex Wall, "Programming the Urban Surface," 234.

38 Ibid. Emphasis in original.

39 Ibid.

40 Gilles Deleuze and Felix Guattari, "Introduction: Rhizome," in *A Thousand Plateaus*, trans. Brian Massumi (Minneapolis: University of Minnesota Press, 1987 [1980]), 3-25.

41 Ibid., 7.

acentered, nonhierarchical, nonsignifying system without a General and without an organizing memory or central automaton, defined solely by a circulation of states."[42] It is this distributed and loose condition of the rhizome that Wall projects into his image of the urban surface and allows him to read it as an endlessly enabling field, a connective tissue that engages disparate fragments into unexpected relationships and possibilities.[43] Flexibility and looseness enable performance.

And vice-versa, performance allows adaptation.[44] For Allen, Corner, Wall, and their followers during the last two decades, the only things that are dynamic can be functional, for functionality requires "fitness," and fitness is achieved through adaptation to certain conditions.[45] Only things that are functional are "alive" and dynamic. As long as things have the potential to adapt, they will perform; as long as they remain active, they will be able to endure through change. From the optic of the performative and the adaptive, the formal is seen as passive and rigid, as "not working" and "not changing" and therefore, as useless and decrepit.

Before I conclude this section, I want to quote one passage from "What Ever Happened to Urbanism?", from Rem Koolhaas' 1995 contemporary classic *S,M,L,XL*, which exerts a clear influence on all the authors I have alluded to in these last pages, and which will clearly illustrate this engagement between performance and adaptation to the detriment of form in design:

> If there is to be a "new urbanism" it will not be based on the twin fantasies of order and omnipotence; it will be the staging of uncertainty; it will no longer be concerned with the arrangement of more or less permanent objects but with the irrigation of territories with potential; it will no longer aim for stable configurations but for the creation of enabling fields that accommodate processes that refuse to be crystallized into definitive form; it will no longer be

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[42] Ibid., 21.

[43] Wall, "Programming the Urban Surface," 235.

[44] James Corner offers another phrasing of this shift from *form* to *performance*, interestingly, after referencing Marxist geographer David Harvey's *The Condition of Post-Modernity*, when he argues that "the projection of new possibilities for future urbanism must derive less from an understanding for form and more from an understanding of process—how things work in space *and* time." In Corner, "Terra Fluxus," 29.

[45] James Corner speaks about "fitness landscapes" in his article "Not Unlike Life Itself: Landscape Strategy Now," *Harvard Design Magazine* 21 (Fall 2004/Winter 2005), 31.

> about meticulous definition, the imposition of limits, but about expanding notions, denying boundaries, not about separating and identifying entities, but about discovering unnameable hybrids; it will no longer be obsessed with the city but with the manipulation of infrastructure for endless intensifications and diversifications, shortcuts and redistributions—the reinvention of psychological space. Since the urban is now pervasive, urbanism will never again be about the "new;' only about the "more" and the "modified:' It will not be about the civilized, but about underdevelopment. Since it is out of control, the urban is about to become a major vector of the imagination. Redefined, urbanism will not only, or mostly, be a profession, but a way of thinking, an ideology: to accept what exists. We were making sand castles. Now we swim in the sea that swept them away.[46]

Koolhaas' piece anticipates the broader theoretical shift that landscape architecture and the design fields were going to experience during the turn of the twentieth century, one where, as I have shown, ideas of flexibility, functionality, connectivity, organization, operativeness, effectiveness, framework, impermanence, and opportunism, were rendered dynamic and progressive, in opposition to precedent paradigms of alleged spatial categorization and containment. This paradigmatic shift, which, I would synthesize as a shift from *form* to *performance* and *adaptation*—where *form* is considered both physical manifestation of meaning and appearance towards aesthetic experience; where *performance* is capacity to carry out work and have an impact in the material world, and where *adaptation* is capacity to change in order to endure—sought to bolster, as it becomes very clear in Koolhaas' exhortation, the agency of the design disciplines. Now that a few years have passed, it becomes clear that, as I shall explain in the following section, in aiming at expanding the agency of design, this shift also prompted reductive implications for landscape architecture's theory and practice.

The Limitations of Performance and Adaptation. Prescription and Indeterminacy

It has been five decades since the conscious incorporation of ecology into the theory and practice of landscape architecture. And although ecology has been, ever since McHarg and, more recently, as I have shown, through the ecologically-grounded concepts of "performance" and "adaptation," extremely fruitful in expanding the field of landscape architecture, it also has a less promising side, which entails serious limitations for the agency of landscape architecture as a cultural project. The ecological imperative and the *performative*, on the one hand, have exacerbated the techno-scientific dimensions of design; many

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[46] Rem Koolhaas, "What Ever Happened to Urbanism?" *S,M,L,XL*, eds. Rem Koolhaas et al. (New York: Monacelli Press, 1995), 970-971.

ecological ideas are disaggregated into a series of problem-solving and quantifiable techniques, which landscape architecture has to put into practice in search of new models of efficient environmental management. The result is, as I have mentioned, a strong emphasis in landscape's ability to work, and a subsequent lack of interest in landscape's formal associations, that is, landscape's capacity to be looked at and deciphered. As a cultural metaphor, on the other hand, ecology has been and continues today to be primarily used to invoke notions of complexity. Through complexity and the *adaptive*, landscape architecture has been instrumentalized in the aestheticization of process-based notions of unpredictability, open-endedness, and indeterminacy in design, neglecting, as a consequence, alternative modes of formal expression that serve to communicate other ideologies and issues that remain at the core of the discipline.

While the focus of the performative—on landscape's capacity to do work—highlights technics often to the detriment of the aesthetics of landscape architecture, the adaptive's engagement with notions of complexity presents, on the contrary, a strong aesthetic component. But one that is heavily invested in the exploration of the very specific formal languages of flows and processes that serve to naturalize notions of complexity, uncertainty, and provisionality. So, while the lack of aesthetic discourse in the performative limits the very possibility of design as a means for expression and communication, the adaptive's focus on provisionality and surprise not only limits the repertoire of aesthetic explorations to a fetishization of languages of flows—excluding the putatively top-down methods based on permanence and form—but also restrains design agency in favor of positions of passiveness that relinquish the specification of design outcomes to external and abstract forces.

Through the paradigm of sustainability, many precepts of the environmentalist agenda have been projected into our days perpetuating, as a result, the idea of ecology as a scientific mandate that keeps calling for techno-scientific strategies of environmental control and protection. Under the pressure of this "ecological imperative," landscape architects today face challenges from analytical determinism that are analogous to those faced by the generation that experienced the rise of environmentalism. In addition, the discursive bifurcations that so richly expanded ecology's potential for representational and experiential pursuit in the 1980s have been ultimately obscured by the notions of uncertainty and indeterminacy that characterize the scientific paradigm of complexity, and which have also powerfully entered ecology. As a metaphor, ecology's invocation of "ecological complexity" today points to probabilistic models of the environment where behavior is not only ungovernable through the manipulation of its constituent parts, but in fact only describable as an unintelligible set of non-linear adaptive processes that unfold accordingly to uncertain paths of development.

The performative and the adaptive are derived, as I have argued, from these two different and well delineated vectors, by which ecology, despite its plurality of meanings and agendas, exerts a strong influence over the theory and practice of landscape architecture today. The performative follows an idea of ecology as a catalog of technical formulas, and the adaptive deals with ecology as a mobilizer of ideas of complexity. And while the first of these two images of ecology keeps calling for strategies aligned with principles of control, the second one suggests that the intrinsic complexity of the environment is its most fundamental property and, precisely, the reason why governability is just a chimera. One calls for high degrees of prescription in design; the other demands design formulas fundamentally based on indeterminacy. The technological neo-positivism of the "scientific imperative" of ecology clashes with the intrinsic nihilism of "ecological complexity." And although much of today's theory of scientific ecology is invested in the mediation between these two apparently conflicting models—so that new ecosystems management is driven by more flexible and adaptive strategies—in the design fields both paths rarely cross, and, when they do, the conundrum that seems to exist between them remains largely unspoken, or dealt without rigor.

From the consideration that ecology is, despite the reductive implications that it entails for landscape architecture, still a powerful metaphor to synthesize some of the challenges of our time, in the next chapters I shall articulate alternative narratives of ecology as a way to both counterbalance the imaginaries that prevalent ideas of ecology have normalized in the design disciplines and to bolster the agency of landscape architecture as a cultural and cognitive project. I shall begin by examining, in the next two chapters, the concepts of "system" and "process" for their key role in the theoretical development of the "ecological imperative" and the complexity approach to ecology, and also for their key role in the more recent emergence of the notions of “performance” and “adaptation” in landscape architecture. And I shall also prove that the ways in which contemporary landscape architecture deals with system and process are largely dependent on the ways in which ecological theory has managed those same concepts during the last decades. When alluded to in landscape architecture design, system often carries connotations of the thermodynamic quest for efficiency, as well as the mechanistic connotations of the ecological idea of the “ecosystem.” Process, on the other hand, can hardly escape the mainstream ecological view as open-ended phenomenon, giving preeminence to notions of provisionality, indeterminacy, and uncertainty in contemporary landscape architecture discourses.

In order to overcome these biased associations of system and process, and to open up their potential for design, I shall be revisiting some of the ontological debates that have characterized the unfolding of ecological theory during the twentieth century. Debates that, largely unnoticed in landscape architecture’s engagement with ecology, touch upon questions of systemic interconnection and successional processes, by focusing on the ontological status of the primary ecological entity—whether it is the biotic community or the individual organism—and on the ultimate metaphysic constitution of nature itself—whether there is a “balance of nature” or nature is inherently chaotic.

PART 2

CHAPTER 3

Systems and Processes: a Reversed Genealogy of Ecological Theory

Systems and Processes: a Reversed Genealogy of Ecological Theory

In the previous chapter I have argued that, despite the extreme pluralization of meanings that are invoked by the word "ecology" today, the influence that it exerts over the theory and practice of landscape architecture is largely limited to two very different and well delineated vectors. One of these conveys an idea of ecology as a scientific imperative—ecology as catalog of technical formulas at the service of scientific targets—and the other deals with ecology as an aesthetic metaphor—ecology as a mobilizer of specific interpretations of the environment—that is used to call upon notions of complexity.

As I have explained, the current notion of ecology as a scientific imperative goes back to the rise of environmentalism in the 1960s, and the entrance of ecology into the social and political spheres. Ever since, ecology has been constantly invoked as an applied science that should provide the rational basis for intervention in the face of the then newly described environmental problems. Using the notion of the ecosystem as the central unit of ecological inquiry, it was suggested that, through the manipulation of ecosystems, the whole planet should be managed for either the preservation of the balance of nature, or for the improvement of environmental efficiency—both ideas still firmly rooted in the collective imagination. The second vector of influence, ecology as a metaphor for complexity, departs from a reexamination of ecological theory that began in the late 1970s as part of a new approach in the scientific fields at large promoted by what came to be known as "complexity." Complexity emerged in the sciences as difficulties with modeling certain properties of certain systems were considered to be the norm, and when the behavior of such systems seemed to be unpredictable apart from those properties. When complex systems began to be formally studied in the 1970s, ecosystems soon fell within this new category, and the deterministic image of the environment drawn by mid-twentieth century ecology began to shift towards a more probabilistic model where the behavior of the environment was not directional through the manipulation of ecosystems anymore.[1] Following the turn to complexity, which many authors have referred to as a "paradigmatic shift" in ecology, ecosystems do not follow a single "strategy for

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[1] For a review of the conflict between these two different ecological models, see Robert E. Ulanowicz, "Life after Newton: An Ecological Metaphysic," in *BioSystems* 50 (1999), 127-42.

development" whose achievement put the environment in a closing state of balance anymore; instead, ecosystems could unfold towards several different coherent future scenarios through a non-linear process of evolution and adaptation characterized by uncertainty.[2]

The grounds of this conundrum are metaphysical. As I have mentioned, the scientific imperative is largely built upon a deterministic model of reality, one that privileges the idea that natural laws are rigid and that environmental processes follow a rather strict path predetermined by such laws. The model of the environment advocated by complexity is, on the other hand, a probabilistic—therefore non-deterministic—one where reality operates so that the result of any event is not certain, and therefore the outcome of environmental processes is just probable, at most.[3]

In this chapter I shall build a genealogy of the ecological ideas that emerge from these two opposing images of ecology (*Figure 3.1)*. I shall use this genealogy to investigate the ways in which the theory and the philosophy of ecology have dealt with the concepts of "system" and "process," both central in the theoretical development of the "ecological imperative" and the complexity approach to ecology, as well as in the emergence of the notions of "performance" and "adaptation" in landscape architecture. I shall also illustrate that the concepts of "system" and "process" that prevail in contemporary landscape architecture are largely dependent on ways in which ecological theory has managed those same concepts during the last five decades; when invoked in landscape architecture, the idea of "system" still privileges mechanistic connotations proper of the managerial tenets of the ecosystem, and process, on the other

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[2] Among the authors that have referred to the rise of complexity in ecological theory as a "paradigmatic shift" we find environmental historian Donald Worster, botanist Timothy F. H. Allen, and environmental planner Nina-Marie Lister. See, for example, Donald Worster, "The Ecology of Order and Chaos," T. F. H. Allen, "Scale and Type: A Requirement for Addressing Complexity with Dynamical Quality," in *The Ecosystem Approach: Complexity, Uncertainty and Managing for Sustainability*, eds. David Waltner-Toews, James J. Kay and Nina-Marie Lister (New York: Columbia University Press, 2008), 37-50, and Nina-Marie Lister, "Bridging Science and Values: the Challenge of Biodiversity Conservation," in the same volume, 83-108.

[3] A good account of the different ecological theories of the twentieth century in relationship to different metaphysical paradigms can be found in Daniel Simberloff, "A Succession of Paradigms in Ecology: Essentialism to Materialism to Probabilism," in *Synthese* 43 (1980), 3-39. See also Ulanowicz, "Life after Newton."

hand, tends to be presented as an open-ended phenomenon that mobilizes notions of indeterminacy and uncertainty. The genealogy looks back further in time and traces some of the early twentieth century controversies in ecological theory, namely, the ontological status of the primary ecological entity—whether it is the biotic community or the individual organism—and the ultimate metaphysic constitution of nature itself—whether there is a "balance of nature" or nature is inherently chaotic. A closer look at these debates, largely overlooked in landscape architecture's theory and its engagement with ecology, shall help to overcome the current, biased associations of system and process and to open up their potential for design.

Systems of Performance and Processes of Adaptation

As I have shown in chapter 2 and in the introduction to this chapter, the notions of the performative and the adaptive in landscape architecture are rooted in two different images of ecology, the so-called "scientific imperative" and the complexity approach to ecology, which are, in turn, derived from two different metaphysical models of reality, one deterministic and the other one probabilistic. The deterministic model of the scientific imperative assumes that environmental processes follow a single path of development which is predetermined by rigid natural laws. The probabilistic model of complexity suggests instead that the outcome of environmental processes is just probable and not certain. Despite the general turn towards probabilism that has characterized the course of science during the twentieth century, scientific orthodoxy often resists rejecting deterministic models, for they provide science with the metaphysical substratum for one of its most fundamental purposes, namely, the construction of theories that allow us to explain and predict phenomena.[4] The case of ecology is not an exception; although not as overwhelmingly dominant as it used to be during the 1960s, 1970s and 1980s, the deterministic paradigm is still today quite rampant in both the theory of ecology and its development as an applied science.

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[4] The Newtonian or purely mechanical worldview of classical mechanics that guided science during the Modern Age is considered to have been contested at least three times during the twentieth century, first with the rise of quantum mechanics, then with the introduction of spacetime in general relativity, and finally with the discovery of chaos. See Ilya Prigogine, *The End of Certainty: Time, Chaos, and the New Laws of Nature* (New York: The Free Press, 1996).

In ecology, the deterministic view is epitomized by the work of the American ecologists Eugene P. and Howard T. Odum. I have already mentioned that 1953 saw the publication of the first textbook of ecology, *Fundamentals of Ecology*, which revolved around a concept that the British botanist Arthur Tansley had proposed in 1935: the "ecosystem."[5] In *Fundamentals of Ecology,* the ecosystem was defined as "any unit that includes all of the organisms (i.e., the 'community') in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (i.e., exchange of materials between living and nonliving parts) within the system."[6] The Odums gave unparalleled preeminence to the concept of system in ecological theory, inaugurating a new path that would become a whole paradigm in ecology for at least two decades, and which E. P. Odum would come to call "systems ecology." In 1964, he wrote that "*the new ecology is thus a systems ecology* —or, to put it in other words, the new ecology deals with the structure and function of levels of organization beyond that of the individual and species.[7]"

"Systems ecology" broke the original confinement of ecology as a modern branch of biology and transformed it into a more ambitious theoretical field engaged with the interdisciplinary lineage of general systems theory that Ludwig von Bertalanffy had opened in the decade of the 1930s.[8] Borrowing from systems theory, the Odums gave prevalence to a hierarchical mode of thinking of the environment as composed of large interacting units that were made, in turn, of interrelated parts. But more importantly, systems ecology also began to draw strong connections with energetics. System and energy had been closely associated concepts since the rise of thermodynamics back in the nineteenth century. The publications and studies that proposed the establishment of thermodynamics as a branch of physics in the

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[5] Arthur G. Tansley, "The Use and Abuse of Vegetational Terms and Concepts," *Ecology* 16, no. 3 (1935), 284-307.

[6] Eugene P. Odum, *Fundamentals of Ecology* (Philadelphia: W.B. Saunders, 1971 [1953]), 8.

[7] Eugene P. Odum, "The New Ecology," *BioScience* 14 (July 1964), 14-16, 15. Emphasis in original.

[8] Although the term "general systems theory" is first used as such in the title of the book *General Systems Theory* that Bertalanffy published in 1968, he began to develop his theory in 1937 through lectures and other publications. Ludwig von Bertalanffy, *General System Theory: Foundations, Development, Applications* (New York: George Braziller, 1968).

1820s were primarily concerned with the measurement and optimization of performance—again, the capacity to produce work—of steam engines, which, at the peak of the first wave of the Industrial Revolution were widely regarded as strategic vehicles for economic and industrial development.[9] In studying the transmission of heat and other forms of energy, thermodynamics had introduced a strong system-based mode of thinking in the rationalist tradition of the hard sciences; steam engines were, after all, collections of components that interchanged heat with their environment. With its focus on flows of energy across and within ecosystems, systems ecology soon began to draw heavily upon the field of thermodynamics and to also emphasize the quantification of inputs and outputs (*Figure 3.2*). An interest in energy and quantification brought, in turn, an inevitable association of ecology with economics, to the point that systems ecology has been referred to by some historians as a move towards "ecoenergetics."[10]

Systems ecology took, as I have mentioned, the ecosystem as the fundamental unit for analyzing the environment and established that the subject of ecology should be the study of the structure and function of the ecosystem. However, as some authors interpreted almost concurrently with the first publication of *Fundamentals of Ecology*, the focus on energetics and economics soon made the *functional* attributes of the ecosystem more relevant than the *structural* ones. Francis C. Evans, a contemporary of Eugene Odum and another firm proponent of the ecosystem, in an article from 1956 called "Ecosystem as the Basic Unit in Ecology" addressed the importance of both functional and structural aspects of the ecosystem but also recognized the preponderance of the functional ones, which he referred to as quantitative and operative questions related to the transportation and storage of matter and energy:

> In its fundamental aspects, an ecosystem involves the circulation, transformation, and accumulation of energy and matter through the medium of living things and their activities. Photosynthesis, decomposition, herbivory, predation, parasitism, and other symbiotic activities are among the principal biological processes responsible for the transport and storage of materials

[9] Sadi Carnot's 1824 book *Reflections on the Motive Power of Fire* is considered the founding text in the field of thermodynamics. It is essentially devoted to the study of the capacity of heat to produce work, and to the efficient use of that capacity. Sadi Carnot, *Réflexions sur la puissance motrice du feu et sur les machines propres à développer cette puissance* (Paris, 1824).

[10] Robert McIntosh, *The Background of Ecology: Concept and Theory* (Cambridge: Cambridge University Press, 1985), 200. McIntosh also refers to Eugene Odum in "Energy Flow in the Ecosystems: A Historical Review," *American Zoologist* 8 (1968), 11-18, where he wrote that "ecoenergetics is the core of ecosystem analysis."

> and energy, and interactions of the organisms engaged in these activities provide the pathways of distribution. […] The ecologist, then, is primarily concerned with the quantities of matter and energy that pass through a given ecosystem and with the rate at which they do so. Of almost equal importance, however, are the kinds of organisms that are present in any particular ecosystem and the roles they occupy in its structure and organization. Thus, both quantitative and qualitative aspects need to be considered in the description and comparison of ecosystems.[11]

Implied in Evans is the idea that it was through the *functional* engagement of the different components of the ecosystem that the ecosystem could actually be thought of as a *structural* unit, as a whole. Odum was key in the establishment of a broad distinction between "ecosystems ecology" and "population ecology," quite present still today, which some historians of ecology have criticized for inducing an artificial dualism in ecological science.[12] Odum positioned himself as the key figure of "ecosystems ecology," which he dogmatically regarded as a functional, holistic—hence more complete—and more skilled than other reductionist and mathematically-based approaches, which focused more strictly on structural aspects of the environment, such as the number of species in an area or community, the proportions between those, and their evolution.[13]

Eugene Odum's functionalist approach was meticulously endorsed by the new graphic code that his brother, Howard T. Odum, developed over the course of several decades, borrowing from the language of electric-circuit diagrams. Electrical metaphors were not new in ecology. Royal N. Chapman had used them in the 1930s to derive from them the notion of biotic *potential* as the reproductive power an organism has against the *resistance* of the environment in which it lives.[14] But in the hands of H. T. Odum they were used in a very decisive manner, eventually leading him to build ecological models and simulations based on analogies between the environment and electric forces and thermodynamic fields. In other words, the ecosystemic and ecoenergetic approach of the Odum brothers eventually promoted a mechanistic vision of the environment, according to which all relations between organisms and their

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[11] Francis C. Evans, "Ecosystem as the Basic Unit in Ecology," *Science* 123 (June 1956), 1127-8.

[12] McIntosh, *The Background of Ecology*, 201.

[13] Ibid.

[14] Royal N. Chapman, *Animal Ecology* (New York: McGraw-Hill, 1931).

environment could be explained in terms of a materialistic exchange of energy—hence, again, the capacity to produce work.

This vision was largely influenced as well by the work of the biophysicist Alfred Lotka, who, by the 1920s, had published a series of academic papers aimed at translating Darwin's theory of natural selection into physical laws. Lotka's proposal, which the Odums studied carefully and named the "maximum power principle," suggested that the Darwinian selective principle of evolution essentially favored those species that were able to transform the maximum useful energy available in the environment.[15] In ecosystemic terms, and from a rather deterministic stance, Eugene Odum wrote in 1969 that the strategy of development of any ecosystem is "directed toward achieving as large and diverse organic structure as is possible within the limits set by the available energy input and the prevailing physical conditions of existence (soil, water, climate, and so on)"[16]—certainly, a *performative* view of the environment based on the quest for efficiency that characterized early thermodynamic conceptions of system.

As already mentioned, this systems ecology became the overwhelmingly prevailing paradigm for at least two decades. Its dominion began to be questioned as new approaches influenced by theories of complexity began to dismantle some of its precepts in the 1970s.[17] However, the systemic approach eventually was been able to absorb many of the postulates of complexity and to adapt into what some have called a new complex systems approach to ecology.[18] If the percolation of systems into ecological

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[15] See Alfred J. Lotka, "Contribution to the Energetics of Evolution," *Proc. Natl. Acad. Sci.*, 8 (1922), 147-151, and "Natural Selection as a Physical Principle," ibid., 151-154.

[16] Eugene P. Odum, "The Strategy of Ecosystem Development," *Science*, 164 (1969), 266.

[17] For a good account of complex systems thinking in ecology, see for example James J. Kay, "An Introduction to Systems Thinking," in *The Ecosystem Approach: Complexity, Uncertainty, and Managing for* Sustainability, eds. David Waltner-Toews, James J. Kay and Nina-Marie Lister (New York: Columbia University Press, 2008), 3-14.

[18] Among the main proponents of this ecosystem approach adjustment from systems ecology into a complex systems ecology is, again, James J. Kay. See, in this sense, James J. Kay, "Framing the Situation: Developing a System Description," in *The Ecosystem Approach: Complexity, Uncertainty and Managing for Sustainability*, eds. David Waltner-Toews, James J. Kay and Nina-Marie Lister (New York: Columbia University Press, 2008), 15-36. Eric D. Schneider and James J. Kay, "Complexity and Thermodynamics: Towards a New Ecology," in *Futures* 26 (1994), 626-647.

theory eventually bolstered a performative approach in the field, it has been through the emergence of these complex systems ecology that notions of adaptation have come to the forefront of ecological theory. Defined, as we have seen, as the adjustment of an organism to better fit the given environmental conditions, the notion of *adaptation* is closely linked to the Darwinian notion of *evolution*, a central idea in the inception of ecology, as we have also seen in chapter 1, because of the influence of Darwin on Haeckel. However, the notion of adaptation has been reinvigorated in ecology as part of the rise of what came to be known as complexity science since the 1970s.

The formal study of complexity began as the growing power of computers allowed for the creation of more precise simulations to study the behavior of systems, and yet the outcome of the simulations seemed to elude the expected results. Systems whose reactions were intractable were called complex systems. Sometimes this was due to the richness and intricacy of the interactions and dependencies between the components of the system, which make the system's overall behavior incomprehensible, even if the individual components are perfectly understood; some other times it was due to the extreme sensitivity of the system to the initial conditions, as in chaotic systems, where small differences in the inputs could lead to great differences in final outcomes. Complexity soon entered the study of many different kinds of systems. It began to draw on the study of positive feedback and processes of self-organization in physical systems, the study of negative feedback and homeostasis in biological systems, spontaneous order in the social sciences, and chaos theory in mathematics. Chaos theory, in particular, has been predicated as one of the three twentieth century scientific revolutions—along with relativity and quantum theory—that altogether would compose a single paradigmatic shift that, in favor of more probabilistic conceptions of reality, would defy the models, laws, and principles inherited from seventeenth century classic science.[19] As James Gleick argued in *Chaos: The Making of a New Science*, in 1987, "Relativity eliminated the Newtonian illusion of absolute space and time; quantum theory eliminated the Newtonian dream of a controllable measurement process; and chaos eliminates the Laplacian fantasy of deterministic

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[19] "Paradigm shift" is used here in Kuhnian terms. See Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: Chicago University Press, 1962).

predictability."[20] I have already referred to this lack of predictability through a myriad of terms associated with complexity and chaos—indeterminacy, uncertainty, indeterminacy, impermanence, open-endedness—terms which have also emerged in the design fields.

Ecology was not impermeable to the postulates of complexity. Their entrance, however, was relatively slow when compared to other scientific fields—such as mathematics, physics, or meteorology—partially because of the strong momentum that the Odumian paradigm of systems ecology still held by the time that complexity rose. Systems ecology was a still fresh, vigorous, and recently unified theory of ecology which, drawing on the heuristic of the ecosystem, had been able to articulate a widely accepted functional view of the environment. In the context of the environmental awareness that also rose in those years, a unified theory of ecology based on assumptions of mechanistic predictability constituted a valuable foundation for the whole new technological apparatus that an optimistic response to the catastrophic predicaments of environmentalism demanded. Nonetheless, in the 1970s, a new body of ecological scholarship, informed by notions of complexity, chaos, and adaptive evolution, began to grow and move in a different direction, overlapping with the promises of predictability derived from Odum's ideas.

One of the first publications towards the establishment of this new "complex adaptive systems" ecology was William Drury and Ian Nisbet's 1973 article "Succession," published in the *Journal of the Arnold Arboretum.*[21] "Succession" suggested that assumptions of succession being a predictable process were inconsistent and not founded in direct observation. They argued against Odum's definition of the ecosystem, where flows of energy in the environment led again "to clearly defined trophic structure, biotic diversity, and material cycles"[22] and more explicitly against Odum's idea of succession as "an orderly process of community development that is reasonably directional and, therefore, predictable

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[20] James Gleick, *Chaos: The Making of a New Science* (New York: Viking, 1987), 6.

[21] William Drury and Ian Nisbet, "Succession," in *Journal of the Arnold Arboretum*, 54 (July 1973), 331-368.

[22] E. P. Odum, *Fundamentals of Ecology*, 8. See also E. P. Odum, "The Strategy of Ecosystem Development," 266.

(*Figure 3.3*).”[23] Drury and Nisbet's article explained that they were not able to find evidence of any developmental plan in the environment, of any progress towards any larger and neater characterization of the biotic structure. In developing their argument, Drury and Nisbet were rescuing the work of an earlier ecologist, Henry Gleason, who had proposed a similar thesis in the 1920s, arguing against the then also prevalent and deterministic organismic model defended by another early twentieth century influential ecologist, Frederic Clements. Drury and Nisbet suggested that change does not follow any particular direction or develop towards a particular terminal point but instead goes on forever, and its direction is continuously recalibrated by a wide range of different environmental conditions. Succession, in other words, is not *teleological*—it does not have specific direction—but *teleomatic*—it simply has directionality.

I shall go back to these arguments in a later section of this chapter when I discuss with detail the notion of *climax*—the putatively stable state of mature ecosystem—the question of homeostasis versus stochasticity, and the organismic/individualistic debate between Frederic Clements and Henry Gleason. The point that I want to make clear here is that the rise of complexity gave preference to ecological theories that suggest that there are no ultimate termination points in ecological succession and that processes of adaptation are endless. Against the ideas of prediction and control that characterized Odum’s “systems ecology,” new theories of ecology were based on notions of irreversibility, complexity and uncertainty, for which adaptation, flexibility, and anticipation became central tenets.[24] Discussing the content of another influential publication in the establishment of complexity science in ecological theory, S. T. A. Pickett and P. S. White’s 1985 edited volume *The Ecology of Natural Disturbance and Patch Dynamics*, environmental historian Donald Worster argues that:

> the climax notion is dead, the ecosystem has receded in usefulness, and in their place we have the idea of the lowly “patch.” Nature should be regarded as a landscape of patches, big and little, patches of all textures and colors, a patchwork quilt of living things, changing continually through

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[23] Odum, “The Strategy of Ecosystem Development,” 262.

[24] Nina-Marie Lister, “A Systems Approach to Biodiversity Conservation Planning,” in *Environmental Monitoring and Assessment* 49 (February 1998), 123-155.

time and space, responding to an unceasing barrage of perturbations. The stitches in that quilt never hold for long.[25]

Worster goes on to say that the reason why the accent was suddenly put on messy disturbance rather than on ecosystemic predictability is that most of the ecologists participating in this change were never trained as ecosystems ecologists but came instead from the tradition of population ecology. As we have already seen, populations ecologists have generally been considered to use more mathematical and reductionist approaches. They focus more on the analysis of the components of "ecological entities" than on the entities themselves. They look at a forest, and they count the trees of each species. Rather than accepting the existence of the ecosystem as an ecological assemblage that acquires entity by virtue of the operational connections among its components, population ecologists are skeptical of these a priori functional dependencies and look at the structural dimension of the environment, which they see as largely determined by the populations of different organisms, in turn determined by the particular properties of the individual organisms that comprise them.

From this reductionist lens, the capacity of adaptation of the singular organism becomes a key agent in the configuration of the environment at large. As Drury and Nisbet argue in the above-mentioned article, primary succession—that is, succession that occurs in an environment where the substrate is devoid of vegetation or any other kind of organic matter, as the result of a profound disturbance such as a volcanic eruption—is generally carried on by species that are able to develop under high-stress conditions, which remain dominant for as long as it is possible by containing potential competitors.[26] The ecological configuration at each succession stage is seen not so much as a result of the functional associations among different populations, but more as a result of the opportunistic capacity of a given species to adapt to the conditions at each moment for the increase of its population numbers.

As both a continuation and critique of "systems ecology," the more recent ecology of complex adaptive systems has developed new ontological frameworks based on emergence, which, in contrast to the

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[25] Worster, "The Ecology of Order and Chaos," 10.

[26] Drury and Nisbet, "Succession," 360.

intrinsic holism of the ecosystem, has allowed incorporation of more reductionist approaches that depart from the adaptive capacity of the organism. According to these emergentist visions, the ecosystem—the whole—does not necessarily precede the organism—the part. Instead, the opportunistic and non-deterministic evolution of populations can eventually result in functional associations that give rise to larger and more complex entities, which in line with the Odumian notion of the ecosystem might be able to retain some kind of coherence, both structurally and functionally. But they do so only through open-ended processes of adaptation that do not necessarily follow a single strategy of development towards closing states of balance, as Odum argued. Instead, as Canadian ecologist C. S. Holling proposed in his theory of adaptive cycles, complex adaptive systems follow trajectories that are cyclical: they follow long periods of transformation and accumulation of available resources—first in the form of exploitation and then in the form of conservation—followed by shorter phases of release and reorganization (*Figure 3.4*). At the end of each period of accumulation, ecological systems—i.e. mature forests—arrive at various forms of complex organization that certainly exhibit greater stability and interconnectedness than earlier formative stages. However, the energy stored in the systems is far from being a condition of equilibrium and presents, instead, new potentialities for transformation; the accumulation of biomass and nutrients becomes an easy target for new agents of disturbance—fires, diseases, pests, and so on—that will eventually induce a drastic release of that energy, putting the system back into the point of initiation of a new developmental cycle. A new phase of accumulation starts, and the path that the system will follow is not determined; instead, the process of succession might lead to a radically new form of organization.[27]

Complex adaptive systems have, therefore, internalized the ecosystem's notion of succession but only as one "generic" phase—one whose results are not determined but only probable—within a continuous process of regeneration. What ecosystems ecology saw as a conclusive state of successional processes of accumulation of energy in the form of organic matter was seen through the lens of the complex systems as an anabolic phase of a process of organization that will be necessarily followed by a new catabolic

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[27] This theory of complex adaptive systems in ecology was advanced in the 1990s by C. S. Holling. See, for example, C. S. Holling, "Understanding the Complexity of Economic, Ecological, and Social Systems," in *Ecosystems*, no.4 (2001), 390-405.

reaction. Time's arrow gave way to time's cycle. The ultimate balance of the ecosystem gave way to an emphasis of nature in flux, wherein outcomes are never final nor determined but just transitional and probable (*Figure 3.5*). The focus on a system's performance that came out of the maximum power principle of the ecosystem, "directed toward achieving as large and diverse organic structure as is possible within the limits set by the available energy input and the prevailing physical conditions of existence,"[28] gave way in complex systems ecology to a focus on processes of adaptation, on nature as a continuous state of flux; as such ultimate states of energy accumulation began to be seen as just one stage of longer evolutionary cycles characterized by contingency and continuous reorganization. It is the emphasis on the understanding of the ecosystem as a complex system capable of modulating through processes of reorganization in order to maintain its integrity for certain periods of time and the acceptance of catabolic events—disturbances—as "natural" phenomena in the evolution of the environment that have given notions of *process* and *adaptation* a reinvigorated relevance in ecological theory during the last two decades.

The Dialectics of Process: Homeostasis and Stochasticity. Environmental Engineering and Second Order Cybernetics

In the previous section I have discussed how the notions of *performance* and *adaptation*, as they have been understood in the design disciplines for the past two decades, have their roots in systems ecology and the later turn to complexity in ecological theory. In this section I shall expand the discussion of these two major paradigms in ecology by putting the focus on the dialectics that exist between homeostatic and stochastic processes in ecology, that is, between processes that show a tendency towards states of relatively stable equilibrium and those that lack any predictable direction.

I have already discussed the rise of the first comprehensive theory of ecology around the concept of the ecosystem and how the ecosystem eventually became a fundamental epistemological apparatus for ecological theory. I have also discussed how the ecosystem privileged a mechanistic view of the

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[28] E. P. Odum, "The Strategy of Ecosystem Development," 266.

environment, according to which different components—organisms, populations, communities, and so on —were understood to be structurally engaged together by virtue of their functional interactions and interdependencies. Incorporating systems thinking in ecology and drawing from physics and, more specifically, thermodynamics, this vision eventually led to the development of a very analytical approach based on the movement of energy across the environment. As we have seen, the main figure of this stance was Howard T. Odum, whose rationale was that power—or energy—flows analogously across any system, be it electrical, biological, economic, social, or environmental. Besides the mystical appeal of a vision of the Earth as a web of energy flows, Odum's mechanistic vision was heavily influenced by technological and engineering developments of the mid-twentieth century and emphasized the conversion of environmental phenomena into quantifiable and visualizable data. The data was then able to be used to run simulations in his electric circuits models as a way to test and promote strategies for energy management, resource recirculation, energy conservation and so on. The combined efforts of the Odum brothers in the disaggregation of environmental processes and their translation into measurable data was key in the growth of an ecology that very explicitly embraced an engineering or managerial ethos. The environment seemed to show certain tendencies towards states of equilibrium, and ecology was the science that should direct the environment towards the accomplishment of such equilibrium. Coinciding, as we saw in chapter 1, with a period of increasing environmental awareness, this managerial approach to ecology was revealed to be a fundamental tool in the recalibration and the correction of some production trends in the industrial society of the twentieth century. In the words of Eugene P. Odum:

> Until recently ecology was generally considered to be a subdivision of biology dealing with the relationships of organisms with the environment. Then, during the environmental awareness decade, 1968 to 1981, a school of ecosystem ecology emerged that considers ecology to be not just a subdivision of biology, but a new discipline that integrates biological, physical and social science aspects of man-in-nature interdependence.[29]

If, in the face of the newly described environmental challenges, ecology was going to exert a direct impact in the mediation of this interdependence of man and nature, it should acquire a more explicit role as an applied science. Ecology's duties could no longer be limited to the "pure science" study and interpretation of environmental relationships, but should be expanded through the application of the

[29] E. P. Odum in press, quoted in McIntosh, *The Background of Ecology*, 202.

scientific knowledge acquired during the course of a century in the development of more practical applications to help alleviate the environmental problems at stake. In so doing, ecology would use its recently achieved capacity to read the environment in terms of measurable and *graphable* energy flows to help provide higher levels of efficiency—as in thermodynamics—in the use of the available energy in the environment.

The idea that an excessively "recourcist" attitude towards the environment was the cause of its degradation became a generalized assumption, and so did the idea that the degradation of environmental systems would inevitably lead to the degradation of social and economic systems. A new attitude was needed, and the technological optimism that prevailed in the post-war decades induced the maxim that the tendency could be reversed through higher levels of direction and control. Odum's deterministic view of the ecosystem founded a belief in some kind of balance in nature, which he believed could be restored if we were to conserve the energy existing in ecosystems through management. This aspiration, which arguably recalls conservationist attitudes in line with Aldo Leopold's "land ethic" and seems to be in opposition to environmental exploitation, eventually re-enacted the resourcist approach to the environment. Because it was perceived that environmental phenomena could be rendered in the language of quantifiable data, it was also perceived that aiming for an ever-increasing efficiency in environmental resource exploitation was possible; through the modulation and adjustment of ecosystems, it is possible to maximize energy outputs and minimize undesired impacts.[30] Ecology could then be formulated, as H. G. Wells and Julian Huxley did prophetically in 1931, as the making of "the vital circulation of matter and energy as swift, efficient, and waste-less as . . . can be made."[31] Ecology as an applied science, in other words, can help increase the environment's *performance*.

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[30] A good account of the further instrumentalization of the environment induced by the New Ecology of Eugene P. and Howard T. Odum can be found in Worster, "Producers and Consumers."

[31] In "Producers and Consumers," Donald Worster quotes this sentence from Herbert G. Wells, Julian Huxley, and G. P. Wells, *The Science of Life*, vol. 2 (New York: Doubleday, Doran, 1931), 1029.

These are arguments that set the base of what then was going to be called sustainability. Sustainability, which very broadly seeks forms of human relationship with the environment that "meet[s] the needs of the present without compromising the ability of future generations to meet their own needs,"[32] has promoted during the last decades an infinite array of practices that are largely constructed upon this logic of performance and optimization of environmental resources. While the maxims of sustainability and environmentalism generally claim against the instrumentalization of natural resources, the practices derived from them are deeply impregnated by this systemic analytical ecology, whose performance and efficiency ideals have legitimized *de facto* an unrestrained—yet putatively careful and "inoffensive"—human control and management over an objectified idea of the environment. As environmentalist author Neil Evernden criticizes in *The Natural Alien: Humankind and Environment*, this ecology allows "the maximum utilization of the earth as raw material in the support of one species… [even though] environmentalism has typically been a revolt against the presumption that this is indeed a suitable goal. … In combating exploitation, environmentalists have tutored the developer in the art of careful exploitation."[33]

In its technological project of environmental direction and control, ecology aligned itself with an emerging branch in the formal sciences, cybernetics, which since the mid-twentieth century was gaining relevance as a field explicitly invested in the study of regulatory systems. Cybernetics began in the decade of the 1940s as an interdisciplinary field that connected Bertalanffy's systems theory, originally developed in the context of evolutionary biology, with inputs from mathematics, neuroscience, mechanical engineering, electrical systems control, and information technology. Almost concurrently with the development of the Odum brothers in the field of ecology, the American mathematician Norbert Wiener began to work on the translation of systems thinking into mechanical and human organizations. In 1948,

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[32] This definition of sustainability is extracted from "Environmental Ethics," Stanford Encyclopedia of Philosophy, accessed December 1, 2017, https://plato.stanford.edu/entries/ethics-environmental/#SusCliCha, which quotes "Our Common Future," United Nations General Assembly, Report of the World Commission on Environment and Development, available at http://www.un-documents.net/wced-ocf.htm.

[33] Evernden, *The Natural Alien*, 23.

Wiener used the term cybernetics for a book whose title also offered a definition of the field he was willing to formally establish, *Cybernetics: or Control and Communication in the Animal and the Machine*.[34] With cybernetics, Wiener attempted to look with a scientific and analytical approach at daily life phenomena that science had generally neglected. Cybernetics sustained that not only ecosystems but any other condition susceptible to being interpreted as a system—such as the human brain, a city, or even an entire society—were regulated by feedback. In doing so, cybernetics granted special attention to negative feedback loops, that is, situations where the output of a process or a function within a system is such that it tends to reduce fluctuations and therefore help the system reach or come closer to stability, like in a thermostat—either mechanical or biological. It fascinated physicists and biologists alike, for it offered an unprecedented understanding of how systems achieve conditions of homeostasis, that is, how they achieve control and management of steady-states, how, through processes of information transmission between their different components, systems stabilize themselves through feedback loops. In sum, cybernetics explained the regulatory mechanisms through which systems adapt themselves in order to remain in "balance."[35]

Cybernetics influenced the idea of the ecosystem, for it seemed to explain how ecosystems stabilize themselves once they get to their ultimate state of development. In developing their work on regulatory systems, cyberneticians worked, as much as the Odum brothers did on their study of ecosystems behavior,

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[34] Norbert Wiener, *Cybernetics: or Control and Communication in the Animal and the Machine* (Cambridge Mass.: MIT Press, 1948).

[35] Cybernetics's assumption that all human and non-human phenomena are continuous processes of recalibration governed by feedback has bolstered ideas of decentralized control and emergent behavior, where small and simple components share information in order to keep large and complex systems in balance. The seduction of cybernetics as a theoretical model was concomitant with technological applications that eventually achieved enormous success. On the one hand, the Cold War offered a very fertile political and economic ground for the advancement and practical implementation of new modes of thinking that privileged notions of decentralized control through interconnectedness at growing territorial scale, and, on the other hand, the concurrent development of the computer offered a novel technology through which the massive amounts of information that supported these global systems' mechanisms of regulation could be measured and kept track of. Cybernetics, therefore, both bolstered and was granted by a computerized vision of many phenomena that is pervasive today, also in the design fields. It is largely from the combination of these theoretical models and their ancillary technological apparatus that we can derive many of the ideas about networks, fields, information, emergence, self-organization, decentralization, that characterize today's design discourses of flexibility and adaptation.

with relatively simple and manageable models that led to the stability results they were hoping to achieve. However, as computers' capacity to deal with vaster amounts of data increased, the number of simulations actually leading to balance results were progressively reduced, and the faith in ideas of balance and predictability began to fade. The episode that led to the rise of chaos theory is well known; the American meteorologist Edward Lorenz, who had designed a mathematical model to predict the ways in which air moved in the atmosphere, ran the same simulation twice, with minutely different inputs and arrived at radically different weather scenarios—simply by adding fewer decimals in the initial value of one of the variables. As computer simulations began to be able to manage more detailed information, they began to reproduce the chaotic instability that alternative empirical models also seemed to point to. In fact, since the 1960s, there was a general revision of cybernetic theory that gave way to a so-called second order cybernetics, which reacted against the original homeostatic vision of the world offered by early cyberneticians, and put the accent instead on the idea that causality does not necessarily drive systems towards stability and equilibrium, but also towards situations of unpredictable evolution.[36] Cybernetics shifted, then, its focus of interest from homeostatic to stochastic processes, that is, processes where the outcome is randomly determined; a bifurcation of cybernetics which also found its way into ecology. Today, where some ecologists see a degree of balance or stability in nature, others see stochasticity and chaos. For the latter, complex systems, such as ecosystems, behave in unpredictable, nonlinear, nondeterministic ways. The same models that once led to conventional stability or equilibrium have also served to explain nonlinear, non-equilibrium behaviors.

The Dialectics of System: Holism and Reductionism. The Plant Association and the Individual Organism

I have just explained the tension existing in ecological theory between the ecology of ecosystems and the ecology of complex systems. The first of these models, mainly developed during the decades of the 1950s and 1960s, sees the environment as composed of fundamental units of analysis called ecosystems, each of

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[36] For a good account of this shifts in cybernetics and systems theory see William Rasch and Cary Wolfe's introductory essay to their edited volume *Observing Complexity: Systems Theory and Postmodernity*, (Minneapolis: University of Minnesota Press, 2000), 1-32.

which is made, in turn, of parts that are interrelated on the base of functional dependencies. This ecosystemic model is based on a deterministic conception of reality, so that each ecosystem is supposed to follow a single strategy of development towards an ultimate state of homeostatic balance. Such strategies of development, explained as the capacity of ecosystems' to transform and accumulate as much energy as it is possible within the limits set by the environmental conditions, put a strong emphasis on energetic performance. The ecology of complex systems, often described as a paradigmatic shift in ecological theory, calls into question the mechanistically biased interpretation of the world as presented by ecosystems theory, and replaces—or rather supplements—its linear causality and determinism with notions of circular causality, indeterminacy and probabilism. In so doing, it emphasizes an image of the environment as in constant flux, where no state of development is ever final, and where all phenomena are engaged in a continuous and at times stochastic process of adaptation and reorganization.

Because the entrance of ecology into the theory and practice of landscape architecture took effect primarily during the late 1960s and 1970s with the rise of environmentalism and the work of Ian McHarg, the different currents that have characterized the development of ecology as both a theoretical discipline and an applied science during the last five decades have been relatively well documented in the scholarship of landscape architecture. The theory of ecology during the first half of the twentieth century, on the contrary, has been paid very little attention by landscape architects. And, although ecology was definitely not a driver of the work of landscape architecture during the interwar period—during these years, landscape architecture was more concerned with regaining reputation against the general marginalization it went through in modern movement architectural theories—[37] these are decades in which two different and fundamental paradigms in ecological theory were established, the so-called organismic and individualistic ecologies, mainly developed, respectively, by American botanists Frederic

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[37] In this sense, Jens Jensen constitutes the most salient example of a short list of early twentieth century landscape architects that were invested in the development of a landscape architecture practice that evoked regional site qualities through the use of local plants and habitats. In "Site Citations," Beth Meyer provides a quick account of some early twentieth century practices of landscape architecture interested in the relationships of design with notions of plant community and habitat. See Elizabeth Meyer, "Site Citations: the Grounds of Modern Architecture," in *Site Matters: Design Concepts, Histories, and Strategies*, eds. Carol J. Burns and Andrea Kahn (New York, Routledge: 2005), 93-130.

Clements and Henry Gleason. These paradigms would eventually constitute the basis for the development, during the second half of the twentieth century, of both ecosystems ecology and its associated paradigmatic shift towards theories of complex ecological systems.

The first paradigm of ecology was the idea of the plant community as a superorganism, which Frederic Clements deployed in 1905 in the first American ecology book, *Research Methods in Ecology* and elaborated on in various subsequent publications, most notably in the influential *Plant Succession* of 1916.[38] According to the organismic paradigm, the environment was organized in discrete and uniform cognitive units, which Clements called *plant formations* or *plant associations* (*Figure 3.6*). He approximated these plant associations to living organisms—hence the *organismic* approach—that as such would arise, grow, mature, and, under certain circumstances, die. For Clements, these formations developed in specific physiographic conditions and under specific climatic conditions. This direct connection between patterns of vegetation, physiography, and climate, denotes an influence of the early nineteenth century work of Alexander von Humboldt, whom Clements references in his *Plant Succession* volume. As Clements acknowledges, Humboldt himself had profusely used the idea of the plant association more than a hundred years before. In the very introductory lines of his *Essay on the Geography of Plants*, originally published in 1807, Humboldt describes his project of a Geography of Plants as "the science that concerns itself with plants in their local association in the various climates."[39] Anticipating many of the ideas that Frederic Clements would turn into essential ecological theory a century later, Humboldt aimed at establishing new correlations between the distribution of vegetal species and the various physical conditions that form the environment, such as atmospheric pressure, temperature, humidity, and electrical tension (*Figure 3.7*). But not only that, he also claimed that patterns of distribution of certain species happen in relation to environmental factors and also according to the distribution of other species with which, again, "social" relations are established. This argument is made,

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[38] Frederic Clements, *Research Methods in Ecology* (Lincoln: University of Nebraska Press, 1905) and *Plant Succession: An Analysis of the Development of Vegetation* (Washington D. C.: Carnegie Institution, 1916).

[39] Alexander von Humboldt and Aimé Bonpland, *Essay on the Geography of Plants*, Stephen T. Jackson, ed., and Sylvie Romanowski, trans. (Chicago: University of Chicago Press, 2009 [1807]), 64.

nevertheless, in a way that also accepts Gleason's thesis of the individualistic behavior of plants. In the first pages of the *Essay,* he makes a distinction between two large classes of plants:

> one class of plants grows in an isolated and sparse fashion . . . Another class of plants live in an organized society like the ants and the bees and occupy immense terrain from which they exclude any heterogeneous plants . . . These socially organized plants are more common in temperate zones than in the tropics, where the vegetation is less uniform and therefore more picturesque.[40]

Humboldt does anticipate the notion of the plant association but, interestingly enough, he also accepts the existence of uncoordinated vegetal assemblies, which would constitute the basis for an alternative theory that rose against Clements during the mid-twentieth century. Humboldt observed that plants growing sparsely seem to be more recurrent in certain geographic conditions, and he pointed to those closer to the equator. Interestingly enough, Clements developed his ecological theory by working on the temperate landscapes of the Great Plains and the Midwestern United States, mainly Nebraska.

But the plant association was paralleled by two additional concepts that were also central in Clements' theory: the idea of *succession* and the idea of *climax*. In the absence of a disturbance, Clements' plant associations simply existed in balance with climate. In the event of a disturbance, plant associations would be affected and might disappear to spontaneously begin to recover their original aspect and functional characteristics once the disturbance had ceased. This process of evolution towards a consistent plant association over a certain region is called *succession*, and the equilibrium state these associations eventually achieve is the *climax formation* (*Figure 3.8*).[41] The climax was, therefore, the final phase of succession, that is, "the adult organism, the fully developed community."[42] The crux of Clements' view was, as Daniel Simberloff put it, that "single-species populations in nature are integrated into well-defined organic entities, and … that temporal succession is utterly deterministic, analogous to development of an

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[40] Humboldt and Bonpland, *Essay on the Geography of Plants*, 65.

[41] Although there is no specific mention to the field of thermodynamics in Clements's book, he certainly describes the notion of climax through the notion of equilibrium, the state where the forces of habitat and populations have cancelled each other and the tension between them has been dissipated. Clements, "Concept and Causes of Succession," in *Plant Succession*, 3-7.

[42] Clements, *Plant Succession*, 124-25.

individual, and leads inevitably to one of a few climax communities."[43] For Clements, only a small number of different climax communities exist. This theory allowed a form of typological thinking in ecology, according to which any portion of the environment could be immediately classified into one of the established plant community categories. Using the visual language of "landscape patches," generalized during the last stretch of the twentieth century by landscape ecology,[44] the ecologist Michael Barbour has more recently taken the foothills facing the Great Central Valley in California as an example to illustrate Clements' theory.[45] According to Barbour, the Californian foothill landscape appears as a patchwork pattern, with juxtaposed patches of grassland, chaparral, scrub, woodland and forest. The whole foothill landscape, more than ten million acres, is covered by just a few different plant associations, a few ecological "types." Each patch corresponds to a different association unit, conformed by a set of species, some of which are considered dominant species, and adjacent to the next with a relatively well-defined boundary. These associations would act, according to Clements, as indicators of underlying differences in physiographic and climatic conditions and would remain in balance with them.

Plant association, succession and climax were, therefore, the three fundamental concepts in the organismic approach of ecology. The three concepts revolved around a holistic view of the environment, that is, one that privileged the idea that groups of things show properties that cannot be inferred solely from the properties of the individual parts. In organismic ecology, these plant communities acquired an ontological dimension; they were not seen as mere theoretical constructions but as real entities which

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43 Daniel Simberloff, "A Succession of Paradigms in Ecology: Essentialism to Materialism and Probabilism," *Synthese* 43 (1980): 3-39, 3.

44 The patch-corridor-matrix epistemology is a simple graphic language developed by the American landscape ecologist Richard Forman during the 1980s and 1990s, which has been very helpful in the visual understanding of the dynamics of certain ecological processes in relationship with landscape structure. It is built on the gestaltic premise that, when seen from above, the spatial heterogeneity of landscapes is of a kind that might be described as a mosaic, that is, a two-dimensional pattern composed of different elements aggregated that abut the adjacent ones with rather distinct boundaries. In chapter 6 I will dedicate a full section to the explanation of this model in the context of the development of landscape ecology. For more information see, for example, Richard T. T. Forman, *Land Mosaics: The Ecology of Landscapes and Regions* (Cambridge, U.K.: Cambridge University Press, 1995).

45 Michael Barbour, "Ecological Fragmentation in the Fifties," in *Uncommon Ground: Rethinking the Human Place in Nature*, ed. William Cronon (New York: W. W. Norton & Co, 1995), 233-255.

preceded the individual species or the individual organism. In later publications, Clements credited Jan Christiaan Smuts for his development of holism, that is, the theory that "wholes are more than the mere sum of their parts." Although holistic thinking had been present for centuries in human thought about the surrounding world, holism as a term and a theory were proposed by Smuts in his 1926 work *Holism and Evolution*.[46] Smuts worked in the identification of unified structures, which he referred to as wholes, and which were syntheses of parts. The whole, in Smuts' words:

> not only gives a particular conformation or structure to the parts, but so relates and determines them in their synthesis that their functions are altered; the synthesis affects and determines the parts, so that they function towards the whole; and the whole and the parts, therefore reciprocally influence and determine each other, and appear more or less to merge their individual characters: the whole is in the parts and the parts are in the whole, and this synthesis of whole and parts is reflected in the holistic character of the functions of the parts as well as of the whole.[47]

In accordance to Smuts' holistic worldview, Clements' associations showed emergent properties that made them unique and transcendental from the parts of which they were composed.

This organismic approach to ecology enjoyed a positive reception during the first decades of the twentieth century. So dominant was it that an alternative model of ecology that emerged almost simultaneously to it remained dormant for several decades, and it was not until the late 1940s that it began to be seriously considered. Through the so-called "individualistic" approach, a new group of ecologists, with Henry A. Gleason at the forefront, had been proposing a less holistic and less homeostatic conception of nature, where the fortuitous and opportunistic behavior of independent species was the rule rather than the exception (*Figure 3.9*).[48] In a long-ignored paper called "The Individualistic Concept of the Plant Association,"[49] published in 1926, Gleason challenged Clements' paradigm of the plant association as a

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[46] Jan Christiaan Smuts, *Holism and Evolution* (New York: McMillan, 1926).

[47] Ibid., 86.

[48] Gleason had published his "individualistic" theory of vegetation in a series of papers beginning in 1917, then in 1926, and 1939. Henry Gleason, "The Structure and Development of the Plant Association," *Bulletin of the Torrey Botanical Club* 44 (1917), 463-481; idem, "The Individualistic Concept of the Plant Association," ibid., 53 (1926), 7-26; idem, "The Individualistic Concept of the Plant Association," *American Midland Naturalist* 21 (1939), 92-110.

[49] Henry A. Gleason, "The Individualistic Concept of the Plant Association," *Bulletin of the Torrey Botanical Club*, Vol. 53, No. 1. (Jan., 1926), 7-26.

fundamentally metaphoric construction and proposed a much more reductionist and stochastic idea of the environment arguing that, through simple observation, it was possible to discern that the vegetation growing on an area was the resulting combination of two different parameters, the fluctuating and contingent behavior of individual plants, responding to the equally fluctuating and contingent condition of the environment.[50] Coming back to Barbour and the example of the California foothills, Gleason would have put the emphasis on the fact that many of the grassland species that populate the grassland patches are also recurrent in the understory of the oak woodlands, where many chaparral species also spread, as much as the many isolated oak specimens also found growing sparsely into the grassland patches.[51] From this viewpoint, Gleason argued, how could ecologists keep defending the existence of well-delineated boundaries between different ecological associations as Clements had proposed? For Gleason, the boundaries that encapsulated those supposed plant association were the result of a subjective and intentional simplification. Those boundaries, constructed on the basis of the predominance of certain dominant species, can certainly be helpful for establishing typological landscape categorizations, but this activity should be acknowledged at all times as arbitrary, subjective, and simplifying.[52]

Gleason also considered that the fluctuation of vegetation could hardly be regarded as a regular process of succession, as the organismic approach of Clements had established.[53] Instead, Gleason suggested that the development of plants in an area is subject to a multitude of contingencies, most of which transcend the possibilities and properties of the plant organism, including the random dispersal of seeds by external means (such as animal movement or atmospheric vectors such as water and wind), or the presence of competitor species in the area of seeding.[54] The final composition of the vegetation of a given area was the result of chaotic processes; small variations in the conditions of departure and slight changes during

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[50] Ibid., 8.

[51] Barbour, “Ecological Fragmentation in the Fifties,” 237.

[52] Ibid.

[53] Gleason, “The Individualistic Concept of the Plant Association,” 21.

[54] Ibid., 16.

the development of successional processes could result in radically different outcomes. Where Clements perceived predictability, stability, and determinism, Gleason could only see chance, continuous flux, and probability (*Figure 3.10*)—a metaphysical conflict surprisingly analogous to that carried out almost half a century later by the ecologies of systems and complex adaptive systems we have seen in the previous section.

Where Clement appeared holistic, Gleason appeared reductionistic. Clements argued that superorganisms were real ecological entities and the fundamental ones through which an ecological theory of the environment could be articulated, and Gleason's response was the cancellation of any ontological value in the concept of superorganism; Clements' wholes did not exist, plant associations were not real things—the only real things were the individuals, the components of which the superorganism is allegedly composed. For Gleason's reductionistic view, plant associations were merely unstructured assemblies made of independent plants that happened to share similar physiological demands and were therefore able to inhabit the same portion of the land. Communities do not seem to be formed beyond the behavior of the individual organism, and the behavior of the individual organism seems to only respond chaotically, opportunistically, to the limits and constraints imposed by the conditions of the environment.

This confrontation between the organismic and the individualistic paradigms of ecology sparked vivid debate during the late 1940s and early 1950s in ecological theory. The dichotomy derived from the fact that both approaches focused their attention on a rather similar spectrum of environmental information, that is, the structure of vegetation and the evolution of that structure over time. However, in parallel to the establishment of this controversy, some other ecologists began to study the environment from a different stance. One of them was the British zoologist Charles Elton, who disregarded this structural and evolutionary approach to the environment in favor of a more functionalist perspective in his *Animal Ecology*, published in 1927.[55] With his functionalist stance, Elton opened the door to a stronger influence of the science of economy—the etymological partner of ecology, as Haeckel himself had indicated at the

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[55] Charles S. Elton, *Animal Ecology* (London: Sidgwick and Jackson, 1927).

very foundation of ecology—on ecological thinking. Some environmental historians, as Carolyn Merchant, have in fact referred to Elton as the inaugurator of an "economic approach" to ecology.[56] The fundamental principle that made Elton worth such position in the history of ecological theory was the "food chain." Elton's food chain turned food into an essential capital in the natural order, implying the appearance of new roles of producers and consumers within the biotic community. Although Elton was not a supporter of the superorganism approach, the development of the food chain was perceived by some as an opportunity to establish an accurate analogy between the physiology of an individual organism and the ecological concept of the superorganism. The food chain became, in sum, a key force in providing the superorganism the functional rationale it needed to sustain its holistic cohesion.[57]

The notion of the food chain also served as basis for a new concept that would become the central one in ecological theory for the next fifty years: the ecosystem. First described in 1935 by another English scientist, the botanist Arthur Tansley, the 'ecosystem' allowed the advancement of the economic line of thinking inaugurated by Elton and to combine it with the structural and evolutionary discussion posed by the organismic and the individualistic approaches. In this sense, Tansley's "ecosystem" was the first ecological concept that encompassed the biotic community and the abiotic components of the physical environment. According to the first definition he provided in his landmark paper "The Use and Abuse of Vegetational Concepts and Terms," the ecosystem was:

> the whole system (in the sense of physics) including not only the organism complex, but also the whole complex of physical factors forming what we call the environment of the biome –the habitat factors in the widest sense. Though the organisms may claim our primary interest, when we are trying to think fundamentally we cannot separate them from their special environment, with which they form one physical system.[58]

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[56] Carolyn Merchant, *The Columbia Guide to American Environmental History* (New York: Columbia University Press, 2002), 167.

[57] Simberloff, "A Succession of paradigms in Ecology," 4. As Simberloff remarks, in 1939 Clements himself and animal ecologist Victor Shelford cited Elton's *Animal Ecology* of 1927 to stress that trophic structure studies "can be utilized to reveal the significance of each process in the working of the community as a whole." In Frederic Clements and Victor Shelford, *Bioecology* (New York: John Wiley, 1939).

[58] Arthur G. Tansley, "The Use and Abuse of Vegetational Concepts and Terms," *Ecology* 16, no. 3 (1935), 284-307.

The very title of the essay and the explicit reference to physics in the quotation denote Tansley's interest in ridding ecology from its organismic connotations and moving it closer to the more "mature" analytical tradition of the hard sciences. Drawing upon the fields of physics, and more particularly, thermodynamics, he claimed that the idea of the superorganism was beyond the limits of legitimate scientific inquiry[59] and claimed instead a reading of holism where the basic units of nature were also taken into account, for, after all, wholes were "*in analysis* nothing but the synthesized actions of the components in association."[60] Tansley's leaning towards the tradition of physics provided his work with a rather Cartesian and mechanistic stance never seen in earlier ecological theory; in his view, if ecology was called to advance as a mature science, it should be able to separate nature into basic components to later predict or infer combined results from the independent analysis of the parts. Without quoting or mentioning Gleason—at the time Tansley published his influential paper, Gleason's theories were still largely unknown—his position seems to suggest an a priori reductionist approach that would serve as the basis for ultimately conforming to the holistic concept of the ecosystem.

Besides the structural aspects, the concept of "system" had, as I just mentioned, very important implications for the functionalist approach to ecology opened up by Elton. Tansley's concept of "system" was borrowed from the science of physics, which had been using systems to discuss the question of equilibrium in thermodynamics. Tansley's turn to physical systems opened the door for the introduction of the notion of energy into the field of ecology. The first critical contribution in this sense was Raymond Lindeman's, who wrote in 1942 a paper called "The Trophic-Dynamic Aspect of Ecology,"[61] where many historians of ecology have seen the birth of 'ecosystems ecology' that the Odum brothers would turn into the main ecological paradigm since the 1950s.[62] Lindeman used Elton's trophic categories of "producer,"

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[59] Ibid., 289.

[60] Ibid. Emphasis in original.

[61] Raymond L. Lindeman, "The Trophic-Dynamic Aspect of Ecology," *Ecology* 23, no. 4. (1942), 399-417.

[62] See for example Robert P. McIntosh, *The Background of Ecology: Concept and Theory* (Cambridge: Cambridge University Press, 1985), 196.

"consumer," and "decomposer" but also adopted Tansley's "ecosystem" concept, which incorporated both the biotic and abiotic components of the environment in the equation of ecology. Elton's view of food as essential capital moving through trophic chains, like Lindeman's, primarily emphasized energy flow through the ecosystem (*Figure 3.11*). Lindeman recognized the progressive depletion of energy in successive trophic levels—as in the second law of thermodynamics—and introduced the idea that the efficiency of production of a single level of the food chain was relative to the productivity of another level.[63] After Lindeman's premature death in 1942, even before his paper was published, it was Eugene P. Odum, as we have already seen, who took over this comprehensive ambition and put the ecosystem, the flow of energy, and notions of efficiency towards a deterministic idea of balance at the core of ecological theory, where they remained for several next decades. Odum may have used different terms than Clements, may even have had a radically different vision of nature at times, but he definitely did not disagree with Clements in that nature moves towards some sort of stable and holistic balance.

The Dialectics of Form: Essentialism and Nominalism. Ecological Types and Ecological Populations

The path that Clements inaugurated in the early decades of the twentieth century with his holistic and homeostatic theory of discrete superorganisms was frontally opposed by the reductionist and stochastic tenets of Gleason's individualistic approach, which read the environment as a fundamental continuum with no clearly defined boundaries. Focusing less on questions of environmental structure and evolution, Elton opened up, almost concurrently with Clements and Gleason, a parallel functionalist lineage in ecology by working on the concepts of food chain and trophic levels. Tansley and Lindeman followed this path by translating Elton's concepts into the language of energy by offering a description of the environment focused on energy flows across and between new ecological wholes, which he called ecosystems. Elton, Tansley, and Lindeman's theses ultimately served to endorse Clements' organismic theory with the functional cohesion it needed to finally tip the balance to the detriment of Gleason's competing theory. Much of the work developed by this lineage of early ecologists was coherently agglutinated and bolstered in the central decades of the century by the Odum brothers' new ecology,

[63] Ibid., 197.

which, as seen in previous sections, put Tansley's ecosystem at the center of their work, turning it into the fundamental ecological ontology—the basic unit the environment is made of—and ecology's primary object of study. The Odums' work decidedly privileged a holistic and homeostatic approach to the environment, one where each ecosystem's behavior was studied through the functional energetic connections exiting between its individual components and between these and the outside environment, and one where these flows of energy were directed towards the achievement of a final state of balance in the ecosystem.

During the last decades of the twentieth century, as we have seen, the rise of chaos theory and complexity science gave way to new ontological frameworks that fundamentally challenged the ecosystem's approach in ways that resonate quite vividly with Gleason's reactions to Clements. Central to this new ecological theory of complexity is an opposition to the determinism of the ecosystem, which is instead in favor of a probabilistic view of the world that puts chance at the core of causal effects. In giving a new preeminence to chance, it embraces a more nominalist position. While nominalism does not explicitly oppose holism, it does challenge the essentialism that underlies the holistic concepts of the superorganism and the ecosystem. Gleason's reductionist focus on the individual organism had emptied Clements' plant associations of any ontological significance. Only the individual organism existed; the rest were just human constructions. The focus on chance and contingency in chaos and complexity science also diminished the ontological dimension of systems, which are no longer seen as closed and well-delineated entities but as fundamentally open, highly sensitive to inputs from their environment, and less preoccupied with developing clearly coordinated structures and processes of evolution towards the preservation of some sort of balance.

This shift from essentialism to nominalism implies a rejection of the belief that natural things have set and unchanging essences, an idea firmly grounded in Western thinking, which goes back to Greek metaphysics. In 1975, this shift was referred to by evolutionary biologist Ernst Mayr as a replacement of "typological thinking" with "population thinking."[64] Mayr discussed Darwin's theory of natural evolution and the radical implications it brought into science in the mid-nineteenth century as the moment where this replacement from typological to population thinking took place. As Mayr explains, typological thinking has its roots in the basic need of man to classify the bewildering diversity of nature into categories—the *eidos* of Plato is the form of philosophical thinking that codifies nature in such way. With the Allegory of the Cave as the point of departure, typological thinking interprets reality as a number of rigid and unchangeable ideas that underlie the observed variability; the *eidos* is the only real thing, and the perceived variability possesses no more ontological value than the shadows projected by the objects on the wall of the cave.[65] These pure ideas are discrete, and leave gaps in nature. Typological thinking demands, then, the recognition of the essences, the forms of the entities observed in the world, and their discretization into independent categories.

Darwin's evolutionary theory and, before Darwin, Jussieu's natural method of plant classification and Goethe's notions of morphology and metamorphosis came to fundamentally challenge this way of thinking. The work of these authors speculated and ultimately proved that the discrete categories into which natural species had been codified were actually dynamic, engaged in a constant process of mutation that favored the specific variations of some individuals and canceled those of others by natural selection.[66] The alternative way of biological thinking that would be able to accommodate evolutionary theory was population thinking. Contrary to typological thinking, population thinking denies the existence of essences, of pure forms, and stresses the uniqueness of everything in the organic world, putting the emphasis, then, on the variations that essentialism neglects. For the populationist, Mayr writes, organisms are composed of unique features and can only been described collectively in statistical terms, that is, by

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[64] Ernst Mayr, "Typological versus Population Thinking," in *Evolution and the Diversity of Life* (Cambridge, MA: Harvard University Press, 1975), 26-29.

[65] Ibid., 27.

[66] In chapter 5, under the title of "Discreteness and Continuity," I shall explain with detail the revision of essentialist models of plant classification that, before Darwin's theory of natural evolution, took place during the last decades of the eighteenth century, in particular the revision carried on by the French botanist Antoine-Laurent de Jussieu.

determining the arithmetic mean and the statistics of variation that a broad population sample would produce. Metaphysically, the populationist has a radically different viewpoint from that of the typological thinker; only the individual entities are real, and the averages of the populations are simple abstractions. "For the typologists, the type (*eidos*) is real and the variation an illusion, while for the populationist the type (average) is an abstraction and only the variation is real."[67] The populationist assigns names to those abstractions, but assigning names, as in nominalism, is not the same as assigning ontological value, as in essentialism.

The organismic approach by Clements and the mechanistic approach of systems ecology are essentialist models, based on the discretization of the observed world into independent categories. On the contrary, Gleason and more recent ecological theories lean towards nominalism, for they look at the environment as a *continuum* made of assemblies of individual entities primarily ruled by stochastic processes.[68] Coming back to the example of the Great Central Valley in California, for the typological ecologist—Clements—the foothills appear as a patchwork pattern, with juxtaposed patches of grassland, chaparral, scrub, woodland and forest. The whole landscape is covered by just a few different plant associations, a few ecological "types." Each patch corresponds to a different association unit, conformed by a particular set of species, abutting the adjacent ones with relatively well-defined boundaries.[69] The populationist—Gleason—would put the emphasis, instead, on the fact that many of the grassland species that are found in the grassland patches are also present, although in lower proportions, in the woodland patches, as much as many isolated oak individuals are also found in the grassland patches.[70] For some contemporary ecologists, nominalists like Gleason, the emphasis on continuity and chance makes it difficult to accept the existence of ecological entities at higher levels of complexity than that of the individual organism.

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67 Mayr, "Typological versus Population Thinking," 27.

68 For a good discussion between essentialism and nominalism in ecology and biology, see David L. Hull, "The Metaphysics of Evolution," in *British Journal for the History of Science* 3 (1967), 309-37.

69 Barbour, "Ecological Fragmentation in the Fifties."

70 Ibid., 237.

And yet, these ecological entities seem to exist, but not as clearly demarcated as essentialism would claim.

From this discussion, I would like to propose some sort of synthetic view, according to which ecological entities have ontological value. They exist, but they are open entities, with often imprecise, porous boundaries, which allow for the permeability that is necessary for the interconnection between the entity itself and environment to also exist. These boundaries are not only imprecise but also fluctuating; they vary both spatially and over time. A boundary that might appear as well defined at one spatial scale of analysis might disappear if the scale is changed; what might look like a clear cut patchwork pattern on the foothills of California from a certain distance can dissolve into a continuous mixture of species once the observer gets close enough. In terms of temporal fluctuation, ecological entities that appear as relatively stable at certain scales of time, at other scales, often reveal to be immersed in continuous processes of evolution. Rivers often flood areas that are beyond their usual courses, a situation that is simply a different temporal expression of an ecological entity with imprecise and changeable boundaries. From this viewpoint, ecological entities are not positive entities, the distinction between inside and outside is not absolute, but only a question of degree; ecological entities are rather regions of an ecological continuum where there is a rather abrupt intensification in the degree of interaction between different individual components, so that a new kind of structural and apprehensible formation emerges. Such understanding of ecological entities as imprecise, open, continuous with their environment implies that ecological entities internalize and engage, at least to some degree, the environment. Ecological entities *engage* the environment; they are not *placed in* it but, rather, *continuous with* it. In other words, as I shall elaborate in chapter 6, the environment is not transcendental to ecological entities, but, rather, immanent within them.

CHAPTER 4

The Metaphysics of Ecology: Three Syntheses

The Metaphysics of Ecology: Three Syntheses

As I have already argued, the influence of ecology over landscape architecture theory and practice during the last two decades has been largely limited to the idea of ecology as either scientific imperative in seek of higher environmental efficiency or as cultural metaphor in favor of notions of complexity. This limitation contrasts with the fecundity that ecology has shown in producing and supporting different ontic and epistemic frameworks. In this sense, as we have seen in chapter 1, the comprehensiveness of ecology's original project, defined as the study of the relationships of the organism and the environment, has diverted into an extraordinary pluralization of ecological narratives that came first from other scientific fields, and eventually, and especially in the last four decades, also from the humanities.

The fragmentation and promiscuity in the field is such that ecology is seen today at risk of meaning anything and nothing at the same time. This dissertation suggests that, despite its current dispersion, ecology is still a powerful epistemology through which some of our present challenges can be effectively interpreted and acted upon. Thus, it seeks to contribute to the construction of a counter-narrative of ecology that, on the one hand, internalizes ecology's current debates and contradictions, and, on the other, bolsters the agency of landscape as the medium through which such narrative is given form. As I have suggested, the only possible project for a field of knowledge that is explicitly invested in the study of all of the *environment* is a project of *synthesis*. If such is the project of ecology, then ecology will be able to engage productively with the also synthetic ambition at the core of the design disciplines.

This synthetic project finds its best expression in one meaning that ecology has come to connote in recent times, that of a cosmovision, a general way of seeing the world that emphasizes the interaction and evolution of all phenomena. In acquiring this broader connotation, ecology has drawn upon several metaphysical models developed in the history of philosophy. Reversing the argument, it can be maintained that *ecology* is the most recent signifier that we use to designate a historically deep cosmovision, one that privileges monistic interconnection and process-ontology.

In this chapter I shall discuss the philosophical postures that have coalesced in this general vision of ecology, and I will do so through three syntheses. The first and second of these will refer to the already mentioned ecological premises of interaction and evolution, and the third synthesis will revolve around the notion of conjunction. I shall be mainly looking at nineteenth century proto-ecological thinkers such as Charles Darwin, Alexander von Humboldt, and Johann Wolfgang von Goethe (*Figure 4.1*), and I shall also refer more tangentially to the work of early twentieth century philosophers such as a Alfred North Whitehead and Henri Bergson. Although the discussion in this chapter is mainly developed on a metaphysical level, the last part of the dissertation, chapters 5, 6, and 7, will serve to make clear connections between these abstract concepts and more specific landscape and design-based arguments.

The Synthesis of (Processes of) Becoming: The Solid and the Fluid

What is real is the continual change of form: form is only a snapshot view of a transition.

—Henri Bergson (1911)

Ecology was infused since its inception by evolutionary thinking. In 1859, the same year that Humboldt died, Darwin published his groundbreaking *On the Origin of Species* and introduced the idea that living populations evolve over time due to processes of natural selection. Darwin's book had an enormous impact on philosophy, science and religion soon after its publication, and many scientists became enthusiastic promoters of his evolutionary theory. Haeckel, as we have seen, was one of them; the subtitle of his 1866 book *General Morphology of Organisms*—where the term "ecology" was introduced—was *General Elements of the Science of Organic Forms, Mechanically Grounded on the Theory of Descent as Reformed by Charles Darwin*. He also preceded his cut-and-dried definition of "ecology" with an explicit reference to Darwin's theory that read:

> […] without the theory of evolution all the big general series of phenomena of organic nature remain completely incomprehensible and inexplicable riddles, while by means of this theory they can be explained simply and consistently.[1]

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[1] Haeckel, *Generelle Morphologie Der Organismen*. English translation in Stauffer, "Haeckel, Darwin and Ecology," 140.

Of course the work of Darwin marked a milestone in western man's perception of nature, but it was also part of a longer genealogy of incipient evolutionary ideas that were populating the panorama of science in the late eighteenth and early nineteenth centuries. As Ilya Prigogine pointed out, the nineteenth century was the century of evolution.[2] Not only in biology, but also in the fields of geology, sociology, and even physics—where thermodynamics had introduced the arrow of time—new developmental theories introduced an emphasis on processes of *becoming*, as opposed to the permanence of *being*.

As with the notion of interconnectedness in the previous section, the genealogy of this metaphysics of becoming—or the so-called process philosophy—can also be traced in western thinking back to the time of the Pre-Socratics. Its beginnings are often placed in the Milesian philosopher Heraclitus and his famous aphorism "Everything changes and nothing remains still"—we cannot step into the same river twice, for new waters are forever flowing upon us. Still in the context of Ancient Greece, we also find the metaphysics of becoming in the Atomists, such as Democritus and Epicurus, and in Aristotle's theory of potentials, according to which organisms possess an internal principle of growth that enables them to actualize qualities initially contained in them only in a state of latency. This lineage of becoming gets into the nineteenth century through German idealism and, especially, through Hegelian dialectics—which explains reality as a self-unfolding process that builds difference over time as a result of conditioning and constraint[3]—and into the twentieth century through the work of the so-called "process philosophers," with Henri Bergson and Alfred North Whitehead at the fore. Bergson declared in his 1911 book *Creative Evolution* that "reality has appeared to us as a perpetual becoming; it makes itself or it unmakes itself, but it is never something made[4]"—in clear parallelism with Heraclitus—and furthermore developed the concept of "duration," which he defined as the "continuous progress of the past which gnaws into the

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[2] Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantan Books, 1984).

[3] "Process Philosophy," The Stanford Encyclopedia of Philosophy, accessed June 3, 2017, https://plato.stanford.edu/entries/process-philosophy/.

[4] Henri Bergson, *Creative Evolution* (New York: Henry Holt and Company, 1911), 272.

future."[5] Alfred North Whitehead credits the influence of Bergson's 1979 book *Process and Reality*, still today considered the most comprehensive descriptive framework of process metaphysics, and claims, a few years earlier in *Science and the Modern World*, that the scientific mechanism of the modern age needed to give way to a more organismic and developmental conception of nature "as a structure of evolving processes."[6]

From the moment of publication of *On the Origin of Species*, Darwin was accused of not being philosophical.[7] He did not publish any essay or volume dedicated to an exposition of his philosophical ideas or his vision about existing schools of philosophy. However, the Darwinian theory of evolution had a wide and deep impact on philosophy, including metaphysics, logic and ethics. Regarding metaphysics, Darwin's work provided American process philosophy—not only Whitehead but also John Dewey and William James, both credited in Whitehead's preface to *Process and Reality*—a "clear template for understanding how novelty and innovation come into both the human world and the world of nature."[8] Evolution implied a change of paradigm in science that gave a new relevance to the notion of process and forged a new notion of being as eminently variant and open to change.

In turn, Darwin's main influences came from late eighteenth and early nineteenth century scientific developments, particularly in the field of geology. At that time, the field of geology was gaining cultural and scientific relevance because of the increasingly historical explicative power that rocks were acquiring when seen as indexes of past natural events. There were two opposing theories that explained the geological history of the earth. One of these was James Hutton's theory of uniformitarianism—which supported that the Earth as it exists is the result of slow-moving forces that have been acting for a very

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5 Ibid., 4.

6 Alfred North Whitehead, *Science and the Modern World* (New York: Pelican Mentor Books, 1948), 74.

7 Hull, "The Metaphysics of Evolution."

8 Johanna Seibt, "Process Philosophy," in *The Stanford Encyclopedia of Philosophy* (Winter 2016 Edition), ed. Edward N. Zalta, accessed June 3, 2017, https://plato.stanford.edu/archives/win2016/entries/process-philosophy/.

long period of time, and which still act today[9]—and the other was the theory of catastrophism—the idea that the earth's configuration mainly results from abrupt geological changes—popularized by Georges Cuvier. The fact that Cuvier was an anatomist mainly interested in explaining extinctions and fauna succession through the analysis of fossil records accounts for the disciplinary connection of biology and geology around the notion of evolution. Cuvier's catastrophic vision prevailed over Hutton's until Charles Lyell's 1830 book *Principles of Geology*, which had an extraordinary impact on Darwin's thinking, successfully promoted uniformitarianism. When seen through the optics of evolution, uniformitarianism draws a vision of the earth that parallels process-philosophy's postulates, for, in contrast to catastrophism, where the earth's current state is understood as an overlap of singular and discontinuous sudden events that leave long periods of stability in between, uniformitarianism suggest that all that exists is the result of gradual and continuous ever-evolving processes that induce incremental changes.

The development of this gradualist conception of nature was not exclusive of geological debates during the turn of the nineteenth century. It was also active in the field of biology during those same years. That variation is gradual in nature was a central tenet in the already mentioned *The Metamorphosis of Plants*, by Goethe, where plant growth, transformations of organs, transitions from petals to stamens, shape adaptations, and other concepts, are discussed "gradually." Darwin's references to Goethe's theories of metamorphosis in several of his works, including the *Origin,* as well as his great reception of Lyell's advocacy in favor of gradualism, point in the direction of "evolutionary theory . . . [as] Goethean morphology running on geological time."[10]

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[9] James Hutton immortalized his uniformitarian theory of geology in his celebrated phrase "we find no vestige of a beginning—no prospect of an end," originally read in April of 1785 in a conference at the Royal Society of Edimburgh, and later published in James Hutton, "Theory of the Earth, or an Investigation of the Laws Observable in the Composition, Dissolution, and Restoration of Land Upon he Globe," in *Transactions of the Royal Society of Edinburgh* I, Part II (1788), 204-304.

[10] This quote belongs to Robert J. Richards, *The Romantic Connection of Life: Science and Philosophy in the Age of Goethe* (Chicago: University of Chicago Press, 2002), 407, and has been extracted from Gordon L. Miller's extraordinary introduction to a recent edition of Goethe's *The Metamorphosis of Plants*. Johann Wolfgang Von Goethe and Gordon L. Miller, *The Metamorphosis of Plants* (Cambridge, Mass.: MIT Press, 2009 [1790]), xxiv.

During the last fifty years, the notion of gradualism has been revisited in evolutionary biology with several theories that dig into the different speeds or rates of change that a gradualist conception of evolution may involve. From Niles Eldredge and Stephen Jay Gould's theory of punctuated equilibrium,[11] a form of "loose" gradualism that sees species' evolution as primarily characterized by periods of relative stability interrupted by short events of rapid evolutionary change, to Richard Dawkins' notions of "constant speedism," "discrete variable speedism" and "continuously variable speedism," which he uses to discuss the degree of uniformity in the rate of change of evolution, the formerly unitarian idea of gradualism has today branched into multiple meanings that offer a diversified vision of evolution happening at different temporalities and rates of unfolding.

I want to use these evolutionary ideas to counterbalance the more recent cybernetic paradigms that have dominated ecology's ideas about change and adaptation since the 1950s and offer instead a rather gradualist notion of process that enables a synthetic view of the environment as simultaneously solid and fluid. Despite the triggering role that evolutionary conceptions of change and adaptation had in both the establishment and early development of ecology, today we mainly receive these notions as they have been filtered by the different—and divergent—waves of cybernetic theory of the last decades. Originally invested in the management of feedback mechanisms as a way to maintain systems' equilibrium and stability, cybernetics then emphasized the idea that causality processes do not necessarily drive systems towards stability, but, potentially, towards situations of sudden and unpredictable change. In opposition to this cybernetic dichotomy of the preservation of steady-states vis-à-vis the acceptance of catastrophe as the two main and opposing driving forces of the environment, I suggest a gradualist conception of the environment as an aggregate of processes that unfold at different temporalities and which, in their continuous becoming, constitute the source of novelty.

Through the lens of this synthesis, some environmental phenomena might be seen as homeostatic, that is, primarily driven by processes in which variables—or rates of variation—are kept relatively constant, and

[11] Niles Eldredge and Stephen J. Gould, "Punctuated Equilibria: an Alternative to Phyletic Gradualism," in *Models in Paleobiology*, ed. T. J. M. Schopf (San Francisco: Freeman Cooper, 1972), 82-115.

some other phenomena might be seen as stochastic, that is, as the unexpected and relatively sudden outcome of the combined interaction of various processes. Between the extremes of homeostasis and stochasticity there is a full range of temporalities that enable an image of the environment as simultaneously solid and fluid; what we perceive as solid are expressions of specific phases in the longer duration of a fluid process.

The Synthesis of (Systems of) Interaction: The Part and the Whole

All is interaction.

—Alexander von Humboldt (1803)

As we have seen, the establishment of ecology as a formal science happened in 1866 with Ernst Haeckel's coinage of the neologism "ecology." There is a general consensus in the field of environmental history, however, that the publication of Alexander von Humboldt's *Essay on the Geography of Plants* in 1807 constituted a major step in the foundation of ecological thinking. Of course, before Humboldt, other authors had studded the classic literature of natural history with references to notions of interconnectedness. Humboldt's work, however, is the first mature and systematic description of a unified environment, where different environmental parameters derived from various scientific disciplines are coherently presented in relationship with patterns of distribution of vegetation. In combination with its accompanying and almost legendary *Tableau Physique del Régions Équinoxiales*, offering in a profile of the Chimborazo volcano in Ecuador a genuinely broader and integrated vision of science, the essay expresses, like no other work, Humboldt's aspiration for a unitary vision of the world and its phenomena, and his success in synthesizing botanical—the *organism*—and geographic—the *environment*—ideas.

Besides the *Essay*, which he published in Paris after his 1799 to 1804 expedition across the New World, there is one sentence that he wrote in one of his diaries in 1803 which captures excellently this synthesis of interconnection. This fundamental ecological maxim is "Alles is Wechselwirkung,"[12] normally

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[12] Alexander von Humboldt, *Reise Auf Dem Rio Magdalena, Durch Die Anden und Mexico*, vol. 1, ed. and trans. Margot Faak (Berlin: Akademie Verlag, 1986), 358. Originally published in von Humboldt's Travel Diary of August 1803, while at the Valley of Mexico.

translated into English as "Everything is interconnected," or, as Sanford Kwinter has suggested, "All is interaction."[13] As I also presented in the introduction, this famous aphorism has been paraphrased by other intellectuals of ecology in the twentieth century, such as John Muir—"When we try to pick out anything by itself, we find it hitched to everything else in the Universe"—and Barry Commoner—"Everything is connected to everything else."[14] But also before Humboldt, other authors had also noted the mutual interdependence of different entities in the environment. While the transformative influence that living organisms exert upon their physical environment may be simply regarded as empirical evidence, deriving the contrary, that the abiotic environment induces adaptive processes upon organisms, requires a higher sense of discernment. However, as far back as ancient Greece's 4th century BC, the philosopher Theophrastus of Erestus, disciple of Aristotle and follower of his naturalism,[15] discussed through the question of color change in animals the idea that living beings actively adapt to their surroundings, and that therefore adaptation is the result of internal biological processes responding to external stimuli.[16] Pliny the Elder, who largely drew from Theophrastus's botanical work, extended into the Roman world this interest on the relationship between organism and environment, dedicating full passages of his exhaustive *Historia Naturalis* to the influence of climatic, geologic and physiographic conditions on the existence of different kinds of trees and crops. Much closer in time to Humboldt, in the eighteenth century, the French biologist Georges de Buffon and the German anatomist Johann Friedrich Blumenbach strongly supported the theory of monogenism—according to which all races share a single origin—and in so doing they believed that human races had evolved differently due to environmental factors.[17] Even more closely, Johann Reinhold Forster, father of a close friend and colleague of Humboldt

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[13] Kwinter, "Neuroecology," 315. Emphasis in original.

[14] John Muir, *My First Summer in the Sierra* (Boston and New York: Houghton Mifflin Company: 1911), and Barry Commoner, *The Closing Circle: Nature, Man, and Technology* (New York: Knopf, 1971).

[15] Theophrastus of Erestus published a highly systematic study of plants in his *Historia Plantarum*, a volume by which he is often considered, along with Linnaeus, the "father of botany."

[16] Edward Zeller, *Outlines of the History of Greek Philosophy* (London, Routledge, 1931), 202.

[17] Despite the scientific racism of Buffon and Blumenbach in suggesting that the Caucasian was the original and "most beautiful" race of men, and that the other races were *degenerations* due to climatic and alimentary factors, the so called "Out of Africa" theory is a monogeist model and currently the most widely accepted theory for human origins.

at the University of Göttingen, had travelled around the world and greatly influenced Humboldt with his acceptance of the role of climate in shaping plant form and distribution, as well as with his vision of vegetation patterns as the most important index of the environmental conditions.[18]

The point that I am willing to illustrate with these examples is that, despite today's most prevalent approaches to environmental interconnectedness, which tend to privilege the techno-scientific and the performative by heavily relying on the late twentieth century notion of the "ecosystem," there have been, in the history of ecology, several alternative elaborations of the idea of interconnectedness that, by emphasizing the relations of reciprocal influence between different environmental components, offer a more synthetic understanding of the environment. In this sense, even though Humboldt's vast compilation and methodical organization of data often portray him as an eminently scientific and analytical figure, his vision is more rightly discussed as heuristic, holistic, and supportive of the existence of a universal coherence in nature. Following this double reading, it can be argued that, if translated as something similar to Commoner's "everything is connected to everything else," Humboldt's "alles ist Wechselwirkung" dictum may invoke a mechanistic image of the environment that makes it accessible to the advocates of ecosystemic approaches; but if, on the other hand, we follow Kwinter's suggestion and we think of Humboldt's aphorism as something closer to "all is *interaction*,"[19] then it suggests a more synthetic—equally systemic yet less mechanistic—vision of the environment, a vision that emphasizes that it is through interconnectedness—through *interaction*—that things are what they are.

In Humboldt, this holistic vision surpassed any concurrent reductionist interest contained in his research program. In 1799, shortly before his departure for the New World, he wrote:

> I shall collect plants and fossils, and with the best of instruments make astronomic observations. Yet this is not a main purpose of my journey. I shall endeavor to find out how nature's forces act

[18] Stephen T. Jackson, "Introduction," in *Essay on the Geography of Plants*, 6.

[19] Kwinter, "Neuroecology," 315.

> upon one another, and in what manner the geographic environment exerts its influence on animals and plants. In short, I must find out about the harmony of nature.[20]

Humboldt's monistic worldview was infused by the romanticist idealism of the late eighteenth century, and more particularly through his contact with Johann Wolfgang von Goethe, whom he had met in 1795.[21] Despite Goethe's universal renown as author of some literary classics, he was also also engaged in several scientific endeavors, including his 1810 *Theory of Color*, or the already mentioned *The Metamorphosis of Plants*, of 1790, and which had an important influence on Humboldt[22]. In *The Metamorphosis of Plants*, Goethe departed from Linnaeus, who had based his taxonomic analysis on the differences between species, focusing on the features that all plants held in common, and whose study would lead to the discovery of some kind of unity in the vegetal world, an original archetypal plant—an *Urpflanze*. He considered that it was the response to the various environmental conditions that explained the variations between different individuals,[23] and the resemblance between certain individuals what would explain the species. In line with Goethe, Humboldt's thesis in the *Essay on the Geography of Plants* was that plants had to be studied not only in terms of their taxonomic relations (following the Linnaean fashion) but also as the result of their interactions with the geographic conditions in which they grew.

In line with the closing lines previous synthesis of becoming, I want to use Humboldt's vision here to counterbalance the prevalent mechanistic and techno-scientifically biased notion of "ecosystem" with a more monistic idea of "system" in order to arrive at a more synthetic understanding of the environment as both compound and unity. This part-to-whole concurrence is what I refer to as the first synthesis of ecology. If we accept ecology's basic premise that there exist relationships between different organisms

[20] Humboldt, in a letter to Karl Freiesleben, 1799, as quoted in Helmut de Terra, *Humboldt: The Life and Times of Alexander von Humboldt, 1769-1859* (New York: Alfred A. Knopf, 1955), 87.

[21] Not only Humboldt's monistic worldview, but also his aesthetic approach to the landscape was influenced by Romanticism. In the *Essay on the Geography of Plants* there are many descriptions that add a strong aesthetic dimension to his scientific approach.

[22] Both Humboldt and Goethe, in turn, had an enormous influence in Haeckel, who uses many quotes from Goethe to introduce every chapter of the two volumes of his *General Morphology of Organisms*.

[23] This responsive behavior of plants to their environment is what Goethe's called the *Proteus actus adaptatus*, the third stage of the plant formation. See Goethe, *The Metamorphosis of Plants*, xxiv.

and the environment, then it is possible to derive that, at least to some degree, these relationships create interconnections between different entities and that these interconnections between things form larger compounds, the largest of which we refer to as "environment." The character of the compounds—be they populations, communities, ecosystems, biomes, or the entire environment—is contingent, at least to some degree, upon the character of their constitutive parts and, vice versa, the identity of each component is also affected by its interconnection with the rest of the whole. In sum, through this notion of interconnectedness, ecology sees the environment as a complex compound of interacting entities, where each entity is an expression of its relations with the rest.

Of course, at the core of this synthesis lies the notion of "system." Yet, freed from its mechanistic connotations, it is less a notion of system that cares about the quantification of energy transmission or the joinability of otherwise separate gears and bolts and more a notion of system that puts the accent on the inviolable interdependence between elements, that is, a notion of system that is closer to a more general definition as a regularly interacting or interdependent group of items forming a *unified* whole. In looking at the environment through this logic of the compounds, we face on the one hand the long reductionism/holism debate in the philosophy of science, which revolves around the definition of the irreducible part of a whole, and on the other we deal with the establishment of various intermediate levels of organization between the most basic component and the totality of the environment, each of which may be said to constitute at the same time a whole in itself and a part of a larger whole. These are part-to-whole questions that have important implications in the development of both ecology and design theory, and which I will develop further in chapter 6.

The Synthesis of (Forms of) Conjunction: The One and the Many

> It lies in the nature of things that the many enter into complex unity.
>
> —Alfred North Whitehead (1930)

In their landmark volume *Order Out of Chaos*, Ilya Prigogine and Isabelle Stengers discuss Whitehead's aim to discover the "connection between a philosophy of *relation* … and a philosophy of *innovating* *becoming*."[24] In the first one, "No element of nature is a permanent support for changing relations; each receives its identity from its relations with others;"[25] in the second one, the task is "to reconcile permanence and change, to conceive things as processes, to demonstrate that becoming forms entities, individual entities that are born and die."[26] According to Whitehead, it is the connection of *interaction* and *becoming*, the correlation of multiple open processes, that constitutes the basis for any sort innovation and novelty.

In the two previous sections, I have discussed, on the one hand, the ecological synthesis of becoming, which offers a gradualist view of the environment as an aggregate of processes that unfold at different temporalities, and, on the other, what I refer to as the ecological synthesis of interaction, according to which the environment might be seen as a complex compound of interactions through which all entities receive their identity. In this third section, I want to follow Whitehead's connective ambition and emphasize the idea that systemic interaction and evolutionary continuity can be actually seen as two elaborations of the same underlying synthesis, one that presents the environment as a correlation of processes interacting with one another as they unfold.

In the elaboration of this third synthesis, I will move the attention away from "systems" and "processes" and instead will put "entities" and "forms" at the foreground. And in order to do so, I want to invoke the figure of Goethe, which I have already alluded to while discussing both the questions of interaction and becoming. In Goethe we find, on the one hand, the seed of what was then to be eminently developed in Humboldt's geographic theory of vegetation—a search for a holistic perception of nature. This search, which was a romanticist response to the models that followed Newton in the eighteenth century, had strong Arcadian echoes of a harmonious idea of nature that should not be disturbed, and urged a new

[24] Prigogine and Stengers, *Order Out of Chaos*, 95. The whole book is a reconceptualization of the role of *time* in physics—through the scientific work of Prigogine in non-equilibrium thermodynamics—and an attempt to synthesize the philosophies of *being* and *becoming*.

[25] Ibid.

[26] Ibid.

organically integrated vision of the environment that no mechanical metaphors could possibly offer. This vision is manifested in several episodes of Goethe's production, both literary and scientific, and is beautifully captured in his 1819 "Epirrhema" poem, which Haeckel would later use to open the second volume of his *General* Morphology. It reads:

> You must, when contemplating nature,
> Attend to this, in each and every feature:
> There's nought outside and nought within,
> For she is inside out and outside in.
> Thus will you grasp, with no delay,
> The holy secret, clear as day.
>
> Joy in true semblance take, in any
> Earnest play:
> No living thing is One, I say,
> But always Many.[27]

According to this vision, therefore, separateness is only an illusion, and one and many are the same.[28] In such organic and integrated whole, no *entity* can preserve its identity, no entity can be explained, if detached from the *whole*—as it would in a mechanism. Even if it is possible to recognize the individuality and distinctiveness of an entity within the whole, that individuality cannot be accomplished with independence from the whole, but has to be in necessary interdependence with it: *one* is always *many*.

On the other hand, it is remarkable that we owe to Goethe the coinage of the term and the development of "morphology" as the study of both *form* and its *change*—formation and transformation of organic natures.[29] The organicist vision promoted an emphasis on the vital and the creative impulse of nature,

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[27] Goethe's epirrhema, in its original German version, reads like this:

> *Müsset im Naturbetrachten*
> *Immer Eins wie Alles achten;*
> *Nichts ist drinnen, Nichts ist draussen:*
> *Denn was innen, das ist aussen*
> *So ergreifet ohne Säumniss*
> *Heilig öffentlich Geheimniss.*
>
> *Freuet euch des wahren Scheins,*
> *Euch des ernsten Spieles!*
> *Kein Lebend'ges ist ein Eins,*
> *Immer ist's ein Vieles.*

[28] Worster, *Nature's Economy*, 82.

[29] Ernst Cassirer, *Rousseau, Kant, Goethe: Two Essays*, James Gutmann et al., trans. (Princeton: Princeton University Press, 1945), 68.

which eventually yielded this notion of morphology in order to define a new idea of *active* form—or formation—that internalized *process*. Goethe explained in 1807 the meaning of "morphology" and his dynamic view of form, when he wrote that:

> Form is something moving, becoming, passing away. The doctrine of form is the doctrine of transformation. The doctrine of metamorphosis is the key to all the signs of nature.[30]

In this comprehensive notion of morphology, he extrapolates to "all the signs of nature" some of the principles of the vegetal world that he had previously elaborated on in his study on *The Metamorphosis of Plants*. Goethe always felt captivated by the formal diversity and richness he could observe in nature, but was also frustrated by the apparent defiance that this diversity presented to his holistic ideals. In ruminating about that discrepancy, he elaborated the theory of metamorphosis, which he used to try to understand the unity which might exist behind diversity. Metamorphosis brought him ultimately to the idea of morphology, to the idea that *form* can only be understood through *process*, in what Ernst Cassirer called a transition from the *generic* to the *genetic* view of organic nature—the shift from a Linnaean approach based on the establishment of classes and genera, to an understanding that focuses less on products and more on the process of life.[31] It is *transformation*—"time-form," to use the expression

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[30] The English translation is from Amanda Jo Goldstein, "'Sweet Science:' Romantic Materialism and the New Sciences of Life" (PhD diss., University of California, Berkeley, 2011), 12. The short passage I have quoted is part of a longer explanation that reads:

> Rests on the conviction that everything that is must also indicate and show itself. From the first physical and chemical elements to the intellectual expression of humans, we affirm this basic principle.
>
> We refer equally to that which has form [Gestalt, figure, shape]. The un-organic, the vegetative, the animal, the human, all indicates itself, it appears as that which it is to our outer and to our inner sense.
>
> Form is something moving, becoming, passing away. The doctrine of form is the doctrine of transformation. The doctrine of metamorphosis is the key to all the signs of nature.

The original German, as published in Dorotea Kuhn, *Naturkundliche Schriften II: Schriften zur Morphologie. Johann Wolfgang von Goethe: Schriften zur Morphologie. Sämtliche Werke, Briefe, Tagebücher und Gespräche* (Frankfurt: Deutscher Klassiker Verlag, 1987), 349, goes like this

> *Ruht auf der Überzeugung, daß alles was sei sich auch andeuten und zeigen müsse. Von den ersten physischen und chemischen Elementen an, bis zur geistigen Äußerung des Menschen lassen wir diesen Grundsatz gelten.*
>
> *Wir wenden uns gleich zu dem was Gestalt hat. Das Unorganische, das Vegetative, das Animale, das Menschliche deutet sich alles selbst an, es erscheint als was es ist unserm äußern unserm inneren Sinn.*
>
> *Die Gestalt ist ein Bewegliches, ein Werdendes, ein Vergehendes. Gestaltenlehre ist Verwandlungslehre. Die Lehre der Metamorphose ist der Schlüssel zu alien Zeichen der Natur.*

[31] Ernst Cassirer, *Rousseau, Kant, Goethe: Two Essays*, James Gutmann et al., trans. (Princeton: Princeton University Press, 1945), 69.

eloquently suggested by Ronald Brady[32]—that mediates between the *unity* and the *diversity* of forms, that mediates between the *one* and the *many*.

I am using this organicist vision to suggest a third synthesis of ecology that adopts “system” and “process” as they are derived from the two previous syntheses and puts the accent on these expanded notions of “entity” and “form.” On the one hand, this third synthesis appeals, in accordance with the premise of interaction, to the idea of environment as “system,” as unified whole constituted through strong interdependence relations between individual entities, and to the idea that each “entity” is what it is because of the others. On the other, and following the synthesis of becoming, it sees the environment as an aggregate of “processes” of change which develop continuously at different temporal rates, and sees “forms” as moments in the longer duration of these processes. According to this third synthesis, then, what we call “entities” are expressions of specific relations in the system of interactions, and what we call “forms” are expressions of specific phases of processes of becoming. Each entity, each form is, through this lens, a literal synthesis of the spatial and the temporal dimensions of the environment, for it is through their interactions in the larger environmental matrix that entities receive their essence and identity, and through the active generation of their processes of becoming that forms receive theirs. Entities and forms are, then, literal synecdoches where larger spatial and/or temporal orders are expressed, where the *singular* invokes the *complex*, where the *one* conjoins the *many*. Hence the synthesis of conjunction: “the whole reflected in each separate part,” which Goethe celebrated in his poem *The Metamorphosis of Plants*;[33] “it lies in the nature of things that the many enter into complex unity,” wrote Whitehead in *Process and Reality*.[34]

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[32] Ronald Brady, “Form and Cause in Goethe’s Morphology,” in *Goethe and the Sciences: A Reappraisal* (Dordretch: Springer Netherlands, 1987), 257-300.

[33] Johann Wolfgang Von Goethe and Miller, Gordon L., *The Metamorphosis of Plants* (Cambridge, MA.: MIT Press, 2009), 1-4. Reprinted from Rudolf Magnus, Goethe as a Scientist, translated by Heinz Norden (New York: Henry Schuman, 1949).

[34] Alfred North Whitehead, *Process and Reality: An Essay in Cosmology. Gifford Lectures Delivered in the University of Edinburgh During the Session 1927–1928* (Cambridge UK: Cambridge University Press, 1929), 21.

That entities receive identity through their spatial and temporal interdependence with their environment does not imply a relationship of mere subordination where the environment determines the essence of entities, or where the course of processes resolves forms. The environment does not precede the entity, nor does process precede form. Instead, there is a two-fold vector of influence in these relationships, one that Goethe already acknowledged in his thinking about morphology when he wrote that it is always the coordinated result of "the law of inner nature, whereby the plant has been constituted" and "the law of environment, whereby the plant has been modified"[35]—a binary proposition that should not be understood dualistically but dialectically; entities influence their environment as much as the environment influences entities and, likewise, past processes influence present forms as much as present forms condition the course of future processes. In other words, both entities and forms are simultaneously autonomous—they are distinct and bounded—and relational; they are open and acted upon.[36] It is this dialectical tension that builds the conjunction between the one and the many, between entity and environment, between form and process, so that it works as an epistemological device, through which we can better understand the interactions and becoming of things and the world, and an imaginary apparatus to construct novel frames of mind that help reveal the world and render it legible.

[35] Johann Wolfgang von Goethe, "Preliminary Notes for a Physiology of Plants," in *Goethe's Botanical Writings*, trans. Bertha Mueller (Honolulu: University of Hawaii, 1952; reprint, Ox Bow Press, 1989), 83 (WA II 6, 292).

[36] Keller and Golley, "Entities and Process in Ecology," in *The Philosophy of Ecology*, 21-34.

PART 3

CHAPTER 5

Discreteness and Continuity

Discreteness and Continuity

Chapter 5 is the first of a set of three where a series of landscape architecture works and projects shall be discussed in order to ground the ecological ideas developed in chapters 3 and 4 into design thinking. As mentioned in the introduction, each of these three chapters presents in its title an association of two antithetical concepts—"discreteness" and "continuity" in chapter 5; "transcendence" and "immanence" in chapter 6; and "tension" and "equilibrium" in chapter 7—that serve to examine, on the one hand, alternative ontological categories by which the notion of environment is defined and, on the other, different formal operations by which landscape architecture can be considered to act as an epistemological project in approaching such definitions.

In the last section of chapter 3, "From Essentialism to Nominalism: Ecological Types and Populations," I explained the antagonism that exists between ecological models that rely on an essentialist conception of nature and models that follow nominalist positions. Essentialist positions, I shall remind, recognize fundamental essences in the entities observed in the world and organize them into a series of discrete typological categories, and nominalism, on the contrary, argues that such essences do not exist and so the encompassing categories are dissolved in favor of a continuous natural order made of individual organisms that show indiscriminate variation. Chapter 5 follows this opposition and uses the notions of "discreteness" and "continuity" to offer a twofold discussion of various systems of classification in the natural sciences during the Modern Age and their contemporary principles of organization in landscape gardening. As I have explained in chapter 3, the tension between essentialism and nominalism in ecology draws on the challenge that Darwin's evolutionary theory presented to the long standing belief that species were immutable, discrete, and essential. But Darwin's theory itself, as I shall explain in this chapter, culminates a nominalist path, which had been opened in the natural sciences by the end of the eighteenth century, when various scientists put the emphasis on notions of continuity and affinity between different species, questioning the fundamental discreteness of Linnaeus' system of classification. By the end of the eighteenth century, the French botanist Antoine-Laurent de Jussieu challenged the then widely accepted Linnaean system of plant classification because he considered it arbitrarily based on numeric criteria that had nothing or little to do with the general character of the plant. In so doing, Jussieu emphasized notions of continuity in the natural order that superseded the intrinsic discreteness of a system based on the logics of counting.

But not only did the field of botany undergo by the turn of the nineteenth century a major revision of discrete frameworks of classification in favor of models that gave prevalence to notions of continuity in nature. A similar shift took place in landscape gardening, which also shifted during the eighteenth century from the French formal garden ideal of Euclidean differentiation to a looser English gardening canon that culminated in the intricacies and continuities of the nineteenth century picturesque.

In order to illustrate this parallelism between the natural sciences and the field of landscape architecture, a quick genealogy of botanic gardens is presented. The botanic garden is invoked here as a landscape architecture typology that synthesizes influences from both botany and landscape gardening. Beginning with the earliest examples of gardens explicitly designed for the study of plants in the sixteenth century, the chapter reviews the various scientific and aesthetic codes that guided the design of botanic gardens in Europe during the following centuries and the role these codes had in the maturation of botany as a modern science. Then it deals with the more complex systems of classification that emerged with the explosion in the number of known species that followed the European scientific expeditions to the New World. The arithmetic regularity of the *Systema Naturae* proposed by the Swedish botanist Carl von Linnaeus is discussed in parallel to the spatial regularity of some contemporary botanic gardens, such as the one at the University of Leiden, in the Netherlands. This regularity is then contrasted to the alternative, so-called *natural* methods of plant classification, which emerged as a reaction to the *artificiality* of the Linnaean system, expressing instead an interest in morphological affinities between species and specimens. A series of relational diagrams derived from these natural methods of classification are presented in parallel to new organizational layouts in the design of botanic gardens that focused on the possibility of establishing more explicit spatial correspondences between groups of plants showing morphological similarities. The chapter continues with a commentary on the work of the British gardener John Claudius Loudon because of his interest in the morphology of plants, his active engagement in the controversy between artificial and natural methods of plant classification, and because of the fundamental place his figure holds in the continuation of the English gardening lineage into the nineteenth century. With his post-picturesque proposition of the aesthetic category of the gardenesque, he offered an exercise essentially oriented towards the reconciliation of scientific criteria and aesthetic principles in landscape gardening. In the last section, a contemporary exercise of landscape architecture, the Bordeaux botanic garden by the French landscape architect Catherine Mosbach, serves to recapitulate notions of discreteness and continuity discussed throughout the chapter, and to update them by introducing new ecological and ethnographic content into the world of botany.

Of the three ecological syntheses proposed in chapter 4, the synthesis of conjunction—the one and the many—will be the one that takes on the highest relevance in this chapter. The relevance that Jussieu gives to the comparative study of different organisms in opposition to the fundamental separateness of Linnaeus's system, and Loudon's gardenesque interest in the aesthetic potential of the full formal development of the plant, will serve to put the emphasis on Goethe's notion of morphology as a way to mediate the unity and the diversity of the forms that exist in nature.

With this chapter, therefore, I shall begin to draw more explicit connections between the metaphysics of ecology and the theory and practice of landscape architecture (*Figure 5.1*). I shall use the botanic garden as a proxy to demonstrate the parallelism that exists between the genealogies of the organizational frameworks developed by both botany and landscape gardening. With a focus on the late eighteenth and the early nineteenth century, the emphasis will be put on the period that precedes the formulation of ecology as a formal discipline and which constitutes, therefore, the scientific magma from which ecology would ultimately emerge. Interestingly enough, these are also the formative decades of landscape architecture. This parallelism serves to neatly illustrate the epistemological bind between ecology and landscape architecture that lies at the core of this dissertation: both botany and landscape gardening reciprocally inform the construction of their respective formal frameworks. If, as I shall prove, botanic gardens were both agents and indexes of the construction of a natural order, it was through the shift towards notions of continuity and affinity in the natural sciences that the ecological worldview was conceivable, and through the parallel shift towards continuity in landscape aesthetics, I suggest, that landscape architecture played a key role in making the ecological worldview apprehensible.

Formal Systems of Early Botanic Gardens

"There are as many kinds of gardens," wrote J. B. Jackson, "as there are concepts of art and work and community, and of relationships to the natural world."[1] As part of this exercise of continuous reinterpretation of gardens in their larger cultural contexts, the unfolding of botanical science has informed the evolution of garden design over time and, more particularly, of botanic gardens. Only an incipient typology in the sixteenth and seventeenth centuries, botanic gardens became complex and important institutions in the eighteenth century in Europe, which would eventually play a fundamental role in the revolution that botany would undergo in the eighteenth and nineteenth centuries.

Modern botanic gardens as they began to proliferate across Europe in the sixteenth century had their precedents in the medieval *herbularius* or physic garden.[2] Frequently found in the context of monastic complexes, physic gardens' main purpose was the cultivation of plants because of their medicinal properties. Taking the famous plan of Saint Gall in Switzerland, of the ninth century, as a representative case, early medieval monasteries often incorporated, besides the more solemn cloister garden or *hortus conclusus*, three additional gardens strictly dedicated to the cultivation of plants. These were the kitchen garden, where various kinds of vegetables were grown, the fruit orchard (in the case of Saint Gall the fruit trees were planted in the cemetery), and the *herbularius*—or medicinal garden (*Figure 5.2*). The *herbularius* was often located near the *domus medicorum* or infirmary, where monasteries would center

[1] J. B. Jackson, "Nearer than Eden," in *The Necessity for Ruins* (Amherst: University of Massachusetts Press, 1980), 20.

[2] Parallel to the development of monastic physic gardens in Europe was the maturation of a more intellectual agronomic tradition in the medieval Islamic world, which included Spain, and which emphasized much more the ecological perspective, that is, the environmental conditions in which each plants species would exist. See, for example, D. Fairchild Ruggles, *Gardens, Landscape, and Vision in the Palaces of Islamic Spain* (University Park: The Pennsylvania State University, 2000), or Karl Butzer, "The Islamic Traditions of Agroecology: Cross-cultural Experience, Ideas and Innovations," in *Ecumene* 1, no. 1 (January 1994), 7-50.

the assistance to the sick in medieval Europe.[3] Monks used these physic gardens to grow those medicinal herbs that they considered useful and that would not otherwise grow in nearby woodlands or farms. The result of their efforts was an indiscriminate catalog of plants that cannot be considered scientifically driven in a strict sense; the primary goal was the utility of the plants, rather than the establishment of a methodical organization of plants aiming at the expansion of botanic knowledge. And yet, according to the plan of Saint Gall, the different species were planted in separate rectangular beds displayed in accordance to a carefully regularized schema. So, while their primary ambitions were not scientific or even educational, the purposeful collection, organization, and display of plants in the physic gardens offered the seed for a more systematized study of plants to come.

In the sixteenth century, the study of medicine instigated the creation of more complex collections of plants intended expressly for the scientific knowledge of plants in the context of the new emerging universities. Some of the earliest examples include the botanic gardens at the University of Pisa, in 1543, the University of Padua, in 1545, Bologna, in 1547, and Zurich, in1560. Unlike its medieval predecessor, the *hortus botanicus* was invested in the disinterested quest for knowledge, in the understanding of plants beyond their medical properties, but rather as subject of study in themselves, whose structure and position within a larger theoretical schema merited examination. The scientific establishment of organizational principles in botany gained progressive relevance during the sixteenth century with the emergence of the new order of nature, dramatically larger in extent and complexity, that resulted from the early explorations of the Far East and the discovery of the Western Hemisphere by the end of the fifteenth century. In order to discern the increasing diversity of newly discovered species, these modern botanic gardens inherited the *herbularia*'s logic of independent planting beds where the different species were cultivated separately, yet some of them also began to combine that utilitarian logic of spatial compartmentalization with new formal explorations and symbolic languages.

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[3] Walter Horn and Ernest Born, *The Plan of St. Gall*, 3 vols. (Berkeley: University of California Press, 1979), vol. 2: 181, 203, 205, 212. The list of medicinal plants depicted in the plan of St. Gall includes sage, watercress, rue, cumin, iris, lovage, pennyroyal, fennel, climbing beans, pepperwort, costmary, Greek hay, rosemary, mint, lilies and roses (*saluia*, *sisimbria*, *ruta*, *cumino*, *gladiola*, *lubestico*, *pulegium*, *fenuclum*, *fasiolo*, *sataregia*, *costo*, *fenegreca*, *rosmarino*, *menta*, *lilium*, and *rosas*, in the original latin of the codex).

One of the most paradigmatic examples of the sixteenth century, the garden in Padua, was designed as a square inside a circle, divided into four quadrants, each quadrant subdivided in turn into small beds, and each bed designated for one specific species (*Figure 5.3*). The explanation behind the circle in Padua, instead of the prevailing square rule imposed by the long tradition of the monastic *hortus conclusus*, is the Renaissance adoption and exploration of the aesthetic Platonic ideals of geometric perfection.[4] Similarly, the exhaustive intricacy of the subdivision of the quadrants into the small planting beds, which largely exceeds the mere utilitarian requirements of planting compartmentalization, can only be explained as part of a larger aesthetic quest for the mastery and control of geometry. The superimposition of the square on the circle has been described, along the same lines, as a translation of Leonardo da Vinci's *Vitruvian Man* into the field of garden design.[5] However, and despite the choice of a circular shape, the general schema of the botanic garden at Padua did follow the lineage of the medieval *hortus conclusus*—an enclosed and square space subdivided by walking paths into four quarters with a fountain at the center. For over two millennia of gardening history, this spatial subdivision had represented the four corners of the world in a hierarchical composition that placed God—or the fountain of life—at the center. As the great age of explorations unfolded, the discovery of America brought a new continent which completed—along with Europe, Asia and Africa—a subdivision of the world that allowed for the creation of a straightforward fourfold correspondence between the cosmological and the geographic, as the British Historian John Prest has shown.[6] The four quarters of the *hortus conclusus* became the four continents of the earth in the sixteenth and subsequent centuries, and many botanic gardens of the time made efforts, although generally vague, to plant each quarter accordingly with such geographic rationale. The botanic garden became a microcosm, a synecdoche that allowed for contemplating the whole world in one space. As navigators and travelers quit their quest to find, after a few decades of explorations in the Far East and the

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[4] Lucia Tongiorgi Tomasi, "The Origins, Function and Role of the Botanical Garden in Sixteenth- and Seventeenth-Century Italy," in *Studies in the History of Gardens and Designed Landscapes* 25, no. 2 (2005), 103-115.

[5] Tomasi, ibid.

[6] John Prest, *The Garden of Eden: The Botanic Garden and the Re-Creation of Paradise* (New Haven and London: Yale University Press, 1981), 1.

Americas, the lost Garden of Eden, the alternative motivation was to reconstruct, out of the scattered pieces collected across the world, a microcosm—the botanic garden as the new Garden of Eden.[7]

The sixteenth century explorations had a great impact in the Netherlands, which were at that time the most important trading center in the world. Many new plants began to arrive in the Netherlands from both the East and West Indies, and the University of Leiden established in 1587 its own botanic garden, which would later become a fundamental institution in the development of botanical science. The garden at Leiden followed the tradition of the *hortus conclusus* and matched the cosmological and geographical symbolism of Padua, with two main axes crossing at the center. It diverged from Padua, however, with a planting-beds' arrangement that followed a much simpler plan, a more austere language reminiscent of the medieval *herbularia*, like Saint Gall's. Padua was not the only botanic garden that was designed with an intricate planting compartmentalization (*Figure 5.4*); other important examples of the early seventeenth century, such as the *Giardino dei Semplici* at Mantua (1603), the Botanic Garden at Oxford (1621), and the *Jardin du Roi* at Paris (1626) developed similar geometries, proving that aesthetic canons derived from contemporary non-scientific gardens and other artistic sources often prevailed over scientific principles of spatial organization.[8] In the sixteenth century, an incipient elaboration of complex and intricate geometries, an expression of a new order of nature shaped by reason, was taking place mainly in Italy, inaugurating what would later came to be thought of variously as "formal gardening." However, these geometries coexisted with more austere methods of spatial compartmentalization, which borrowed directly from the utilitarian foundations of agronomy.[9] Following this lineage, Leiden's *pulvilli* were

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[7] Ibid, 46.

[8] Lucia Tongiorgi Tomasi, "Projects of Botanical and Other Gardens: A 16th Century Manual," in *Journal of Garden History* 3, no. 1 (1983), 1-34.

[9] Emilio Sereni has suggested, using Villa d'Este as the paradigmatic example, that the regular fragmentation of the Italian gardens of the Renaissance celebrated the regularity of the productive landscape. See Emilio Sereni, *History of the Italian Agricultural Landscape* (New Jersey: Princeton University Press, 1961), 149. Some other authors have argued that the origin of compartmentalization in garden design goes back to water distribution and channelization across the arid territories of the primeval Persian garden. See, for example, Donald Newton Wilber, "Persian Gardens and Paradise," in *Persian Gardens and Garden Pavilions*, (Washington DC: Dumbarton Oaks Other Titles in Garden and Landscape Studies, 1979), 4.

designed in accordance to the regularity of the agricultural grid, where long, straight, and narrow planting beds facilitated, in the manner of agricultural rows and furrows, easy and equal access for the adequate care and cultivation of plants (*Figure 5.5*). Each *pulvillum* gathered a family of plants, and was subdivided into numbered smaller units, each dedicated to one particular species and equally accessible, both visually and physically, to the students and researchers that analyzed them from the gravel of the paths that allowed for navigation of the space in-between. As Prest has indicated, it was the regularity and permeability of the arrangement of Leiden's garden, the possibility of accessing plants as if they were technical sheets in a scientific publication, what marked, more than any other design characteristic, the transformation of the botanic garden into a living encyclopedia, and what constitutes, therefore, the academic inception of the botanic garden.[10]

It was its separation from the developing doctrines of non-scientific garden design what allowed the botanic garden to enter and eventually play a central role in the evolution of the science of botany in the centuries that followed. Yet, if the organization of their catalog of plants was not going to follow the aesthetic and symbolic principles of contemporary garden design, the question that remained was "what principles of organization should botanic gardens follow then?"

Early Systems of Classification

During the seventeenth and, especially, the eighteenth century, botanic gardens developed in Europe as increasingly complex and important institutions. This development ran parallel to the process of maturation in the field of botany that had begun, as I have already mentioned, in the late fifteenth century with the launch of the Age of Discovery.[11] The discovery of America and the subsequent Spanish transatlantic voyages, as well as the Portuguese establishment of the sea route to India, both events taking place in the 1490s, certainly marked the starting point of an extensive overseas exploration that bore a

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10 Prest, *Garden of Eden*, 2.

11 See, for example, Prest, *Garden of Eden*, 38, and Elisabeth MacDougall's editorial introduction to *John Claudius Loudon and the Early Nineteenth Century in Great Britain* (Washington DC: Dumbarton Oaks Colloquia on the History of Landscape Architecture, 1978), 2.

phenomenon of unprecedented movement of humans (including slaves), culture, religion, diseases, food, animals, plants, and seeds at a global scale. During the sixteenth and the seventeenth centuries, explorers brought many specimens of plants they found on their voyages across the Americas and East Asia back to Europe. What began as a gathering process chiefly driven by an economic quest for new agricultural products soon incorporated plants that were already well-known in Europe and that were collected simply because of their ornamental value, and then turned, in the eighteenth century, into an accumulation primarily motivated by the scientific aspiration to master the increasing complexity of nature. By the early eighteenth century, botany was certainly evolving into a mature science, and some formally trained botanists also joined the explorations, returning to Europe with hundreds of specimens that were then kept and cultivated in the botanic gardens spreading across the continent. In rendering this new order of nature legible, botanic gardens progressively consolidated as important research institutions, as indexes of scientific knowledge, and as physical manifestations of the beginnings of modern science.[12]

The number of observed species increased dramatically in Europe with the arrivals from the East and West Indies and, for many years, different scientists employed different taxonomies to classify and gave different nomenclatures to designate the new material. The diversification of systems of classification and naming complicated communication between scientists and across regions, even more so in the context of the definition of a scientific field whose subject of study was changing and expanding rapidly. The various intellectual frameworks that emerged during the maturation of botany demanded new organizational arrangements to display the plants, and so the different botanic gardens across Europe were planted in accordance to the system of classification at use in each research institution.

By the beginning of the eighteenth century, under the prefect-ship of the physician Herman Boerhaave, the University of Leiden became the world's leading institution in botany and medicine. Boerhaave, building upon the work of early systematists such as Cesalpino, Morison, Ray and Tournefort, developed

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[12] Therese O'Malley, "Art and Science in the Design of Botanic Gardens, 1730-1830," in *Garden History: Issues, Approaches, Methods*, ed. John Dixon Hunt (Washington DC: Dumbarton Oaks Colloquia on the History of Landscape Architecture, 1992), 279-302.

a system of classification of plants which relied heavily on the morphology and the arithmetics of the flower, putting emphasis on "the figure of the leaves, stem, calyx, petals, and seeds; the number of petals, seeds, and capsules; the substance of the leaves; the situation of the flowers, and their difference in point of sex."[13] During Boerhaave's prefect-ship, the abstract and regular framework of Leiden's garden was expanded and reorganized to accommodate the content—a collection of about six thousand plants at that moment—in accordance with his new system of classification.

Such was the garden that the young botanist and physician Carl Linnaeus found when he arrived in Leiden in 1735.[14] Linnaeus came to the Netherlands in 1735 to get a doctoral degree in medicine. Shortly after his arrival, and with the patronage of some colleagues he met in his visit, he published his own method of classification in a short book—in the forms of tables only, in twelve folios—called *Systema Naturae* which, through its twelve subsequent editions published until 1766, became the most widely accepted system in botanical studies in the eighteenth century, and the basis of the binomial nomenclature that is today universally used in naming species of living organisms. Unlike the more intricate schemas of other contemporary gardens, the simple regularity of Leiden's framework served as an effective model for the implementation of the new systems of classification that were devised during those days. As landscape historian Therese O'Malley has observed, the second edition of Linnaeus' *Systema Naturae* showed on its front page the illustration of a garden that was arranged in rectangular planting beds like Leiden's; and such also was the layout at the botanic garden of Uppsala after its reorganization, which was done according to Linnaeus' ideas and later documented in his 1748 work *Hortus Upsaliensis* (*Figure 5.6*).[15]

It is the corresponding regularity of Linnaeus' intellectual framework what explains the selection of Leiden's model for the display of his system of classification, and what also explains the general acceptance of his method in the eighteenth century. The agreement of the scientific community around the

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13 Benjamin Waterhouse, *The Botanist* (Boston: Joseph T. Buckingham, 1811), 104.

14 Richard Pulteney, *A General View of the Writings of Linnaeus* (London: R. Taylor and Co., 1805), 44.

15 O'Malley, "Art and Science in the Design of Botanic Gardens," 286.

Linnaean *Systema Naturae* and the eventual universalization of the binomial nomenclature it followed, eased the task of plant cataloguing extraordinarily and enormously facilitated communication among botanists (*Figure 5.7*). Having continued the lineage of Boerhaave—whom he met during his stay in Leiden—Linnaeus' taxonomy organized the world of plants accordingly to arithmetic criteria derived from the morphology of the flower. In order to locate a plant in the Linnaean table, one only needed to look at the sexual system of the plant, and more precisely, at the number, union, and grouping of stamens and pistils: flowers with one stamen would enter the *monandria* class, with two stamens, the *diandria*, three stamens, *triandria*, and so on. It was a purely arithmetic system of classification, which garnered much praise and success for its simplicity, regularity and effectiveness but was soon criticized for its *artificiality*—to use the wording of the time. It was considered a deficient and *artificial* method because it had arbitrarily selected a few visible differential features of the plant as the basis for deploying a whole system of classification of the natural world. In so doing, it ignored other characteristics that others might have considered more relevant to the overall understanding of the plant's structure and functioning.[16] It was the definition of these more essential characteristics what became the central task of several botanists growing up under the influence of Linnaeus and who, towards the end of the eighteenth century, aimed at using them to develop a new *natural* system of classification.

Classes and Phases

One of the most widely acknowledged systems of classification presented as alternatives to Linnaeus' was the one offered by the French botanist Antoine-Laurent de Jussieu in his 1789 publication *Genera Plantarum*. Jussieu had arrived in 1770 at the *Jardin des Plantes—*originally named *Jardin du Roi*—in Paris, as a professor of botany. From a family of naturalists originally from Lyon, his vision was influenced by the previous and unpublished work of his uncle Bernard Jussieu who, during the central decades of the eighteenth century, had been a central figure, along with the institution's director Georges-

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[16] William T. Stearn, "Linnaean Classification, Nomenclature and Method," in *The Complete Naturalist: A Life of Linnaeus*, ed. Wilfred Blunt, (New York: viking, 1971), 242-245. For a more technical analysis see also Peter F. Stevens, *The Development of Biological Systematics: Antoine-Laurent de Jussieu, Nature, and the Natural System* (New York: Columbia University Press, 1994), 12-13.

Louis Leclerc, Comte de Buffon, in the transformation of the *Jardin des Plantes* into a major research center and museum in the European context.

Antoine de Jussieu considered, as other contemporary naturalists, that the arithmetic rules of Linnaeus' system actually destructed natural affinities between plants and, conversely, created very frequent connections between plants that were dissimilar. He considered, as well, that such a system, constructed in an arbitrary manner, would lead to false, unnatural science, and an incomplete knowledge of plants. Although he praised Linnaeus' efforts in investigating a natural method, he also declared that botany had been largely invested in the determination of an adequate nomenclature—a task that could only be regarded as a prelude to botany—rather than in the scientific understanding of plants.[17] He thought that this understanding would be possible through the observation of all the characters of the plant, its entire organization, so that mutual affinities between different plants would begin to emerge and help to build a complete knowledge of them.[18] Jussieu believed that a natural method should be simple and be established in conformity to the "law of affinities, which links all plants by an unbroken bond, and precedes step by step from simple to composite, from the smaller to the largest in a continuous series."[19] To those who considered that such a continuous schema of nature could not be established unless all the links in the chain were known, he responded that a complete knowledge of all beings should not be hoped for and that there were enough beings already known in order to begin to construct some stretches of that chain.[20] Despite the likely impossibility of being able to know the whole chain of nature, Jussieu was nevertheless convinced that nature was continuous: "*natura non facit saltus*," ["nature does not make leaps"] he stated in a posthumously published introduction to *Genera Plantarum*.

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17 Antoine Laurent du Jussieu, *An Introduction to the History of Plants* (introduction to the *Genera Plantarum Secundum Ordines Naturalies Diposita*), trans. Susan Rosa, reprinted in Stevens, *The Development of Biological Systematics*, 353-354.

18 Ibid., 355.

19 Ibid.

20 Ibid., 356.

In order for this ontological continuity of nature to be approached, a few methodological revisions had to be made in the field of botany. He announced some of these in a short essay in 1788, a year before the publication of *Genera Plantarum*:

> The route to be followed in finding it [the natural method] is different from that we have followed up to now … The impossibility of uniting, or even being acquainted with, all the plants which must make up the general chain will always be an insurmountable obstacle and will leave gaps that are difficult to fill; but Nature has scattered the material intended for the construction of this order, she allows us to catch at least a glimpse of the principles in which it is based. Among the characters that plants provide, some are essential, general and invariable, which, it appears, must serve as the basis of the order that we seek. They are not arbitrary, but based on observation, and are not to be obtained except by proceeding from the particular to the general.[21]

Firstly, and unlike Linnaeus, who had arbitrarily chosen one particular feature of the plant to develop his system of classification, Jussieu aimed at creating a method based on the subordination of different features in terms of their relative importance. He began by marking a distinction between different signs of distinction among plants. On the one hand, he discussed *characters*, which expressed some fundamental indicators of the internal structure of the plant. These were considered essential to the proper definition of the plant as well as in the adequate location of the plant within the general organizational system. On the other hand, there were external *differentiae*, external features without essential value.[22] He thought that the combination of some of these *characters* should be the leading criteria in the construction of a natural method of classification. If a continuous natural series were to be understood, naturalists would have to work synthetically, rather than analytically; not just one single *character* should be observed—as in the Linnaean manner—but the whole organism—again, a combination of characters. The valid study of nature investigates the whole plant, looking at all its features and not excluding any, for only through the observation of the whole do the relative value of the different characters become apparent, and it is only then that the establishment of adequate relationships between different organisms becomes possible.[23] Jussieu's method was also synthetic in the sense that it was conceived as an upward classification, which would proceed—as nature does, in his view—from the simple to the compound or

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[21] Antoine-Laurent de Jussieu, "Exposition d'un Nouvel Ordre des Plantes Adopté dans les Démonstrations du Jardin Royal," *Mém. Math. Phys. Acad. Roy. Sci.* (Paris, 1778), 178. Translated in Stevens, *The Development of Biological Systematics*, 29.

[22] Jussieu, quoted in ibid., 339.

[23] Ibid., 30.

the composite: organisms would be grouped into successively larger taxa, so that the arrangement of all the different levels was directed by affinities between specimens, rather than imposed from the subdivision of larger into smaller groups (*Figure 5.8*).[24]

This shift from downward subdivision to upward grouping models is what Ernst Mayr has also referred to as a general shift in the sciences of classification of the early nineteenth century from "the use of single key characters for the establishment of higher taxa" to "the grouping of species (or other lower taxa) into higher taxa on the basis of character combinations."[25] This distinction also has been illustrated by Michel Foucault, who opposes, precisely, the figures of Linnaeus and Jussieu—along with Buffon and Adanson—as epitomes, respectively, of "system" and "method," the two epistemological techniques that natural history employed in its exercise of establishment of comparisons in the world of living beings. In Foucault's distinction, the system is Linnaean, for it establishes identities and differences by choosing aprioristically a limited set of features and studying, in all the individuals that present them, constants and variations. The method, on the other hand, is Jussiean, and operates empirically, by making holistic comparisons, where the number of initial similarities is very high and the number of differences is comparatively very small.[26] To oppose both epistemologies is to oppose, Foucault remarks, the idea of a motionless nature in favor of the idea of a numerous continuity of beings that communicate with one another, get mixed and, perhaps, mutate.[27]

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[24] Ibid, 5.

[25] Ernst Mayr, *The Growth of Biological Thought: Diversity, Evolution and Inheritance* (Cambridge, Mass: Belknap Press of Harvard University Press, 1982), 204. Stevens makes a similar distinction by confronting "analysis" and "synthesis," where analysis is equated to artificial systems of classification—those that subdivide—and synthesis is the late 18th century procedure of natural methods—were larger groups are successively *formed* in natural arrangements. In Stevens, *The Development of Biological Systematics*, 5.

[26] Michel Foucault, *Las Palabras y las Cosas* (2a. ed. revisada y corregida), trans. Elsa Cecilia Frost (Mexico: Siglo XXI, 2010), 155.

[27] Ibid.

This same idea of continuity emphasized affinities and blurred distinctions between organisms that had been considered to belong to different species. It came, then, to challenge the very notion of species, whose discreteness, fixity and immutability had been reinforced by Linnaeus' taxonomy and nomenclature. Aristotelian essentialism gave way to nominalism, which suggested that no substance essences or *forms* existed, and that species are just names that different groups of entities receive by virtue of some resemblances among them, even though these resemblances do not reflect any fundamental underlying biological concurrence. According to nominalism, as I explained in chapter 3, the only thing that the members of a species share is their name.[28] This shift from essentialism to nominalism entered biology during the eighteenth century, and Buffon, then director of the *Jardin des Plantes*, where Jussieu taught botany, was a key participant in the transition, claiming that perhaps two species cannot be distinguished through their morphological constitution but through their reproductive compatibility—two animals belong to the same species if they can perpetuate themselves through copulation—facilitating the rise of evolutionary hypotheses that would soon be developed more deeply by Lamarck and, of course, Darwin.[29]

The rejection of underlying essences and forms in the definition of species, which is so linked to the Jussiean conception of nature as a continuum, brought an epistemological conundrum to the natural sciences that in fact explains the extraordinary development of biology during the nineteenth century. Not only did it pave the way for the development of the theory of evolution, but also explained the explosion during the first half of the nineteenth century of biology into several fields of knowledge, such as anatomy, phylogenetics, ontogenetics, physiology, and so on, which focused on the study of different constitutive characteristics of organisms in an attempt to more informedly delineate groups of beings

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[28] For a more detailed explanation of the different metaphysical positions that encountered in the field of biology during the scientific revolution up to Darwin's evolutionary theory, see David L. Hull, "The Metaphysics of Evolution," in *British Journal for the History of Science* 3 (1967), 309-37.

[29] Georges Louis Leclerc, Comte de Buffon, *Natural History, General and Particular*, Vol. 2, William Smellie, trans., (London: W. Strahan and T. Candell, 1785), 10, quoted in Hull, "The Metaphysics of Evolution," 255.

existing in a continuous order of nature.[30] If an idea of nature as continuum emphasizes the relationships between different classes, families, and genera, tending to blur distinctness between then, then the idea of a *natural* system of classification—versus the Linnaean *artificial*—seems an oxymoron: the idea of class implies the discretization of the observed world into independent categories, and the idea of nature as a *continuum* essentially challenges this vision. A productive oxymoron, however, for this oppositional relationship between taxonomical discreteness and natural continuity is, as Foucault reminds us, a fruitful and creative one; in order for taxonomy to be possible it is necessary that nature is actually continuous, so that classification is based on the principle of the minimum possible difference.[31] It is precisely the continuity of nature that offers memory the possibility of being exercised, because, since we are confronted with always blurry identities and representations of identities, memory is forced to recall a previous representation that is similar to the one in course and link both through a common name.

The path opened by Jussieu was followed by many naturalists of the nineteenth century. Most of them, however, were less concerned with the ontological constitution of nature—whether nature was continuous or not—than they were with the general utilization of the methodological principles offered by the natural method; in fact, more than twenty four different new methods were developed between 1800 and 1860.[32] Yet, although not literally adopted by some of his most prominent followers in the natural sciences, Jussieu's conception of nature as a continuum had obliterated preceding and artificially discretizing models of nature and was going to have a strong correlation with contemporary developments in landscape architecture theory and practice.

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30 I must also remind here that Haeckel himself, in the proposition of the science of ecology, complained about the exhaustive dedication of the field of biology to the comparative understanding of the different internal parts of the organism, at the expense of the understanding of the external relationships of the organism with its environment.

31 Foucault, *Las Palabras y las Cosas*, 177.

32 Stevens, *The Development of Biological Systematics*, 64.

Relational Diagrams and Spatial Relations

I have discussed how, during the eighteenth century, botanic gardens became important scientific institutions, serving economic as well as academic functions. The development of the field of botany kept many European scientists traveling in organized expeditions to distant regions of the world, and the collections held in botanic gardens were continuously expanded with the arrival of new specimens that often belonged to unknown species. The gardens were managed by important figures in the field, who often rearranged the collections in accordance with scientific systems of classification of their preference. I have mentioned, in this regard, the great expansion and reorganization of the plant collection that the Dutch botanist and physician Boerhaave undertook at Leiden in the early eighteenth century, and Linnaeus' design for the botanic garden in Uppsala, which closely followed the spatial schema of Leiden's, and where plants were arranged in accordance with his own *Systema Naturae*. Leiden and Uppsala eventually became pivotal gardens in the development of what came to be known as *artificial* systems of classification. The regularity and abstraction of their spatial organizations—roughly consisting of a series of uniform and rectangular planting beds—suited well the equally rational and effective approach of these *artificial* systems—which distributed organisms across a range of species and higher order taxa, discretely demarcated from one another by virtue of the differences deduced from the examination of one single feature. Increasingly criticized since the 1750s, these *artificial* systems lost relevance as the so-called *natural* methods of classification began to develop by the turn of the nineteenth century. Rather than focusing on one single aspect, *natural* methods, more observational and synthetic, investigated the organism as a whole, privileging similarities rather than differences among individuals in an attempt to derive a more relational understanding of the order of nature.

Diagramming relationships among different groups of plants became a big concern among naturalists. The Jussiean proposition of a continuous chain of organisms began to complexify as an increasing variety of characters were used in the classifications.[33] Linear diagrams where families of plants branched out gave way to more intricate networks of relationships (*Figure 5.9*). In this sense, it is remarkable that

[33] Stevens, *The Development of Biological Systematics*, 169.

analogies between systems of classification and geographic maps had been made by Jussieu and also, before him, by Linnaeus himself:[34] not only the correspondence between the levels in the taxonomic hierarchy and the administrative scales of the territory—district, provinces, kingdoms, and so on—but also shared notions of continuity, spatial proximity, areas yet to be discovered, and even arbitrariness of boundaries, seemed to endorse the pertinence of the analogy between the construction of maps and the representation of affinities between plant families. The continuous linear arrangement suggested by Jussieu yielded the development of more reticular and two-dimensional schemas which, often confined to specific regions, allowed to describe more complex and subtle relationships between species and groups.

While the diagrammatic representation of the natural order was a central question for early nineteenth century naturalists, another key challenge that emerged was the arrangement that these new organizations should follow in the ground of the botanic garden. If the regular and gridded layout of Leiden and Uppsala had been the spatial counterpart of earlier analytical systems of classification, the adequate spatial schema for methods focused on the holistic observation of organisms and in the establishment of correspondences between them would be one that allowed to group plants according to the greatest number of morphological similarities.

One of the first botanists who tried to give an answer to this question was Augustin-Pyramus de Candolle, who worked under the influence of Jussieu's natural system and became one of the leading botanists in Europe during the first half of the nineteenth century. Candolle, who was familiar with Linnaeus and Jussieu's analogies between systems of classification and maps, had also prepared numerous diagrams of relationships in his publications—some of which were intended to be understood as a section of the branches of a tree, acknowledging the concomitant development of tree and genealogical diagrams. In 1816, when he returned to Switzerland after several years working in Montpellier, he designed a new planting layout for the botanical garden in Geneva. The design, which Peter F. Stevens has redrawn from a sketch conserved at the *Jardin Botanique* at Geneva, is a translation of his ideas on the relationships

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[34] Stevens, *The Development of Biological Systematics*, 28, 165.

between plants into the physicality of the garden (*Figure 5.10*). As such, it presents a series of different lines and several discontinuous groups of plants, organized by families, arranged at various distances according to their distinctness. As the field of botany shifted from artificial systems of classification to other methods where different classes of organisms were not understood to be discrete, so began to do the organization of botanic gardens, were specimens were not arranged anymore by principles of regularity but, rather, morphological grouping and continuity.

Scientific criteria and aesthetic principles. Loudon and the Gardenesque

The eighteenth century has gone down in the history of landscape architecture as the century of the English revolution in the canons of gardening. It has been often illustrated as a shift from the aesthetic tenets of the rigid and symmetric euclidean geometry of the seventeenth century *jardin à la française* to the looser, softer, and predominantly curvilinear forms of the pastoral English landscape gardening, which eventually would give way to the more theoretical discussion around the aesthetics of the picturesque. This progression in landscape architecture unfolded concurrently with the shifts in the natural sciences that, as we have seen in the previous sections of this chapter, followed a move away from an interpretation of the natural order built on the essentialist tradition of static species and into nominalist positions more compatible with the ideas of interaction and evolution, in preparation of the evolutionary and ecological propositions of the second half of the nineteenth century. John Claudius Loudon was one of the most prominent landscape designers of the first half of the nineteenth century in Great Britain, and was particularly interested in the theoretical transformations that Jussieu and some other scientists were introducing in of botany. As several landscape architecture historians have pointed out, Loudon was one of the authors that best exemplifies, in this context, the confluence of art and science in nineteenth century landscape architecture.[35]

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[35] See for example Melanie Simo, *Loudon and the Landscape: From Country Seat to Metropolis, 1783-1843* (New Haven, Yale University Press, 1988), Elisabeth MacDougall, ed. *John Claudius Loudon and the Early Nineteenth Century in Great Britain* (Washington DC: Dumbarton Oaks Colloquia on the History of Landscape Architecture, 1978), Mark Laird, “Ornamental Planting and Horticulture in English Pleasure Grounds, 1700-1830,” in *Garden History: Issues, Approaches Methods*, ed. John Dixon Hunt (Washington DC: Dumbarton Oaks Colloquia on the History of Landscape Architecture, 1992), or Therese O’Malley, “Art and Science in the Design of Botanic Gardens, 1730-1830,” ibid, 279-302.

Loudon began to work as a landscape designer during the first decade of the eighteenth century. These years had witnessed the publication of a large amount of texts that were eventually framed within what came to be known as The Picturesque Controversy.[36] Schematically, the controversy emerged from the continuous criticism of Richard Payne Knight and Uvedale Price against the work of Humphry Repton, who had become the main figure of landscape gardening in England since the death of Capability Brown in 1783. Knight opened the controversy by attacking Repton's work for its resemblance with Brown's landscape improvements; Repton's interventions were too refined, polite, scenic and manicured for Knight's aesthetic theses and political convictions. Aesthetically, Knight's picturesque was inspired by the rough landscapes represented in most of the paintings he had collected during his Grand Tour. Politically, it was influenced by strong liberal ideals that had emerged primarily from the wide political tensions associated to the French Revolution. Repton, whose work had already shown, nonetheless, clear picturesque leanings, counterattacked Knight defending that a certain degree of comfort in the landscape should be prioritized over the 'situations ill adapted for the residence of man' he saw in Knight's claims.[37] Price, the third party in the picturesque controversy, also criticized Repton, but claiming, from a different perspective, that there was some sort of implicit despotism in Repton's general systems of improvement, which produced more dehumanized landscapes than those represented in the art of painting.

The incongruences and the belligerence of the discussion served to accelerate the consolidation of the aesthetic theory of the picturesque, which Uvedale Price referred to in his *Essay on the Picturesque* as one that came to fill up "the vacancy between the sublime and the beautiful (*Figure 5.11*)."[38] Besides the social and political connotations of the controversy, Price presented the picturesque fundamentally in aesthetic terms, and described it mainly through ideas of "continuity," "variety," "intricacy," "engagement," and "transition," which resound remarkably well with the terms that, as we have seen,

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[36] For a good account of the discussion around the theory of the Picturesque see Stephen Daniels, "The Picturesque Landscape," in *Humphry Repton: Landscape Gardening and the Geography of Georgian England* (New Haven; Published for the Paul Mellon Centre for Studies in the British Art: Yale University Press, 1999), 103-47.

[37] Daniels, "The Picturesque Landscape," 113.

[38] Uvedale Price, *Essays on the Picturesque* (London: 1810 [1794]), 114.

were also recurrent in the development of the parallel controversy taking place within the field of botany. The organizational intricacy and continuity of the networks of relationships that botanists were using to represent their new scientific understanding of the natural order was concomitant, interestingly, with the rise of the theory of the picturesque in landscape gardening, and its new sympathies toward notions of aesthetic intricacy and continuity.

Loudon was a key figure in mediating the picturesque interest in aesthetics and the concomitant changes in the scientific interpretation of the natural order. The son of an important Scottish farmer, he had developed in his youth a practical knowledge of horticulture and the efficient the use of the land, especially in a context of scarcity associated to the Napoleonic Wars. As a young man, he went to study biology and botany at the University of Edinburgh, and became acquainted with the theoretical discussions undergoing in the field of botany. In the 1827 volume of *The Gardener's Magazine*, the journal he edited for more than fifteen years, he acknowledged that the Linnaean taxonomy constituted a good beginning in the approach to nature, for the mind needs to classify items into larger groups in order to facilitate the retention of information into memory. But he also praised the convenience of using natural methods in garden design; the Linnaean system appeared unsatisfying to him as a crowd of unconnected images and facts, lacking connection and discourse, while the natural methods, built upon resemblances of the multiple parts of plants, their properties and qualities, proposed classifications where different species could be read as segments of a naturally harmonious and discursive whole.[39] For Loudon, gardens had a clear educational component, where the science of botany could be learned. And accordingly, natural methods like Jussieu's could make the learning experience more accessible to the untrained eye. In this regard, he wrote:

> "Whoever wishes to study plants so as to derive the greatest possible quantity of knowledge and enjoyment from the least possible quantity of exertion, in study and expense of books, figures, or living plants, ought to direct his view towards the natural system… Parents who wish their children to acquire, at an easy rate, a general knowledge of botany, will plant in their gardens an index to the natural system."[40]

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[39] John Claudius Loudon, *The Gardener's Magazine* 2, (1827), 301.

[40] Ibid, 301, 302.

Loudon recommended to anyone having a garden to exemplify all the orders of the natural system through the plantation of 330 plants, 94 of them being exotics and requiring the protection of the hot-house or the green-house. So, there was a design potential inherent in the natural system, that could be used as a guide for laying out not only botanic gardens but also pleasure grounds.[41]

However, Loudon's strategies for planting were not only informed by his preference on the available scientific methods for botanical classification. He had assumed the mantle of the English landscape improvement after Repton's death in 1818, and he also cared about aesthetics. The combination of Loudon's interest in the aesthetic and the scientific dimensions of plants led him to develop the notion of the gardenesque,[42] which rose from the principles of the picturesque as formulated by Gilpin, Price, Knight, but aimed instead for a more splendid development of the different specimens, both native and exotic. The gardenesque quest was informed, on the one hand, by his admiration of plants as living things of beautiful expression, as well as from the conviction that landscape gardening should not be an imitative art that used nature's arrangements as fundamental models, as both the pastoral and the picturesque were thought to be. He suggested that natural methods of plant classification could serve as a basis in laying out plants in the design of pleasure grounds and parks, so that the morphological expressions and similarities between different organisms could be easily understood. The better understanding of the physical needs of the different species would also lead the creation of new sequences of planting where each specimen would find the conditions for its growth to perfection.

He was proposing a freer imitation of nature than that proposed by the English gardening to the date. His sequences would follow an explicit endeavor, where natives would be blended with exotics, providing sites with a higher variety of plants and with planting arrangements purposely structured, sometimes in accordance to what he referred to as the mingled planting manner, sometimes in accordance to the

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[41] Ibid, 302.

[42] John Claudius Loudon, *The Gardener's Magazine* 7, (1832), 701.

grouped manner (*Figures 5.12 and 5.13*).[43] He worked in the proposition of a comprehensive theory of gardening, that would provide systematic principles to be followed in any part of the world, no matter what the available species were. In a context of increasing botanic knowledge and increasing range of species available, the exploration of the ornamental and aesthetic capacities of gardening as informed by scientific principles became an imperative for some landscape designers. Therefore, he somewhat abandoned the predominant naturalistic contours and green tonalities of the preceding picturesque landscape, in favor, on the one hand, of more formal or geometric layouts that showed a wide variety of colors and textures. If the picturesque had been the culmination of a continuous movement away from the artificial disfigurement of the plant specimen in the *jardin à la française*, and towards the inherent intricacy of nature as fundamental aesthetic canon, Loudon was arguing with his proposition of the gardenesque, and, more generally, with his abundant discussions around the specific aesthetic effects of different plant arrangements, an exploration of the accurate morphological expression of plants in landscape gardening. His work, heavily influenced by the tenets of the natural methods of classification developed by the late eighteenth and early nineteenth century botanists, constitutes a particularly illustrative expressions of how landscape architecture has historically internalized and help advance conversations around discreteness and continuity in the natural order.

Ethnography and Ecology in Botany. Mosbach and Bordeaux Botanic Garden

As a landscape architecture type, the botanic garden has incorporated a multitude of ambitions in the twenty-first century, transcending the concerns about plant collection and classification that characterized the period following the age of explorations. Although questions of taxonomy remain at the core of botany, and although they continue to be important in the establishment of the program of a botanic garden in the twenty-first century, there is also a growing interest today in fostering stronger connections with the general public, in order to provide information relating to environmental issues and to the different values around which the relationships between humans and the botanic world have been

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[43] John Claudius Loudon, *An Encyclopaedia of Gardening* (London: Longman, Hurst, Rees, Orme, Brown and Green, 1822), 804-7.

constructed over history. In this last section of chapter 5, I shall discuss the botanic garden at the city of Bordeaux, by the French landscape architect Catherine Mosbach, where a variety of these ambitions are represented.

The botanic garden at Bordeaux is part of a larger municipal project of redevelopment of the right bank of the Garonne river (*Figure 5.14*). Contrary to the more urban and consolidated left side of the river, the right bank has been immersed since the late twentieth century in a process of postindustrial reconversion, for which the botanic garden was thought of as an opportunity to compose a new local centrality. The garden, built between 1999 and 2007, was assigned an elongated and narrow plot by Dominique Perrault's local masterplan for La Bastide, which follows the morphology of systems of land subdivision often found in areas immediately next to river courses. Six hundred meters long and only one hundred meters wide, adjacent to the river on one of its extremes, the garden takes this morphological constraint as an opportunity exploit the permeability of its long urban interface in contact with new office and residential buildings, and define the structure of the garden as a sequence of galleries that extends perpendicularly to the water. In the internal organization of these galleries, but also in the overall structure that formulates their sequence, there is an attention towards the scientific and research objectives intrinsic to any botanical garden, but there is also the ambition to establish a strong public and educational program that incorporates the garden into the network of public green spaces of the city differently from the modern period examples already accounted for in this chapter.

The sequence of main spaces of the garden begins at the area closest to the Garonne river, in the so-called *jardin aquatique*. Here, a mosaic of pools serves to grow various kinds of aquatic vegetation, and constitutes the point of departure of the exhibition, for aquatics was the first form of plant life that appeared on earth. The second stage in the sequence is the *galerie des milieux*, or "gallery of the environments," which shows a variety of natural landscapes found across the Aquitaine basin in southwestern France, in which the city of Bordeaux sits. The next major area in the garden is the *champs de culture*, or "fields of culture," where the visitor gets acquainted with the different uses that plants have developed as they have been cultivated by humans over history. The sequence ends in the area that is further from the river, where species that are not suited to Bordeaux's climate are cultivated in a set of greenhouses, with particular emphasis on plants from the Mediterranean region.[44] There is also an arboretum, which is broadly distributed across the whole space of the garden, and other minor events situated on the flanks of this central sequence in the garden, such as the vertical gardens, where a collection of climbing plants is cultivated to raise awareness about the diversity of plant morphologies and the allée of pioneers, an old and denuded oak wooden fence, 450 meters long, recovered after a storm in 1999, which is being progressively colonized by lichens, ferns, and sedums growing under the shade of nearby trees. But the general discourse offered by the structure of the four central sectors is primarily educational, consisting of a spatial reading of a botanic timeline, which departs with the exhibition of early plant life kinds such as hydrophytes—plants that grow in water—and helophytes—plants that grow in marshy environments—to then enter into the plants' conquest of the land in the form of a set of "natural" formations, then progress to the domestication of plants for a multitude of different cultural purposes, and culminate in a glimpse of the potential "mediterranization" of the Aquitaine as a epiphenomenon of global warming.

Besides the more scientific pursuit of the classic botanic garden, that is, the incorporation of a wide collection of plants as a means to recognize, investigate, appreciate, and preserve the diversity of the botanic world, the design puts the emphasis on the educational potential of botanic gardens in the twenty-first century. In order to bolster this vocation, Mosbach proposes two additional programs in the garden: the ethnobotanic, in the *champs de culture* or "fields of culture," and the ecological, in the *galerie des milieux* or "gallery of environments."[45] Through the *champs de culture*, the garden is conceived as an ethnobotanical demonstration, that is, as an exercise in representing the different social roles that the kingdom of plants has developed across the different cultures of the world and over centuries of cultivation. The *champs de culture* follow, in the manner of Leiden's botanic garden, a regular

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[44] See the statement about the promotion of biodiversity at the Jardin Botanique de Bordeaux website. "Dans les Jardins," Jardin Botanique Bordeaux, accessed March 25, 2018, https://jardin-botanique-bordeaux.fr/promouvoir-diversite/dans-jardins/jardin-botanique-bastide.

[45] Catherine Mosbach, "Le Nouveau Jardin Botanique de Bordeaux," in *Anthos* 42, no. 1 (2003), 19-23.

organizational framework made of long, straight, and narrow *pulvilli* or planting beds (*Figure 5.15*). Despite their small size—they have widths that vary between 7 and 4 meters, and lengths between 20 and 12 meters, approximately—and as a way to bolster the cultural dimension of the world of plants in this section of the garden, these planting beds are labored through the traditional technique of ridges and furrows, as if they were actual agricultural fields. The elongated shapes of the fields, their linear combination, and the direction of the furrows, all together, exaggerate the overall site's length, and seek the optical effect of creating a real agricultural landscape. As in agricultural fields, the plots serve as permanent canvas for the growth of temporary crops. And, since crops are in continuous transition, each planting bed is provided with an adjacent and independent water reservoir for irrigation, which allows for maximum control of soil moisture towards the growth a maximum variety of species.

Following the ethnobotanic program of the garden, the rotating collection that is exhibited on the 44 different planting beds is not organized in accordance to the morphological expression of species in the collection, but rather in accordance with the social values that plants have acquired over time. In this sense, among other categories and subcategories, the collection presents edible plants (oils, mints, berries, vines, grapes, leafy vegetables, cereals, sugar plants, plants for the production of alcoholic beverages), ornamental plants (flowered legumes, aromatic plants, or simply assortments of flowers), medicinal plants (allergenic plants, conifers, essential oils), toxic plants, plants that are useful in various ways (dyeing plants, textile plants, basketry plants, and agrofuels), and other stand-alone chapters, such as plants that move rapidly, horsetails and fossil rocks, pioneer species, bulbs, bamboos, and so on. Each of the planting beds is monographically dedicated to a different subcategory and, therefore, the garden offers spaces which display, for example, a collection of textiles, such as mulberry (*morus alba)*, cotton (*gossypium hirsutum*), or teasels (*dipsacus*)—anciently used as comb for raising the nap on fabrics, particularly wool—or plants for production of alcoholic beverages, such as wormwood (*artemisia absinthium*), sugarcane (*saccharum officinarum*) or hop (*hummulus lupulus*), among others.[46] But the regular organizational

[46] This information has been extracted from the documentation available at the at Bordeaux Botanic Garden website. See "Plan Thématique du Champs de Cultures 2015-2016," Jardin Botanique Bordeaux, accessed March 25, 2018, https://jardin-botanique-bordeaux.fr/sites/jardin-botanique-bordeaux.fr/files/upload/plan_des_thematiques_du_champs_de_culture_2015-2016.pdf.

framework serves as armature to overlay, on top of this utilitarian classification of plants, a sensorial classification of the collection, which highlights the senses that are most adequate in the appreciation of the different species.[47] In this sense, the garden features plants that are better sensed by touch and smell, such as mints, lemongrasses, and other aromatics; by ear, such as bamboos and plants that attract and feed birds; or by sight, such as ornamentals, plants that move rapidly, or dyeing plants. In order to favor this experiential aspect of the crops, the fields are flanked by small sitting rooms with benched in the shade under a tree, which is part of the arboretum.

In line with these fields of crops, the aquatic garden, situated right beside the Garonne river, follows a similar logic of discretization of species in accordance with their cultural values, resulting in seven different categories: medicinal, purifying, edible, aromatics, ornamental, captivating, and useful plants in general, for purposes that range from the production of papyrus and ink in antiquity to colorants in today's pastry making.[48] A mosaic of sixty-five small independent pools surrounds a larger body of water, altogether a hectare in area (*Figure 5.16*). The compartmentalization of the aquatic environment allows for independent manipulation of the conditions in each pool, control of parameters, such as the composition and depth of the substrate, and, in some cases, introduction of additional elements, such as protruding rocks. The controlled design of the environmental conditions for the development of the plants serves to unfold on top of this cultural classification of plants, as in the case of the field of culture, an alternative recombination of plants, in this case based on the physiological expression of plants as a response to the conditions of the aquatic medium where they develop. As such, in the aquatic garden, some of the plants, regardless of their utilitarian purpose, flourish between air and water on the protruding rocks; some others rise up from the bottom of the pools, while others float on the water and more yet grow in underwater planters.

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47 Ibid.

48 See "Jardin Aquatique," Jardin Botanique Bordeaux, accessed March 25, 2018, https://jardin-botanique-bordeaux.fr/sites/jardin-botanique-bordeaux.fr/files/upload/film_jardin-aquatique-droite.pdf

In pursuing this multifold reading of the collection, Mosbach stresses the idea of modularity. The establishment of a modular system is a central tenet in the internal organization of both the *champs de culture* and the *jardin aquatique*. Modules put the emphasis on the discrete individuality of each unit but without implying fragmentation: each unit is presented and evolves independently but is also understood as part of a larger whole, and as such is seen in continuity with the forms and rhythms of other units in the garden, the result being a landscape with innumerable possibilities of combination.[49] Modules allow a focus on the content of particular moments and, at the same time, integrate them into larger scales of landscape that transcend the physical limits of the garden and enter the scope of the territorial.[50]

This is the ultimate aspiration of the *galerie des milieux* or "gallery of environments," where the controlled reproduction of different environmental conditions turns the garden into a synecdoche that seeks to represent the whole Aquitaine basin in southwestern France. In the *galerie des milieux*, eleven natural landscapes are reconstituted above ground, on their geological base, as emerging "promontories." The five *milieux* to the north represent the landscapes of the right bank of the Garonne—the wet meadowlands, the pubescent oak forests, the dry meadows, the limestone green fields, and the limestone hills—and the six to the south represent the left bank of the river—the dunes, the dune fixation forests, the dune hinterland forests, the ponds, the dry moors, and the wet moors (*Figure 5.17*).[51] The reconstruction of these landscapes is produced exclusively by using natural substrates, derived as synthesis from a series of surveillance campaigns carried out in these different environmental categories. And the exposure of these substrates offer, on the one hand, an understanding of the geomorphology and the stratigraphy of the regions, and, on the other, and more importantly, an understanding of the interrelationships that exist between plants, soils, and subsoils—an understanding of how the composition of the abiotic components

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49 Mosbach, "Le Nouveau Jardin Botanique de Bordeaux."

50 Ibid.

51 See "La Galerie del Milieux," Jardin Botanique Bordeaux, accessed March 25, 2018, https://jardin-botanique-bordeaux.fr/promouvoir-diversite/dans-jardins/jardin-botanique-bastide/partie-exterieure/galerie-milieux.

of the physical environment determine, to a great extent, the vegetal formations that are perceived on the face of the land (*Figure 5.18*).[52]

Part of the scientific program of the garden, these galleries are intended for researchers to study the development of ecological processes. As such, they are subject to scientific monitoring and periodic botanic inventories, but the overall management regime is kept at a minimum, so that the plant communities develop along successional processes with no major human intervention. With clear resonances with Derborence Island, the inaccessible and unmaintained structure that Gilles Clement completed in the Henri Matisse Park in Lille in 1995, the environmental galleries produce a very powerful visual effect on the urban environment, as if fragments of the Aquitaine landscape had been actually cut out and deposited on the gravel. Each of these plinths unfolds independently, and each constitutes an individuality, an island with its own internal processes. But following, however, Mosbach's idea of modularity, as in the other sectors of the garden just discussed, their individuality is not at odds with the possibility of reading these landscapes in continuity with each other (*Figure 5.19*). The design proposes a set of different criteria that allow a construction of these continuities. The five galleries to the right of the Garonne, in this sense, are arranged according to a twofold progression, that of geological time, from the Secondary period of the limestone hills to the Quaternary wet meadows, on the one hand, and that of the evolution of the vegetal formations, from the absence of soil to the richest soil, on the other. The structural logic of the six galleries to the left of the river all formed during the Quaternary period is a topographic progression that moves inland from the ocean, a section where the gradual disappearance of the sea sand of the dunes gives way to the moors. The different geologic sections share tones and palettes that also allow for these visual interconnections and enhance the unity of the composition.

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[52] Catherine Mosbach, "From Nature to Culture: Bordeaux's Botanical Garden, Catherine Mosbach in conversation with Michel Menu," in *Studies in the History of Gardens & Designed Landscapes* 23, no. 2 (2012), 175-181.

Referred by Mosbach as a cabinet of curiosities, where the natural history items of exhibition are, in this case, the landscapes,[53] the *galerie of milieux* can be certainly regarded as a theater of the surrounding environment, as an ecological microcosm, ecological insofar as it puts the accent, not on the natural objects or phenomena themselves but on the active interrelationships that exist between them, and on the combined forms and evolutionary processes that derive from them (*Figure 5.20*). This position recalls quite neatly the very establishment of the agenda of ecology as a scientific field, where Haeckel had criticized physiology as a biological science for being "incomplete," for being limited to the study of the relationships of the different parts of the organism to each other and to the whole.[54] Physiology had focused, in other words, on internal relationships within the organism, neglecting external relationships between the organism and the environment. In his view, this was problematic, for it was not possible to understand the organism independently from its processes of formation, which, in line with Darwin's recent and groundbreaking theory of evolution, were governed by the adaptive relationships of the organism to its medium. In line with Haeckel's program, the botanic garden at Bordeaux rejects a focus on the study of plants through different frameworks and criteria for internal classification. Instead of being a closed system arranged in accordance to relationships—be they arithmetic or morphological—that exist within the world of plants, the botanic garden at Bordeaux emphasizes the external relationships these plants establish with their physical medium, made of both biotic and abiotic components, as well as on the external relationships established with the world of humans.

[53] Catherine Mosbach, in an interview carried out by Bernadette and Jean-Marie Blanc, as part of a video documentary, "Bordeaux et set paysages", YouTube video, 3:00. Posted by Agora Bordeaux, November 22, 2017, www.youtube.com/watch?v=WaIB2Gz9AhU.

[54] Haeckel, *Generelle Morphologie Der Organismen*, 141.

CHAPTER 6

Transcendence and Immanence

Transcendence and Immanence

In chapter 5 I have shown the parallel progressions that landscape gardening and the still incipient field of ecology followed during the eighteenth and the nineteenth centuries. Botanic systems of classification and the landscape arrangements that gave them support and expression experienced similar shifts from an accent on discreteness in nature to models where nature was seen as a continuum. These shifts had, as I explained in chapters 3 and 4, metaphysical underpinnings. Following a lineage of botanical thinking that emerged in the Middle Ages and that had been influenced by Neoplatonism and Aristotelian essentialism, Linnaeus developed a system of classification in accordance to a widely accepted belief in the distinctiveness of the essences of species. However, as already shown, during the second half of the eighteenth century, attention was progressively turned to the individual organism, and the concept of species lost relevance as the belief that the essences of species did not actually exist began to take hold among naturalists. Essentialism gave way to nominalism. At the core of nominalism was the idea that only individual organisms existed, and the idea that the only thing that the individuals of one species shared was their common name, their shared consideration as members of that one species. The distinctiveness between species was, therefore, not real but an artificial construction.[1]

This discussion between essentialism and nominalism in the development of eighteenth century botany is ultimately a discussion about the acceptance of transcendental sources in the construction of an order. In transcendental habits of mind, such as essentialism, there is a fundamental distinction between the material world or the human experience of it, on the one hand, and the forms, essences (or deities) that explain it, on the other. In nominalism, on the contrary, this distinction is not fundamental or does not exist at all. Applied to botany and ecology, as I have explained, the rejection or disregard of transcendental essences and forms turned the direct observation of particular organisms, with their similarities and variations, into all that was to be considered in the deduction of a natural order.

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[1] I have already referred to David Hull's "The Metaphysics of Evolution" for a more elaborated discussion between essentialism and nominalism in eighteenth century naturalism.

In pursuing its disciplinary project, ecology has also invoked the idea of transcendence in the examination of the relationships between the organism and an environment which is often conceptualized as external to it. Likewise, as part of its efforts to build modes of relation alternative to this idea of external environment, ecology has also called upon the notion of immanence, in opposition to transcendence. From the early twentieth century work of the German biologist Jakob von Uexküll and his idea of *Umwelt*, in which the image of a transcendental environment gave way to environment as an order created by the organism's subjectivity, to more recent discourses in environmental philosophy, where the image of the organism as *placed in* the environment is questioned in favor of the idea that organisms are *continuous with* the environment, transcendental habits of mind have been increasingly criticized in their struggle with immanent conceptions of environment. The predominance of humanism, Cartesianism, and other forms of dualistic thinking in the Western tradition have generally privileged transcendental metaphysics according to which entities exist objectively and detached from their environment. However, the last decades have witnessed the proliferation of alternative views, according to which entities and environment are seen as a continuum, with the distinction between one and the other, inside and outside, not being absolute but only a question of degree.[2]

In the present chapter, I shall use the dialectic between transcendence and immanence as a way to draw analogies between the modes in which ecology looks at the relationship between ecological entities and

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[2] Among these immanent views we find Gregory Bateson's discussion on the relationship between mind, body, and the world as an "ecology of the mind," or Felix Guattari's similar thesis on human subjectivity as a "third ecology." See Gregory Bateson, *Steps to an Ecology of Mind* (Chicago: The University of Chicago Press, 2000 [1972]) and Felix Guattari, *The Three Ecologies*, trans. Ian Pindar and Paul Sutton (New York: Bloomsbury Academic, 2014 [1989]). The relationship between the self and the environment has been also discussed, as I referred to earlier in this work, in the context of environmental aesthetics by Arnold Berleant in *Art and Engagement* (Philadelphia: temple University Press, 1991), and in *The Aesthetics of Environment* (Philadelphia: Temple University Press, 1992). In *Art and Engagement*, Berleant writes:

> environment, then, is no foreign territory surrounding the self. Understanding environment involves recognizing that human life is lived as an integral part of a physical and cultural medium, under conditions through which people and places join together to achieve shape and identity. Within this environmental medium occur the activating forces of mind, eye, hand, climate, and the other processes of nature, along with the perceptual features and structural conditions that engage these forces and evoke their reactions. To grasp environment, every vestige of dualism must be discarded. There is no inside and outside, human being and external world, even in the final reckoning, no discrete self and separate other."

In Berleant, *Art and Engagement*, 12.

the environment, and those in which landscape architecture deals with the influence between the design entity and its context. In line with the general ambition of the dissertation to establish a stronger epistemological bind between landscape architecture and ecology, and advancing the ideas introduced in the proposition of the ecological synthesis of interaction—according to which, I shall remind, no single ecological entity can be understood independently from the environment it is a part of—the chapter draws upon a series of fundamental relational concepts in ecological theory in order to offer an interpretation of landscape architecture that emphasizes part-to-whole relationships.

As a way to begin to ground the question of transcendence versus immanence into the scope of design, the chapter begins with a landscape architecture theory discussion on the idea of context by looking at the two fundamental landscape architecture archetypes—the garden and the clearing—and the very specific relationship to context that they offer, that is, the construction of exceptions against the surrounding medium. As I shall suggest, these exceptions, in accordance with the predominantly dualistic bias of our culture, are generally described transcendentally, through the establishment of an abrupt boundary that secludes the inside of landscape architecture design object from its outside. The chapter will then elaborate on the establishment of a conceptual and formal analogy between the boundedness of landscape archetypes and that of another transcendental metaphor—the biological organism. A comparison between the ecological metaphors of "organism" and "system" is presented as a way to propose a relaxation of the concept of boundary, by which a less dualistic and more dialectical narrative of relations in both ecological theory and landscape architecture is suggested. In this sense, the chapter elaborates on various categories of spatial analysis proposed by Richard Forman in the context of the late twentieth century ecological sub-discipline of landscape ecology. Forman's patch-corridor-matrix spatial model is invoked by virtue of its combination of analytical approaches largely derived from system-based theories of ecology with a rather gestaltic stance towards the landscape that is based on heterogeneity and the perception of difference.

Once these conceptual and formal concepts have been established, they are tested in a discussion on two paradigmatic projects of the incipient stages in the profession of landscape architecture, Central Park in

New York, and the Metropolitan Park System in Boston, where some ecological approaches began to be implicitly formulated. The chapter ends with a translation of these ideas into a contemporary landscape architecture project, the Bordeaux right river bank by the French landscape architect Michel Desvigne, offering a reinterpretation of landscape architecture as system that rejects questions of quantitative performance in order to focus, instead, on qualitative and formal interrelations. An emphasis on immanence is made, so that the project can be read as an entity whose boundary and the internal relations that unfold within, despite their apparently unequivocal and strictly imposed configurations, constitute an expression of the specific relations that the project establishes with its environment.

Bounded Archetypes: The Garden and the Clearing

In his 1999 Raoul Wallenberg Lecture, "Megaform as Urban Landscape," architectural historian Kenneth Frampton ended by citing Vittorio Gregotti, who in 1983 declared, "The origin of architecture is not the primitive hut, but the marking of ground, to establish a cosmic order around the surrounding chaos of nature."[3] Following the Abbé Laugier's theorization of a universal architecture in his 1753 *Essay sur L'Architecture*, Gregotti's suggestion was that the underlying fundamentals of the discipline of architecture are not to be found in the Vitruvian archetype of the primitive hut but, instead, in the demarcation of a portion of the land.[4] In so doing, Gregotti equates the most basic act of architectural creation to that of another archetype, one that is often discussed as being at the origins of landscape architecture—the garden.

The very term "garden" denotes the idea of enclosed space. A quick look at its etymological roots in the English language reveals that it is derived from the Indo-European *gher*, which is shared by many Latin,

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[3] This citation of Vittorio Gregotti can be found in Kenneth Frampton, *Megaform as Urban Landscape: 1999 Raoul Wallenberg Lecture* (Ann Arbor: University of Michigan, 1999), 42.

[4] "Man wishes to make himself a dwelling which covers him without burying him. A few fallen branches in the forest are the suitable material for his design. He chooses four of the strongest that he raises up vertically and disposes in a square. Above them, he places four others horizontally; and on these he raises others which slope and come together at a point on two sides," in Marc-Antoine Laugier, *Essay sur L'Architecture* (Paris, 1753). The famous allegorical engraving of the primitive hut by Charles Eisen illustrated the frontispiece of the second edition of 1755.

Greek, Slavic and Germanic words, each of them with a different meaning, yet all pointing to a sense of bounded space.[5] The early gardens in human history were essentially enclosures, built for different purposes, from defense to privacy, from the productive cultivation of plants to their aesthetic appreciation or both. It was only in more recent times that the term *garden* came to predominantly connote a place for the growth and appreciation plants.

In this sense, two parallel archetypes may be said to actually branch out from this primeval act of boundedness: the walled garden and the forest clearing. Derived from landscape formations that are not the result of human action—the natural oasis and the glade, respectively—both the garden and the clearing are operations that aim at "establishing a cosmic order around the surrounding chaos of nature," to follow Gregotti's words, yet their divergence rests in the different climatological and soil conditions from which they depart. The garden, on the one hand, constitutes a discontinuity of shade and freshness in the hostile openness of the steppe or the desert. The desolate vacuum of the world outside is counterpointed with the control and channelization of water—which allows the growth of plants by providing shade and nourishment in this harsh environment—and with the erection of the walls—which replace the natural horizon with an artificial one intended to create the image of paradise. The clearing, on the other hand, is also a break, a gap, this time, within the surrounding dark wilderness of the forest. As much as the walled garden creates an entity in the emptiness of the desert, the clearing creates a void in the continuous mass of the forest, opening a patch of open sky and light amidst the dark density.[6] In the case of the clearing, the boundary and horizon are not deliberately constructed, but are simply derived from the very act of removal and conformed to the mass of vegetation that begins where the opening ends.

The references in the literature of landscape architecture that discuss either or both the walled garden and the clearing as the two fundamental types that form the basis of a genealogy of landscape architecture are

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[5] J. B. Jackson, "Nearer than Eden," in *The Necessity for Ruins* (Amherst: University of Massachusetts Press, 1980), 20.

[6] Robert Pogue Harrison, *Forests: The Shadow of Civilization* (Chicago: Chicago University Press, 1992).

uncountable.[7] Their condition as archetypes is explicable because of their exceptional character, because of the distinction they produce against the continuous field that surrounds them. The exceptional and distinctive character of the design work against the background of its environment is a critical consideration in landscape architecture, for it helps overcome one of the theoretical dilemmas that the field has dealt with since its beginnings: in landscape architecture, subject, medium, and canvas, are all the landscape. This concurrence puts landscape architecture at the risk of cancelling the distance or autonomy that is premised in the creative fields. Elizabeth Meyer puts it in the form of a question: "How one could design with the materials of nature, in the place of nature, and about the content of nature and not have the result be confused for nature itself."[8] Meyer's concern, formulated in the late twentieth century context of environmental mandates in landscape architecture, is paralleled by others developed during the formative stages of landscape architecture as a conscious discipline. John Claudius Loudon, as I have explained in chapter 5, introduced the word *gardenesque* with the intention to distance the practice of landscape architecture from the English landscape tradition inaugurated with the pastoral and followed by the picturesque, where design results were often considered to look too much like nature. His work in fact constitutes, as Melanie Simo summarized, a response to the French Academician and theorist of typology Quatremère de Quincy, who had excluded the English landscape garden from the realm of the fine arts, or arts of imitation, for it imitated nature by employing nature's own materials—trees, shrubs, flowers, turf, water, and so on—and for aiming in some cases at the very concealment of all artifice.[9] In the foreword to his ample survey of the discipline, *Design on the Land*, American landscape architecture historian Norman Newton offers one answer to this disciplinary dilemma, which echoes the idea of structural distinctiveness of the garden and the clearing, as well as the disclosure of artifice that characterizes the garden:

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[7] Among the recent publications that have dedicated some chapters to these archetypes we find Rob Aben and Saskia de Wit, *The Enclosed Garden: History and Development of the Hortus Conclusus and its Reintroduction into the Present Day Urban Landscape* (Rotterdam: 010 Publishers, 1999), or Christophe Girot, *The Course of Landscape Architecture: A History of our Designs on the Natural World, from Prehistory to the Present* (New York: Thames & Husdon, 2016).

[8] Meyer, "The Post-Earth Day Conundrum," 204.

[9] Simo, *Loudon and the Landscape*, 172.

> If it is to be truly effective and satisfying, space must have a positive character; this means, simply, that the space must appear intended rather than accidental, the conscious product of a purpose rather than the mere by-product of other operations. Positive space never looks like something left over. One of the best sources for positive spatial character is clarity of overall form; this occurs most convincingly when one can readily perceive the boundaries or limits of the space, the vertical planes of masonry or vegetation implied or explicit that contain it. A space thus clearly bounded is felt to have integrity, to be something in and of itself; its form and size are unambiguous.[10]

Just a few lines below, Newton opens the first chapter of the book discussing, among other ancient times' examples of landscape architecture, the walled garden depicted on a painting on the tomb of Amenhotep III, fourteenth century BCE, describing it as an enclosed capsule whose walls would offer vertical shelter against the winds, whose vegetation would offer overhead shelter from the sun, and where a series of pools offered provision of water in an arid environment (*Figure 6.1*).[11]

Leaving aside the primarily symbolic and cosmological approaches to the garden archetype that predominate in the historiography of landscape architecture, I want to emphasize here the idea that the origins of the garden are fundamentally pragmatic, that the garden is, above all, a purposeful transformation of the order found on a particular portion of the land to make it operate in a way that better serves specific demands. Using the example of the ancient garden referred to by Newton, the provision of water on the pools and the construction of both vertical and horizontal shelters, are all the result of the introduction of a radically new order on a land that would otherwise be a desert. The key agent in these ancient gardens was water, and all transformations on the land were oriented to the reorganization of water in order to preserve it and take advantage of its associated effects: slowing down of water flows, redistribution by means of irrigation networks, use of water for the introduction and growth of edible vegetal species, introduction and organization of other species to project shadow over the irrigation network and minimize water evaporation, and so on. All these operations can be aptly described through the framework of the Odums' performative view of systems ecology, for which the environment is saturated with energy flows that can be redirected for different purposes. The wall enclosing the garden

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[10] Norman T. Newton, *Design on the Land: The Development of Landscape Architecture* (Cambridge, Mass.:The Belknap Press of Harvard University Press, 1971), xxiv.

[11] Ibid., 4.

constitutes, in this sense, the architectural membrane, the boundary, that is constructed to preserve the creation of a new order from the environmental energy flows that tend to upset it. It separates, as the skin does on our human organisms, the biophysical regime that rules the processes and relations unfolding on the inside from the one that rules those taking place on the outside (*Figure 6.2*).

We may refer to this ambition of boundaries, so at the core of the history of landscape architecture, through the notion of "islandness." The archetypes of the garden and the clearing address questions of identity and difference through the act of sharply marking the edge between the territory that is under control and the "stormy ocean" of the unknowable beyond.[12] However, this idea of boundedness implied in the notion of islandness might not be understood as a secluding boundary condition that creates a dichotomy between figure and ground, that is, between the thing-in-itself and its constitutive other. Following literary critic Marc Shell, the idea of islandness might be better seen through the dialectics established by the etymological roots of the word "island." "Island," in English, is derived, on the one hand, from the Latin *insula*, which brings the meaning that we are more familiar with, that of the "land surrounded and isolated by water." Through the *insula*, the work of landscape architecture is to emphasize the establishment of a positive space, following Gregotti and Newton, on the separation or "cutting off" of the work of landscape architecture from the surrounding chaos. The second meaning, less common and in apparent disagreement with the one just described, comes from the Norse word for "water-land," and stresses, quite explicitly, "the situation where land and water mix."[13] Using this idea of "water-land," which refers to the ambiguous moment where both elements are blended—as in tidal zones, marshlands, bogs, or mud—the islandness of the garden and the clearing implies that there is no clear differentiation between the work of design and the landscape around it.

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[12] See Immanuel Kant, "Of the Ground of the Division of All Objects into Phenomena and Noumena," in *Critique of Pure Reason*, trans. F. Max Müller (London: Macmillan, 1881), A235/B294; and Friedrich Nietzsche, *The Gay Science*, ed. Bernard Williams, trans. Josefine Nauckhoff and Adrian Del Caro (Cambridge: Cambridge University Press, 2001), sec. 343.

[13] Marc Shell refers to these two meanings of "island" (one boundary-oriented and the other closer to the idea of the interface, of two worlds happening at once) in his book *Islandology* (Stanford, CA: Stanford University Press, 2014). See, in particular, the chapter "Defining Islands and Isolating Definitions," 13–25.

If we take, as Marc Shell suggests, both definitions as the thesis and the antithesis of a Hegelian dialectic, then the derived synthesis should conjoin, cancel, and transcend them.[14] Seen through this dialectical lens, the clarity of the overall form of a work of landscape architecture, which provides it with its positive character, to use, again, Newton's words here, should not be merely seen as a boundary condition that marks the sharp distinction between a humanly ordered space and its unruled surrounding environment. Rather, the work of landscape architecture should be seen as a thing-in-itself, with its own ordering principles, but also as an interface through which the environment that lies beyond that order is rendered legible.[15] In this view, the work of landscape architecture shuts itself off from its environment but at the same time also gathers it (*Figure 6.3*). It is then through the garden that we can see the desert; it is through the clearing that the forest is made visible. It is then through this dialectical lens that the synthesis of interaction begins to be realized, that we begin to see the work of landscape architecture as expression of its relationships with the larger environmental system of which it is a part, and the larger environment, conversely, as an expression of its interaction with the work of landscape architecture. In the reconsideration of this dichotomy between environment and the boundedness of the work of landscape architecture, I will argue next, not only the notion of system, but also the organism, both central to the constitution and development of ecology, have played an important role.

Organisms and Systems

The human experience of living in a body that seems to be separated from the environment by a membrane has made of the organism a recursive metaphor from which we can derive insights and extrapolate them across fields.[16] The organism presents two primary characteristics that offer great value

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[14] Marc Shell, "Defining Islands and Isolating Definitions," 18.

[15] This idea of landscape architecture form as interface between itself and the surrounding conditions has been also recently used by Anita Berrizbeitia in "On the Limits of Process: The Case for Precision in Landscape Architecture," in *New Geographies 8: Island* (2016), 111.

[16] Kristina Hill, "Shifting Sites," in *Site Matters: Design Concepts, Histories, and Strategies*, ed. Carol J. Burns and Andrea Kahn (New York: Routledge, 2005), 131-56.

as cognitive devices. On the one hand, an organism is an entity characterized by the strong internal relations that exist between its constituent parts—the organs—for those relations are essential for the functioning of the organism. On the other, the organism is generally understood in opposition to its environment; that is, it has noticeable boundaries that make it identifiable against its space/time background—hence the organism-environment binary formula, which I referred to in the introduction to the chapter. Of the two landscape archetypes discussed in the previous section, the garden can be very aptly equated to the idea of the organism. Not only does the garden present a hard boundary condition—the wall—which establishes a strong differentiation between an inside and an outside, but it can also be explained by means of its internal relations, without which it could not exist as different from its surroundings—organization and maintenance as means to sustain its differentiation.

So powerful is the idea of the organism that it has been able to permeate as a metaphor even the field of ecology, for whose definition and scientific project the organism already constitutes a fundamental concept. As discussed in chapter 3, in the context of the debate between holism and reductionism, according to the early twentieth century ecologist Frederic Clements, entire communities of organisms have specific structures of tight internal relations, which allow us to see these communities as organisms themselves. In the decade of the 1910s, Clements referred to these as "organic entities" that, as such, would arise, grow, mature, and die.[17] In this idea of the "super-organism" was implicit the idea of a conceptual boundary within which the community would develop in accordance to a particular set of climatic and physiographic conditions and in order to carry out its functional relationships towards its climax expression. Looking at the landscape through the Clementsian lens, the conceptual boundaries within which each community developed would be spatially manifested as a pattern conformed by the juxtaposition of different landscape patches, that is, relatively stable and discretely bounded areas. Each patch contains a different ecological super-organism—an organism made of other organisms—with its own set of species, and each patch narrowly abuts the next.[18]

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[17] Clements, *Plant Succession*, 3.

[18] Michael G. Barbour, "Ecological Fragmentation in the Fifties," in *Uncommon Ground: Rethinking the Human Place in Nature*, ed. William Cronon (New York: W. W. Norton & Co, 1995), 233-255.

However, the metaphor of the ecological superorganism had to compete with another powerful image that emerged in the 1930s, which would eventually become the most prevalent paradigm in scientific ecology for several decades—the system. As I explained, the "organismic" tradition that Clements inaugurated in ecology was soon contested by the so-called "individualistic" approach proposed by Henry Gleason, which neglected community associations and emphasized instead the contingent and opportunistic behavior of the individual organism. Elements from both the organismic and the individualistic approaches eventually coalesced in the notion of the "ecosystem," that Eugene and Howard Odum brought to the fore of ecological theory in the 1950s, as part of their work on systems ecology. The ecosystem distanced ecology from biology and moved it closer to physics, and the metaphor of the mechanical or electrical system took prevalence.

The use of both organisms and systems as ecological metaphors had different implications for the study and interpretation of the environment. When transferred from the conceptual to the diagrammatic and the spatial, the emergence of systems thinking also implied new visual codes in order to represent them. The Clementsian notion of the super-organism was influenced, as I have shown, by the tradition of physiography, and it found, accordingly, its ultimate spatial expression in the Cartesian projection of clearly bounded patchwork patterns. Systems ecology, on the other hand, was derived from a systems theory lineage where physics and mathematics had also played an important role, and, as Kristina Hill has remarked, was less dependent on the geographic projections and more reliant on mathematical structures called graphs. The association of these graphs—basically networks of nodes connected by lines—[19] with systems thinking reached its ecological culmination in the work of Howard Odum: the electric-circuit diagrammatic language into which he translated his ideas is perhaps the most exhaustive collection of visual manifestations of systems thinking, and it is largely built upon the visual logic of graphs.[20] No matter what the complexity of the system—of the network—might be, the graph representation of it will

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[19] Hill, "Shifting Sites," 131-56.

[20] See, in this sense, *figure 1.2* and *figure 3.2* in the appendix at the end of this dissertation.

be based exclusively on a combination of pairwise linkages between nodes, organized in accordance to their arrangement and interactions.

Of the theoretical adjustments that the incorporation of the system metaphor brought to ecology, there is one with deep epistemological implications. I am referring to the question of the relaxation of the concept of boundary. From the systems perspective, the functional associations between components are not interpreted as neatly confined within the extents of a distinct boundary, as the organism metaphor suggests. The focus on the tight internal relationships that keep the organism "alive" is counterbalanced, instead, with a higher attention to the exchange with the environment, resulting in a more diversified attention towards the system's both external and internal relationships. In other words, the linkages between nodes that are represented in systems ecology graphs, not only explain the system's internal structure, but also its coupling with the environment. Linkages then blur the system's distinctness, and make of it an open entity, not a closed one, an entity where external processes of exchange and flow are as important as internal ones, and where the boundaries become, necessarily, imprecise.[21]

When compared to the comfortably unequivocal boundedness of the organism, the relaxation of the concept of boundary in systems thinking brought a new set of epistemological questions. If systems are open entities, how can their boundaries be determined? If their boundaries are imprecise, how can systems still be recognized as entities? Is the demarcation of boundaries, in fact, a relevant operation? These questions have percolated, along with the concept of system itself, in the design fields for the past few decades and have influenced, more particularly, the ways in which contemporary landscape architecture looks at the relationship between the design project and the environment. In what follows I shall elaborate on the spatial and design associations of this discussion, by using some of the ideas provided by landscape ecology and, in particular, the work of Richard Forman, and other specific examples of landscape architecture.

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[21] Keller and Golley, "Entities and Process in Ecology," 21-34.

Landscape Patches, Corridors, Boundaries. Forman and Landscape Ecology

Of the numerous disciplinary ramifications of ecology during the second half of the twentieth century, the work of landscape ecology has been concerned with the spatial implications of a multitude of ecological theories derived from other areas of ecology. In such exercise, it has produced its own set of theoretical models, through which it aims to mediate the spatial configuration of the landscape and the ecological processes that take place on it. As I have shown, since the time of Clements and Gleason, ecology described and modeled the complexity and variability observed in the structure and distribution of both biotic and abiotic components of the environment. But it was not until the 1980s, with the wider availability of spatial data and analysis methods, that landscape ecology began to gain relevance with its more explicit focus on the understanding of these configurations through their projection on the Cartesian dimension of regional geography.[22]

Landscape ecology's study of the reciprocal interactions between landscape spatial patterns and ecological processes departs from the simple premise that there is heterogeneity in the landscape. The land is always spatially heterogeneous; it always has structure. Invoking the second law of thermodynamics, according to which entropy can only increase in any closed or isolated system—that is, a system which neither energy nor matter can enter or leave—landscape ecologist Richard Forman reminds us that the Earth itself is after all an open system—that is, it exchanges energy with its environment—and that the heterogeneity that is observed in the landscape is the result of the input of solar energy, which causes an uneven, non-random distribution of conditions over the land.[23]

In the venture of describing and understanding the complex configuration of landscapes, landscape ecology has seen, as systems ecology did, an attractive possibility in the use of graphs. Aiming at

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[22] For a comprehensive review of the development of landscape ecology as a scientific field since the 1980s up to the first years of the 21st century, see Monica G. Turner, "Landscape Ecology: What Is the State of the Science?," in *Annual Review of Ecology, Evolution, and Systematics*, Vol. 36 (2005), 319-44.

[23] Richard T. T. Forman, *Land Mosaics: The Ecology of Landscapes and Regions* (Cambridge, U.K.: Cambridge University Press, 1995).

compiling a catalog of recurrent patterns of interaction between different landscape elements, Margot Cantwell and Richard Forman developed a theoretical method based on graph theory that analyzed the spatial organizations of a multitude of different landscape configurations to then reduce the expression of these organizations to the nodes and connecting lines of a graph (*Figure 6.4*).[24] In this model, nodes represent landscape elements, and linkages between them represent common boundaries and points of adjacency where different elements meet. The structures produced by the graphs are indifferent to the geographic unfolding of the two dimensional landscape and only describe the topological connectedness that exists between elements.

Much of Richard Forman's efforts have been directed, however, towards the mediation between the abstraction of systems and graphs, on the one hand, and the more empiric physiographic perception of landscapes, on the other. In so doing, he has elaborated a simple spatial language based on the patch-corridor-matrix triad (*Figure 6.5*).[25] The model is built on the gestaltic premise that, when seen from above, the spatial heterogeneity of landscapes is of a kind that might be described as a mosaic, that is, a two-dimensional pattern composed of different aggregated elements, forming rather distinct boundaries.[26] The surface of the land is reduced to an Euclidean plane. If we pick any point in the landscape, Forman tells us, we see that it is always either within a patch, a corridor, or a background matrix.[27] A patch, a notion that I already alluded to when describing Clements' super-organism, is defined by Forman as a "relatively homogeneous nonlinear area that differs from its surroundings," which results from the aggregation of similar elements in the mosaic.[28] A corridor is, as much as the patch is, an area that can be recognized by virtue of its relative homogeneity but which, compared to the patch, is rather linear. For the

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[24] Margot D. Cantwell and Richard T. T. Forman, "Landscape Graphs: Ecological Modeling with Graph Theory to Detect Configurations Common to Diverse Landscapes," *Landscape Ecology* 8, no. 4 (1993), 239-255.

[25] Forman, *Land Mosaics*, 5.

[26] Ibid., 4.

[27] Ibid., 6.

[28] Ibid., 39.

matrix, Forman does not provide a very positive definition but mainly keeps it, instead, as the background in the mosaic, that is, as the constitutive other against which patches and corridors are perceived as such.[29]

With the patch-corridor-matrix model, landscape ecology challenges the dissolution of boundaries suggested by the notion of system, and brings the notion of boundary again to the fore. The patch-corridor-matrix model is founded on the principle that all three elements actually exist because there are relatively distinct boundaries that mark differences between patches, corridors, and their surrounding matrix. The sharpness of these boundaries may vary, but in many cases they can be outlined with some degree of precision over the surface of the land. And, as with any other shape that can be drawn over the two dimensions of an Euclidean plane, their outlines have morphological properties through which the patches and corridors they demarcate can be described or classified. In this sense, patches can be large or small, elongated or rounded, symmetric or asymmetric, etc;[30] corridors can be wide or narrow, continuous or discontinuous, straight or curvilinear, and so on.[31] Forman consciously chooses simple graphic and textual vocabularies to facilitate communication between the many different agents that intervene in the description and transformation of landscapes, but also, and more importantly, because they serve to describe specific formal conditions that have specific implications in the ecological behavior of landscapes.

Large patches, for example, constitute the main habitat of large vertebrates and therefore are essential for the development of this kind of fauna. They are also more persistent or stable than small patches, and can act as buffers against extinction in the face of an environmental change.[32] They operate as the source of species to be dispersed through the landscape, a process in which small patches across the matrix can play

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[29] Ibid., 38, 39.

[30] Ibid., 43.

[31] Ibid., 148.

[32] This correlation between larger spatial scales and longer durations, sometimes referred to in landscape ecology as the *space-time principle*, is well presented in Dean L. Urban et al., “Landscape Ecology: A Hierarchical Perspective Can Help Scientists Understand Spatial Patterns,” in *BioScience*, 37, no. 2 (Feb., 1987), 119-127.

a key role as stepping stones. Landscape patches with compact forms are more effective in conserving resources, for the areas in the interior are protected from exposure to potentially detrimental pressures on the edge. Conversely, convoluted forms maximize interaction with their surroundings (*Figure 6.6*). Corridors, on the other hand, perform five major ecological functions in landscapes—habitat, conduit, filter, source, and sink—which are largely affected by the structural attributes of the corridor, especially by width and connectivity. Wide and highly connected corridors generally enhance all five different functions when compared to narrower and fewer ones, although the thresholds of impact for each function is to be found at different values of both attributes (*Figure 6.7*).[33]

As with any other epistemological framework, the patch-corridor-matrix model of landscape ecology uses boundaries to circumscribe and thus define. What is more interesting is that not only can the entities defined by the boundaries—patches and corridors—be discussed in formal terms, but so can the very boundaries themselves. The boundary between two adjacent areas can be hard or soft. A hard boundary implies a high contrast between both areas. Turning again, as Forman does, to thermodynamics, hard boundaries and contrast imply low entropy, and are normally the result of a drastic or a recent energetic input—an input that has a human origin, or an input whose consequences have not been blurred yet by the generally “entropizing” tendency of long term non-human environmental forces. Soft boundaries, on the contrary, are more common in landscapes that have been less exposed to human pressures, or in landscapes that have not been subject to recent disturbances. Softness, moreover, can be the result of a gradual transition between two areas, a curvilinear outline, or the result of some sort of patchy interpenetration.[34]

And, again, as with patches and corridors, these formal properties of boundaries can also be analyzed through their ecological implications. Not surprisingly, for example, landscape ecology research has

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[33] In *Land Mosaics*, Forman dedicates more than half of the book to the description and analysis of patches and corridors. These ideas are borrowed from different passages of the book.

[34] *Land Mosaics* also contains a full chapter dedicated to the examination of the different properties of boundaries in landscape ecology, from which many of these examples have been extracted.

revealed that soft boundaries tend to allow a higher degree of species penetration than hard boundaries and, on the contrary, hardness tends to privilege movement along boundaries, rather than across (*Figure 6.8*). Also, the presence of a boundary creates what in landscape ecology is known as the *edge effect*: because the boundary is the moment where two different areas meet, the boundary is also the moment where the different conditions that define each of the two areas also meet. Therefore a higher number of conditions are found in the intermediate zone around the boundary, which is called "edge." It is in the boundary and its surrounding edge, therefore, where different situations in the landscape have the opportunity to engage the otherness that is different from them, and where the terms of those relationships are most critically defined—what is inside, what is left outside, what is allowed to cross.

Boundaries, therefore, enable the conceptual and experiential recognition of entities—patches and corridors—from their background—the matrix—but they also serve to engage this background and to negotiate the terms of the interaction. This functionally exceptional capacity of boundaries has not only served to extrapolate ideas across scales and fields, from the membrane of a cell to the skin of a human being, from the political borders between countries to "the marking of the ground" implicit in any landscape architecture work, but also to interrogate old binaries. American ecologist Steward Pickett and other authors, for example, have discussed the notion of urban ecosystem to reject the dualistic distinction between the "urban" and the abutting "wild," arguing instead that boundaries, flows, and interactions in urban ecosystems can be conceived in the same way they are in any other ecosystem. They define the urban ecosystem as one "in which people live at high densities, or where the built infrastructure covers a large proportion of the land's surface,"[35] and use it to distinguish between two different approaches to urban ecological studies. The first of them, which they consider still the most common at the turn of the twenty-first century, and which they refer to as "ecology in cities," "examines ecological structure and function of habitats or organism within cities."[36] The second one, which they refer to as "ecology of

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[35] In S. T. A. Pickett el al., "Urban Ecological Systems: Linking Terrestrial Ecological, Physical, and Socioeconomic Components of Metropolitan Areas," in *Annual Review of Ecology and Systematics*, Vol. 32 (2001), 129.

[36] Ibid., 130.

cities," "examines entire cities and metropolitan areas from an ecological perspective."[37] With this change in the preposition—ecology *in* cities versus ecology *of* cities—they point to a crucial difference. Ecology *in* the city departs from the premise that "nature" in cities is reduced to the "green" of parks and street trees and focusses on the understanding of the stresses and constraints that urban environments represent for the biota that inhabit them. Ecology *of* the city, on the other hand, calling for a more systemic perspective, suggests that the difference between city and nature is either cancelled or seen as gradual, so that ecological ideas and principles can be extrapolated across all areas of the urban/non-urban spectrum.

This cancellation or relaxation of the constitutive boundary of the urban does not imply, however, the cancellation of all boundaries. Quite the contrary, in fact: it allows an analysis of urbanized environments thought the lens of landscape ecology and its ideas: patches, corridors, boundaries, and landscape heterogeneity. In this sense, I shall use here a few paradigmatic projects from the incipient stages of the profession during the last decades of the nineteenth century, and especially Central Park, in New York, by Frederick Law Olmsted, in partnership with the English architect Calvert Vaux, and the Metropolitan Park System in Boston, driven by Charles Eliot in collaboration with Sylvester Baxter.

The Public Park as Permeable Organism. Olmsted and Central Park

Frederick Law Olmsted, pioneer of landscape architecture in America, began to develop an interest in landscape architecture as part of a promising career as a journalist in his early years. He visited England in 1850, when he was twenty eight years old, and in Liverpool he was impressed by Joseph Paxton's Birkenhead Park, which at that time was a very recent work of landscape architecture and the most relevant example of a still embryonic public parks movement in Britain. In his book *Walks and Talks of an American Farmer in England*, published in London in 1852, Olmsted famously wrote:

> And all this magnificent pleasure-ground is entirely, unreservedly, and for ever the people's own. The poorest British peasant is as free to enjoy it in all its parts the British queen. More than that, the baker of Birkenhead has the pride of an OWNER in it… Is it not a grand good thing?[38]

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[37] Ibid.

[38] Frederick Law Olmsted, *Walks and Talks of an American Farmer in England* (London, 1852), 74-83.

After a preliminary public park experience in Victoria's Park, in London, a few years earlier, Birkenhead Park in Liverpool became the first successful example of landscape architecture to respond to the growing pressure for parks in the industrial towns of Britain (*Figure 6.9*). Following Loudon, Paxton offered a design in Birkenhead that roughly responded to the gardenesque canon in terms of planting design. In other aspects of the project, such as the curvilinearity of the circulation, the undulating topography, and the distribution of water, Paxton did not introduce any major discrepancy with the formal language that had characterized the lineage of private estates design in English gardening since the early eighteenth century. The radical shift in Birkenhead Park is the use of this same vocabulary of landscape architecture in the development of a public space within a highly urbanized context. Whereas the English landscape tradition sought, in many respects, an extension of the pastoral landscape into the space of the private estate, the space of Birkenhead Park constituted, as much as the patch does into the matrix, a fundamental exception against its surrounding environment, in this case, an urban one. The exceptional character of the park within its context is reinforced by the fact that, unlike most private states, the space lacks a mansion, and so, the different landscape elements are not anymore at the service of the scenery around the house; the emphasis is, instead, centripetal, it is on the boundary, on the people that live outside of the park, where the urban fabric is.

In this sense, it is easy to perceive at Birkenhead what landscape ecologists refer to as the "edge effect." The park presents a main peripheral drive that, despite the reversals in its curvature, runs parallel to the outline of the park, which is defined by the surrounding streets. All the space that is confined between both boundaries is reserved for hosting a more intense and specific programmatic agenda than the interior of the park. While the norm in private estates had been to confine the garden design within walls often concealed behind a forested buffer, in the public park the boundary needs to be reconfigured in order to respond to the new terms of relationship between the object of landscape architecture and its surroundings; there is no moment of separation between an inside and an outside anymore but a moment of interaction between two different conditions.

The influence of Birkenhead on Olmsted became evident in Prospect Park, in Brooklyn, in 1866, which shows a very similar circulatory scheme, with a peripheral drive and a transverse road that allows for reconnection to the urban fabric across the park (*Figure 6.10*). However, the boundary edge does not offer, as Birkenhead does, a programmatic characterization that allows the urban environment to permeate beyond the external outline of the park. Instead, Prospect Park vegetates its perimeter quite heavily and seems to maintain a position towards its surroundings that is similar to that of the eighteenth-century English gardening on private estates—one of exclusion. Olmsted's particular attention to the plasticity of glacial landforms in this project, and his larger and often discussed belief in the psychological effects of landscapes that offer an aesthetic experience of "nature," might explain this apparent separation.[39]

Frederick Law Olmsted's first design commission and an exercise in landscape architecture that has been widely commented on, Central Park is worth being revisited here as a paradigmatic example of landscape architecture that, despite the apparently fundamental boundedness of its figure, is essentially continuous with its environment, that of the island of Manhattan and, beyond, the Hudson Valley region. So continuous are Central Park and its environment that, in many respects, the very act of differentiation of Central Park produces at the same time the park itself and its environment. A physically bounded work of landscape architecture, a landscape conceived as organism, it certainly illustrates very aptly many of the ideas that I have been discussing in the previous sections.

Above all, it presents a clear boundary condition that, on one hand, allows easy demarcation of the limits of the park against its background matrix and, on the other, brings the initial focus to the internal relationships that exist within the park rather than to the exchange between park and surroundings (*Figure 6.11*). Central Park also serves as a very representative example of the extrapolation of ecological principles across different moments in the urbanization spectrum, as predicated by Pickett's "ecology *of*

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[39] For a review of Olmsted's estimation on the appearance of landscapes to alter the observer's mental and psychological state see Elizabeth K. Meyer, "Sustaining Beauty. The Performance of Appearance: A Manifesto in Three Parts," in *Journal of Landscape Architecture*, 3, no. 1 (spring 2008), 6-23. In it, Meyer refers to the work of Olmsted's historian Charles Beveridge as a good source to read about Olmsted's theories on the psychological effects of landscapes. More precisely, Charles Beveridge and Paul Rocheleau, *Frederick Law Olmsted: Designing the American Landscape* (New York: Rizzoli, 1995).

the city." In this sense, if we take the patch-corridor-matrix model of landscape ecology, originally developed in the analysis, as I have shown, of non-urban landscapes, and apply it to the urbanized condition of Manhattan, we can interpret the urban grid as a *mosaic*—a two-dimensional pattern made of different elements, be they the individual buildings or the blocks, which form a composition of distinctive boundaries—and Central Park as a *patch*—a relatively homogeneous area that results from the aggregation of similar elements, which is seen in opposition to its surrounding matrix. Lastly, the boundary condition that demarcates the park from the urban fabric around it is a hard one, a very sharply defined condition that stems from the high quality forms of energy that produce the patterns normally found in anthropic environments—in this case a rectangular grid.[40]

The boundaries of Central Park were received rather than produced by the project. They were set by the Commissioners' Plan of 1811, which established the grid that would guide the development of Manhattan. By the mid-nineteenth century, it was already clear that the whole island would be soon fully constructed, and the discussion about the pertinence of reserving some unoccupied lands for the development of park spaces arose.[41] When the lands for Central Park were acquired in 1853, the central portion of the island was still largely undeveloped and, in fact, the soil was disturbed and deforested as a result of the exigencies of port activity. By the time of its completion in 1873, Central Park constituted an immense

[40] As I explained before, in thermodynamic terms, hard boundaries imply low entropy, and are normally the result of a drastic or a recent energetic input—an input that has a human origin, or an input whose consequences have not been blurred yet by the generally "entropizing" action of long term non-human environmental forces. Soft boundaries, on the contrary, are more common in landscapes that have been less exposed to human pressures, or in landscapes that have not been subject to recent disturbances.

[41] Among the strongest advocates of the reserve of lands in Manhattan for parks was the American landscape architecture pioneer Andrew Jackson Downing, who exerted a great influence in the young Olmsted, and the New York poet and journalist William Cullen Bryant who, in 1845, wrote:

> "The population of your city, increasing with such prodigious rapidity; your sultry summers, and the corrupt atmosphere generated in hot and crowded streets, make it a cause for regret that that in laying out New York, no preparation was made, while it was yet practicable, for a range of parks and public gardens… There are yet unoccupied lands on the island which might, I suppose, be procured for the purpose, and which, on account of their rocky and uneven surfaces, might be laid out into surpassingly beautiful pleasure-grounds; but while we are discussing the subject the advancing population of the city is sweeping over them and covering them from our reach."

As quoted in Frederick Law Olmsted, Jr., and Theodora Kimball, *Frederick Law Olmsted* (New York, 1928), 23.

picturesque oasis in the center of a still largely desolated land, as the famous Taylor map of New York shows. Central Park emerged, in this sense, from the bare grounds of the island as an enclosed garden, as a mass of vegetation that counterpointed the barrenness of the world outside through a different regime of organization and maintenance.[42] A paradoxical garden, however, for it soon became also a clearing, by conforming a gap within the continuous mass of the city that circumscribed it, as the Manhattan grid got overfilled during following century (*Figure 6.12*).

But if Central Park is going to respond to the organismic metaphor of the garden, as I have suggested earlier, it should not only do so through clear opposition against its environment, but also by means of the internal relationships between its different components—organs—through which this opposition is actually realized. It is interesting to note, in this sense, that Central Park is so vast a garden that it contains several clearings and gardens within it. Olmsted and Vaux purposely shrank the large size of the park by moving the focus from the whole to its various and smaller components: the Mall, the Reservoir, the Ramble, the Green, the Lake, the Meadow, etc. Taken one by one, each of these elements possess a strong character, but the overall arrangement does not compose an organic and unified idea of a whole. It lacks the unity of the whole that Prospect Park achieved a few years later through the organization of the large open spaces and the treatment of landform. In Central Park, Olmsted's often discussed interest in recuperating a fragment of the idyllic landscape of the Hudson Valley, and his confidence in the restorative effects of the introspective contemplation of a picturesque scene, induced, instead a composition where the different elements are inward-looking: each of them offers a strong character as an individual entity, but does not participate clearly in the composition of an overall scheme.

There are, however, a few moments in the park where the internal relationships between different elements in the composition are carefully established. In this sense, the spatial sequence that begins at the Scholar's Gate, at the confluence of Fifth Avenue and 59th Street and goes all the way to the Ramble is

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[42] John W. Reps referred to Central Park as "an Oasis in the Urban Desert" in his seminal work, *The Making of Urban America: A History of City Planning in the United States* (New York: Princeton Architectural Press, 1965), 331.

remarkable. The edge between the park and the urban fabric around it widens at Scholar's Gate more than at any other point on the perimeter of the park, as Fifth Avenue was already a particularly prominent street of New York at the time the park was commissioned. From there, East Drive serpentines smoothly towards the center of the park, flanked by the sensitive exposure of rock outcroppings that open up strategically to allow views of the Pond below. East Drive climbs slowly to the beginning of the Mall, one of the few straight lines in the whole plan of the park, which runs below the high-arched shady canopy of a double-alley of elm trees, and across the most gardenesque and manicured area of the park. At the end of the Mall lies the grand Bethesda Terrace, which offers a composed view of the Lake and the Ramble, one of the main features of Olmsted and Vaux's vision for the park. The Lake at the foreground allows for the open panorama of the Ramble, which, in opposition to the monumentality of the Mall and the Bethesda Terrace, appears as the most variegated and intricate landscape in the park, planted with a assortment of both native and introduced species, with rocky outcroppings of glacially scarred bedrock, artificial streams of water, and small glades, all features at the service of producing the effect of a patch of wilderness within the urban landscape. As much as the ancient garden archetype seeks to create an exceptional and distinctive character of lushness against the desolate landscape of the desert that extends around it, Central Park produces difference by introducing events of great intricacy, confusion, and lack of maintenance at the core of the rational landscape of the modern metropolis. A difference that has only increased with the course of time, as the regularity of the grid has been projected upward by Midtown skyscrapers that rise behind the trees surrounding the Lake.

The inward character of the various landscape events in Central Park is not effective in constructing an organic whole. But it is this inwardness, precisely, that opens up the park to its surrounding environment. It is through these independent events that the park produces a wide range of experiential and programmatic possibilities that respond to the needs arising from its public condition and the urban context around it. Its hard boundary condition does not foster internal relations that are as strong as one would expect in an organismic logic, but it contributes to the reception of the park as a green object that follows radically different logics than those of its surrounding environment. It is this tension between entity and environment, between these two sets of radically different logics, what creates the rich interaction between the park and its environment. The different elements in the composition of the park are less oriented to functional connections with other elements than they are to conditions that originate beyond its limits. The boundaries of the park as an organism are, in sum, softer than what seems to be suggested by the hardness of their geometry.

Proto-ecological Systems in Landscape Architecture. Eliot and the Boston Metropolitan District

If one of Olmsted's intentions with Central Park was, as I have mentioned, to recreate a fragment of the Hudson Valley landscape as a way to induce positive effects, both physical and psychological, through the experience of nature at the center of the metropolis, in the Metropolitan Park System of Boston the direction of this vector between city and regional landscape was the opposite. It was less about the introduction of a fragment of a natural landscape into the city, than it was about addressing the processes of expansion of the city into the natural landscape. Based on the thesis that, through unprecedentedly expansive and densifying rates of urbanization of the late nineteenth century, cities were going to irremediably encroach on their enclosing territories, a new consciousness about the need to preserve fragments of these territories began to arise. In an article in 1892, centered on the imminent appointment of the Metropolitan Park Commission, the organization that was formed to lead the preservation plan for Boston's park system, the American botanist Charles Sprague Sargent, first director of Harvard University's Arnold Arboretum and editor of the journal *Garden and Forest*, wrote that, twenty five years after Central Park, there was no longer "any need of argument to prove that ample and convenient open spaces for public resort and recreation are essential not only to the pleasure and comfort, but to the physical health and the mental and moral growth of the people."[43] Both Central Park and the Metropolitan Park System shared, in sum, the same conviction. How such an agenda was to unfold beyond the limits of the nineteenth-century compact city was the challenge that this second experience had to confront.

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[43] Charles S. Sargent, "Parks for Growing Cities," in *Garden and Forest: A Journal of Horticulture, Landscape Art and Forestry*, Vol. 5, No. 207 (February 1892), 61.

The two main proponents of the Metropolitan Park System of Boston, the landscape architect Charles Eliot and the newspaper writer Sylvester Baxter, envisioned "a network of open spaces, of varied sizes and shapes that articulate and connect the entire territory."[44] Drawing upon his personal fascination with the science of geology—the then prominent science of modernization and economic growth—[45] Eliot turned to physiography and historical geography as the central narratives in his argumentation for the particular attractiveness of the Boston Basin's landscape—the rock foundation, the glacial rubbish, the fresh water, and the sea—as well as for the establishment of the criteria that should govern the selection of sites for public recreation to be incorporated into the plan.[46] Observed through the lens of geology and physiography, the landscape presented structural logics that collided with the municipal limits brought about by the administrative compartmentalization of the region. Eliot and Baxter's plan for the Metropolitan Park System sought to radically transcend these political boundaries in a new form of metropolitan urbanization based on the cancellation of the distance between human development and those areas considered to be natural (*Figure 6.13*). In so doing, they drastically bolstered the still incipiently civic character of the profession of landscape architecture, expanding its range of scales of intervention, and establishing a new identity for the field that, as I shall prove in the lines that follow, was inherently—if only implicitly—ecological.

It was during the fall of 1892 that the newly established Metropolitan Park Commission visited, with Eliot and Baxter, every potentially valuable landscape site or park within a radius of 10 miles from the State House in Boston.[47] These visits were primarily planned and organized by Eliot who, having spent much

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[44] Anita Berrizbeitia, "Between Deep and Ephemeral Time: Representations of Geology and Temporality in Charles Eliot's Metropolitan Park System, Boston (1892–1893)," in *Studies in the History of Gardens & Designed Landscapes* 34, no. 1 (2014), 38-51.

[45] Berrizbeitia, "Between Deep and Ephemeral Time," 38.

[46] Charles Eliot, *Report to the Board of the Metropolitan Park Commission*, of January 1893. Eliot's report was reproduced in full, with the exception of the photographic illustrations that accompanied the text, diagrams, and maps, in the commemorative volume that his father, Charles William Eliot, president of Harvard University, published in 1902, five years after Charles Eliot's premature death. See Charles William Eliot, *Charles Eliot, Landscape Architect* (Boston, 1902), 386.

[47] Charles William Eliot, *Charles Eliot, Landscape Architect* (Boston, 1902), 381.

of his youth in the outdoors, camping, sailing, and hiking cross-country around Boston, was already fully acquainted with most of the sites that would eventually become part of the Metropolitan Park System. Interestingly enough, it was also in the fall of 1892, in late November, more precisely, when the pioneer of environmentalism, Ellen Swallow Richards, in a grand opening at the Boston Boot and Shoe Club, first used the word "ecology" in North America. Richards referred to ecology as "the science of the conditions of the health and well-being of everyday human life," using the word, in this sense, with a meaning that was very much in line with some of the arguments that were already mainstream among landscape architects by the end of the nineteenth century.[48] It is unlikely that Eliot was familiar with the term "ecology" or its content and, as I explained in earlier chapters of this work, it would still take many decades before ecology began to develop a theoretically and methodologically articulated body. Far from discrediting the ecological value of Eliot's work, however, this serves to actually highlight it, for the Metropolitan Park System of Boston anticipates, with extraordinary audacity and intuition, some of the premises that landscape ecology would come to develop during the last decades of the twentieth century, as part of its establishment as a tool for regional landscape analysis and planning.

In was this vein that, in October 6, 1892, during the course of these trips around the metropolitan region of Boston, Eliot wrote, in a letter to the chairman of the Commission that:

> As I conceive it, the scientific "Park system" for a district such as ours would include—(1) Spaces on the ocean front. (2) As much as possible of the shores and islands of the bay. (3) The courses of the larger tidal estuaries (above their commercial usefulness), because of the value of these courses as pleasant routes to the heart of the city and to the sea. (4) Two or three large areas of wild forest on the outer rim of the inhabited area. (5) Numerous small squares, playgrounds, and parks in the midst of the dense populations.[49]

Eliot identifies, then, a set of five different elements, with different morphological characteristics and functional capacities, all of which need to be incorporated for the collection of reserved spaces to actually

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[48] Robert Dyball and Liesel Carlsson, "Ellen Swallow Richards: Mother of Human Ecology," in *Human Ecology Review* 23, no. 2 (2017), 22. See also Robert Clarke, *Ellen Swallow: The Woman who Founded Ecology* (Chicago: Follett Publishers, 1973). Charles Eliot was acquainted with the Boot and Shoe Club in Boston, and he actually gave at least one talk there, in August of 1892, a few weeks earlier than Richards. See Charles William Eliot, *Charles Eliot, Landscape Architect*, 378.

[49] Charles William Eliot, *Charles Eliot, Landscape Architect* (Boston, 1902), 381.

constitute a system, that is, an interacting group of elements that form a more or less coordinated whole.[50] If we look at Richard Forman's "Land Planning and Management" chapter in the aforementioned 1993 volume *Land Mosaics*, we find extraordinary correspondences between his "Principles in a Generic Plan" and Eliot's Metropolitan Park System (*Figure 6.14*).[51] In the development of what Forman refers to as a *whole* landscape plan, he recognizes four *indispensable patterns* as a top priority: a few large patches of natural vegetation, wide vegetation corridors along major water courses, connectivity for movement of species among the large patches, and heterogeneous bits of nature throughout human-developed areas.[52]

The correspondence between both Forman and Eliot's models is remarkable. First of all, Forman calls for a few large patches of natural vegetation, and Eliot's list for the park system explicitly includes two or three large areas of forest cover. With this demand, Eliot was willing to satisfy the protection of the only two large areas that, by the end of the nineteenth century, remained relatively well preserved in the metropolitan region of Boston, i.e., the Middlesex Fells and the Blue Hills. Still today the largest land reserves in the Boston's area, in Eliot's mind these were to be given priority and, accordingly, were secured by the Metropolitan Park Commission in 1893 as part of its first acquisition package. For Eliot, large areas like these provided a kind of scenery that would otherwise not exist in a metropolitan setting, and participated, as well, in the protection of the purity of the waters—particularly in the case of the Middlesex Fells.[53] Forman, on the other hand, describes these large patches of natural vegetation, as Eliot does, as essential in water quality protection for aquifers and lakes. He also recommends that they are connected to low-order stream networks—such is the case of the Middlesex Fells area—and discusses some additional animal ecology benefits of these large patches, such as their capacity to provide habitat

[50] See chapter 4 of this dissertation, the section called "The Synthesis of Interaction: the part and the whole."

[51] Forman, "Land Planning and Management," in *Land Mosaics*, 436-480.

[52] Ibid., 452.

[53] Eliot, *Charles Eliot*, 398.

for patch interior species and large-home-range vertebrates, or their potential to perform as the source of species dispersing through the matrix.[54]

The second key principle of Forman's generic plan is the provision of vegetation corridors along major water courses, since, he argues, almost any natural resource or human activity depends in some measure on stream and river systems, if present in a landscape.[55] In Eliot's recommendations, we see that point 3 also mentions the need to preserve the courses of the larger estuaries in the region, primarily those of the Mystic River, Charles River, and Neponset River. Following Forman's point, water courses had certainly played an important role in the articulation of the Boston region during the modern age, for they formed a network that allowed for shipment and distribution of goods between the harbor and the hinterland. In his report to the Metropolitan Park Commission, Eliot acknowledges the critical value of streams, insofar as they are infrastructures, for they provide a series of routes leading from the country, through the suburbs, to the heart of the city, and even to the bay or oceanside beyond.[56] But, by turning again to physiography and geology as a way to emphasize the scenic richness of the Boston region—also understood in the complex configuration of its hydrology—he laid an aesthetic layer over the performative one. Eliot understood that acting upon the water streams was to act upon the infrastructural network that explained, to a great extent, the patterns of urbanization of the metropolitan region of Boston. He understood, as well, that a landscape architecture strategy based on the recuperation, widening, and scenic restoration of the spaces around the water streams, would allow the introduction of a new network of promenades, playgrounds, and open spaces for recreation (*Figure 6.15*), which would automatically yield a socially-oriented re-articulation of the whole metropolitan region.[57]

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[54] Forman, *Land Mosaics*, 47.

[55] Ibid., 452.

[56] Eliot, *Charles Eliot*, 395.

[57] Ibid., 395. Additionally, Eliot makes also several considerations about the dangers that flooding and sewage and factory waste pouring into the water streams represented for public health, and about the real state opportunities that the public control and ownership of the banks of the streams could represent for the municipalities.

Forman's third and fourth indispensable components are the connectivity among the large natural patches, and the presence of a heterogeneous bit of nature across the most densely developed human areas.[58] For landscape ecology, the strength of a system is related to the degree of connectivity between its constitutive elements. In this sense, the width and the degree of continuity of landscape corridors is essential. Forman discusses the desirability of having, in any generic plan, wide continuous corridors and large vegetated patches forming a major green network as the best possible mechanism to secure the movement of key species across the landscape, and discusses the presence of clusters of independent patches, close enough to each other so that they can act as stepping stones, as the best alternative to the corridors.[59] Eliot's diagrams of the Boston Metropolitan District reveal that he also sensed this landscape ecology principle of connectivity, which he reinforced by duplicating the just mentioned system of riverine corridors with an additional network of parkways, not necessarily attached to any water route—such as Fellsway's, which served to link the Middlesex Fells to the north with Broadway Park in Somerville. These parkways acted as vectors, allowing, on the one hand, the large green areas on the periphery to percolate the density of the city center and, on the other, to drastically increase the length of the interface between the system of parks and its constitutive urban fabric, facilitating access to the system. Part of this network is, of course, the Emerald Necklace by Olmsted, a landscape system itself, nested within Eliot's, which starts near the Charles River basin at the center of the metropolitan district, and extends southward for almost ten miles in an attempt to connect with the Neponset River and, beyond, with the Blue Hills Reservation—again, one of the only two large patches of natural vegetation in Eliot's plan (*Figure 6.16*). The continuous sequence of large urban parks and parkways that comprise the Emerald Necklace can be read, as much as the larger network of the Metropolitan Park System is, not only through the epistemological lens of Forman's patch-corridor-matrix model, but also through the visual logic of graphs, which, as I explained before, translates landscape configurations into basic

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58 Forman, *Land Mosaics*, 453.

59 Ibid.

mathematical structures made of nodes—the patches, in this case—and the links between nodes—the corridors—as a way to analyze the topological connectedness of the landscape as a whole.[60]

Lastly, Forman's recommendation for the presence of heterogeneous bits of nature in the human-developed areas is also analogous to Eliot's recommendation for the existence of numerous small squares, playgrounds, and parks in the midst of the dense populations. With this network of small spaces, Eliot was drawing upon a claim that had been gaining momentum in North American landscape architecture during the years that followed the completion of Central Park in New York. In his short guide, published in 1873, *Landscape Architecture as Applied to the Wants of the West*, the landscape architect Horace W. S. Cleveland noted that single parks, no matter how large they were, would always be limited to how accessible they were. Using Central Park as an example, he criticized its incapacity to supply the demand for an easily accessible place for pedestrians from the older and more densely populated areas of the city, and suggested, instead, the necessity to think of a series of small parks, anticipating, in almost idealistic terms, what Eliot sought to implement a couple of decades later:

> Let us suppose the central and most important business portion of the city to be surrounded by a series of small parks, connected by broad avenues or boulevards, tastefully planted and adorned with fountains, flower beds and appropriate works of art. Let other portions of the city, appropriated to special branches of business or manufactures, be similarly surrounded and isolated, and from each of these areas, let a series of boulevards radiate on lines diagonal to the general course of the streets, and extend as far as might be desirable, till they merge in other similar avenues, or connect with extensive outlying parks or suburban additions.
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> The effect would be that the inhabitants of every part of the city would find in these small parks and boulevards attractive pleasure grounds immediately accessible to their homes, to which they could resort when the tolls of the day were over…. The beauty and attractive interest of the city in the eyes of visitors and strangers would be incalculably increased by the refreshing variety and superb effect of coming at intervals upon these beautifully verdant areas, and the importance of attaining such a reputation is rarely appreciated as it deserves.
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> […] I am of course aware that this general and incomplete statement of a *system* is liable to criticism, and many serious and perhaps some insuperable obstacles to its detailed execution will present themselves to the practical mind. I shall not enter upon the discussion of these questions. I do not presume even to say that in any case it would be possible to carry out such a design as I have suggested in all its details. My object has been to point out defects in pre-existing systems which cannot be denied, and to suggest principles by which those evils may be averted. How far those principles are capable of practical application, remains to be seen. It is certain that we have

[60] Cantwell and Forman, "Landscape Graphs."

> such an opportunity as no nation ever before enjoyed of testing and developing both the theory and the practice of the art.[61]

As it becomes clear, Charles Eliot and Sylvester Baxter's proposal for the Boston Metropolitan Park System foresaw many of the tenets that Richard Forman and the field of landscape ecology at large formalized during the last decades of the twentieth century. The evident correspondences that exist between these two models makes the Metropolitan Park System also a very illustrative example of what S. T. A. Pickett defined, by the turn of the twenty-first century, as "ecology of the city," that is, the notion that ecological ideas and principles can be extrapolated between the different agents and areas across the urban/non-urban spectrum; certainly, where Forman sees small and heterogeneous patches of vegetation as key in the provision of connectivity and habitat for a wide range of species, Eliot, and Cleveland before him, see them as key in easing people's access to open spaces for various kinds of recreation and aesthetic pleasure. The analogies are not only conceptual, but also formal: Eliot's proposal can be very aptly described through Forman's epistemological framework of the patch-corridor-matrix model and through the visual language of graphs. It is, remarkable how landscape ecology's comprehensive approach to the analysis of regions, regardless of their degree of urbanization, is paralleled and anticipated by the holistic ambition of Eliot's proposal, an ambition that becomes explicit in an extraordinarily visionary move, no other than the presence of the very term "system"—denoting an interacting set of elements that form a coordinated whole—in the title of the proposal. The Metropolitan Park System constitutes, in this sense, a pioneering example of systemic thinking in landscape architecture which precedes, by several decades, the tentative beginnings of both a lineage of systems theory and a lineage of ecological theory that would come to impregnate to the core, as I have shown in previous chapters of this work, the theory and practice of landscape architecture in the turn of the twenty-first century.

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[61] Horace W. S. Cleveland, *Landscape Architecture as Applied to the Wants of the West; with an essay on Forest Planting on the Great Plains* (Chicago: Jansen, McClurg & Co., 1873), 48.

Internal Relations and External Relations: Gradients of Interaction. Desvigne and the Right River Bank at Bordeaux

Eliot and Baxter's proposal for Boston and other subsequent metropolitan park systems at the turn of the twentieth century in North America are among the references that the French landscape architect Michel Desvigne often uses to introduce his work.[62] Desvigne has been working for more than fifteen years now on a set of landscape interventions in the city of Bordeaux, all of which are derived from a general urban strategy, whose general schema shows a remarkable formal resemblance with Eliot and Baxter's, and by which the city sought to formalize a new vision and a set of guidelines to transform its landscape at a large scale. In the present section, I shall discuss one of these interventions, often referred to as the right bank of the Garonne River. Desvigne likes to argue ironically that, when compared to the landscape architecture strategy along the right bank of the Garonne, the design of a large urban park becomes a rather simple exercise of landscape architecture.[63] Desvigne suggests that the large urban park is now well-established landscape architecture typology and that, therefore, large urban parks have become rather normalized commissions, where conditions for implementation are clearly established by the competent public institutions. On the contrary, the right bank of the river at Bordeaux did not have, as most landscape architecture professional works do, any a priori site, program, or assigned budget.[64] And now that a large portion has already been implemented, it begins to be clear that the right river bank at Bordeaux constitutes an example of built work in landscape architecture that is quite difficult to

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[62] Michel Desvigne has referred to the park systems of the nineteenth century in the United States in many occasions, including his April 2013 "Intermediate Natures" lecture at the Harvard Graduate School of Design, and in conversation with Anita Berrizbeitia, in April 2016, at the same venue. Michel Desvigne, "Intermediate Natures," YouTube video, 45:00, of the Daniel Urban Kiley Lecture, on April 10, 2013, at the Harvard University Graduate School of Design. Posted by the Harvard University Graduate School of Design, April 24, 2013, www.youtube.com/watch?v=lHlkLtd6nxw. Accessed on February 8, 2018. Anita Berrizbeitia in conversation with Michel Desvigne, "On the Limits of Process: The Case for Precision in Landscape Architecture," YouTube video, 46:30, of a lecture on April 14, 2016, at the Harvard University Graduate School of Design. Posted by the Harvard University Graduate School of Design, April 19, 2016, www.youtube.com/watch?v=xbXd1iznH7I. Accessed on February 8, 2018. See also Michel Desvigne, in an interview carried out by Bernadette and Jean-Marie Blanc, as part of a video documentary called "Bordeaux et set paysages", YouTube video, 37:00. Posted by Agora Bordeaux, November 22, 2017, www.youtube.com/watch?v=WaIB2Gz9AhU. Accessed on April 5, 2018.

[63] Desvigne, "Intermediate Natures," YouTube video, 44:50.

[64] Berrizbeitia, in conversation with Desvigne, "On the Limits of Process," YouTube video, 49:30.

categorize in typological terms. As was the case with the Metropolitan Park System of Boston, the character of the work did not fit into either the disciplinary orthodoxy or the regulatory frameworks established for landscape architecture interventions on the public sphere.

The project for the right bank of the Garonne river departs from a larger commission, as I have just mentioned, that involved the preparation of a *Charte de Paysages*, a set of landscape guidelines for the city of Bordeaux. Instead of following the standard procedure of establishing a set of regulatory documents for the development of a holistic landscape strategy for the city, the team proposed a method based on the formulation of a set of ten small, quick, and cheap landscape architecture operations, whose implementation could be carried out during the stretch of a year. Each of these operations, which Michel Desvigne refers to as "prototypes," responds to a different urban condition that can be extrapolated to other areas of the city—gardens, plazas, riverfront spaces, parking lots, boulevards, and so on. All together, these prototypes aim at the construction of an empirical pedagogy that allows for the expansion of the value of the landscape guidelines beyond the merely regulatory, and help define a new aesthetic for the urban territory of the city of Bordeaux.[65]

As part of this *Charte de Paysages*, the team began to develop a plan guide for the right bank of the Garonne, which, as explained in the previous chapter in the context of the discussion on Mosbach's botanic garden, flanks the district of La Bastide, immersed since the late twentieth century in a process of postindustrial reconversion. Desvigne suggested the city to reclassify and reserve a large stretch of open land along the river, instead of rebuilding the waterfront with new residential and business buildings.[66] The new open space that has begun to unfold parallel to the river course today provides a large urban area, approximately sixty meters wide, for rambling and recreation. It also constitutes a new urban

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65 See micheldesvignepaysagiste.com/en/bordeaux-charte-des-paysages. Accessed April 5, 2018. See also Michel Desvigne, in "Bordeaux et set paysages", YouTube video, 37:00. Posted by Agora Bordeaux, November 22, 2017, www.youtube.com/watch?v=WaIB2Gz9AhU. Accessed on April 5, 2018.

66 Michel Desvigne, "Intermediate Natures," YouTube video, 44:00.

horizon to be looked at from the more consolidated and also recently refurbished left bank,[67] and a new vast geographic continuity that resembles those previously produced by the agricultural and infrastructural pasts of this side of the river (*Figure 6.17*). The plan also seeks to project this spatial continuity into the adjacent neighborhood and beyond, towards the green spaces that cover the slopes of a hilly extension further east. A new set of green corridors is projected to extend perpendicularly to the river course, and to percolate the adjacent urban fabric through the tactical appropriation of some of the new vacant spaces that result from the gradual dismantlement of the warehouses and other industrial vestiges. As they become available, the city progressively purchases and reclassifies some of these parcels, the resulting urban landscape being one of open green strips of land that help to perpetuate and visually emphasize, as with the case of Mosbach's botanic garden, the elongated and narrow landscape morphology received from the original system of land subdivision that characterized this riverine agricultural environment.

The strategy on the right bank of the Garonne seems to branch out, then, into a series of tactical operations. Instead of adopting a top-down master plan formula, which anticipates or proposes long-term trends of development and defines the rules that ensure their holistic realization, Desvigne's plan follows a more individualistic—to use Gleason's language—[68] and open-ended developmental plan. The project welcomes the relatively uncertain process by which small fragments of land will be progressively vacated and potentially appropriated. It is, in this sense, a tactical and contingent, an individualistic and open-ended project. But one that, in so being, does not relinquish the specification of the design outcome to external and abstract forces. Unprecedented contractual formulas were established in the preliminary stages of the commission in order to ensure that a constant dialogue between the landscape architect and the competent public institutions, and to furthermore ensure, in sum, that a continuous and intense curatorial plan would take place. For a project that, initially, has no specific site, no budget, and no

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[67] Michel Desvigne, *Intermediate Natures: The Landscapes of Michel Desvigne* (Basel: Birkhäuser, 2009), 49.

[68] Gleason, "The Individualistic Concept."

program,[69] such managerial framework becomes essential, so that a sequence of coherent stages can be progressively worked out and implemented. No matter how adaptive, non-prescriptive, and open-ended the sequence itself might be, each of the phases by which it unfolds needs to be specific, desirable, and coherent, if the project is to succeed.

Here is where the concept of the prototype becomes key. As part of the general *Charte de Paysages* for the city of Bordeaux, the strategy for the Garonne right bank begins with the definition and implementation of a prototype, in the form of a quick, small, and cheap operation of landscape architecture, able to be implemented across a set of different locations, which is intended to empirically help develop a new urban landscape aesthetic for the city. The prototype Desvigne proposed for the river bank is, roughly, an open green space, rather unclassifiable in landscape architecture typological terms, produced by the combination of three different kinds of landscape conditions, namely, areas planted with trees, areas planted with grasses, and areas paved with hard surfaces for pedestrian circulation (*Figure 6.18*). As land becomes progressively available along the river bank, the prototype begins to propagate, producing a landscape condition that could be described as an irregular and *staccato*-like succession of clearings, which serve as public spaces for recreation and contemplation, and bosques, densely planted with long and precise rows of trees, perpendicular to the river's directrix. The prototypical genesis of the project is evident in the marked contrast resulting from the juxtaposition of the irregular, opportunistic, loose, and open-ended strategy that guides the overall plan, and the extremely strict generative principles that prescribe the internal structure of each of its elements, that is, of each prototype.

Among the premises established by the prototypes we find, for example, that bosques need to be elongated, and even unrestrictedly deep, along the axis perpendicular to the river, but always narrow on the parallel one—they are rarely wider than six rows of trees, and in some cases they consist of one single row. As the bosques' constitutive other, the clearings necessarily follow similar scales and proportions: they are generally wider than the bosques to allow a flexible programmatic agenda, but in most cases they

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[69] Berrizbeitia, in conversation with Desvigne, "On the Limits of Process," YouTube video, 48:30.

are also long and narrow. In some areas, those more strictly dedicated to circulation, the clearings are finished in hard and durable surfaces, but the ground is otherwise covered by a continuous mixture of grasses that extends indifferently across clearings and bosques. To facilitate social occupation, grasses are generally mowed in the larger open spaces. More tactical mowing is also carried out in some of the thinnest clearings, and even along the rows of trees within the bosques, as a way to open narrow paths of secondary circulation in direct contact with the trees. In any other case, grasses are left to grow unrestrainedly, the result being a landscape of a rather rustic aesthetic.

The planting template for the trees conforming the bosques—primarily poplars—follows an extraordinarily strict geometric order, that of an orthogonal, regular, and dense grid. The distinctively dense architecture of the grid responds to two different ambitions, both equally tactical. The small module intensifies, on the one hand, the planting pattern, allowing to create dense vegetal masses since the day of implementation, a condition that is essential for Desvigne, for these large masses are effective in providing, in the absence of grown mature trees, some of the visual and microclimatic conditions desirable in a green public space—even if only a small fraction of the long-term plan is realized at a time.[70] The small modularity also allows, on the other hand, to better respond to the spatial contingencies anticipated by an opportunistic overall strategy that seeks to permeate, virtually, any plot of land or interstice that becomes available, however small it is (*Figure 6.19*).

From this set of premises we might begin to conceive the prototype as a system. As I explained in chapter 4, a system is an interacting group of elements that form a more or less coordinated whole, which, in turn, might be a constitutive part of a larger whole.[71] Following this definition, it becomes clear that the prototype is a system in itself, for it consists of a series of elements that are integrated into some sort of unified structure, but it is also part of a larger system, that of the developmental framework proposed for the Bordeaux river bank, which is produced by the loosely coordinated replication and propagation of the

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[70] Michel Desvigne, "Intermediate Natures," YouTube video, 46:30.

[71] See chapter 4 of this dissertation, the section called "The Synthesis of Interaction: the part and the whole."

prototype. The reason why the prototype can be conceived as a system is because its independent elements—trees, bosques, clearings, hard surfaces, grown and mowed grasses—are certainly coordinated, and this coordination arises from, precisely, the geometric and arithmetic rules just described. This set of rules, however, focuses strictly on the definition of the relationships that need to be established between the components of the prototype; that is, they focus strictly on the internal relations of the system. All together, these rules compose some sort of syntax, that is, an investigation of the prototype's patterns of formation out of its constitutive elements. They define, then, local conditions. They do not define the principles through which the prototype is to propagate along the larger scale of the river bank; that is, they do not define the external relations between different prototypes.

In defining the rules of propagation of the prototype along the river bank, Desvigne turns to a totally different referential framework, that of the patterns of land subdivision received from the context. As the French philosopher Gilles Tiberghien—who has studied the work of Michel Desvigne since the very early *Jardins Élémentaires* speculative project of the mid-1980s—puts it, in Desvigne's work, form does not take precedence.[72] Desvigne, Tiberghien suggests, is a semiologist and an interpreter: he knows how to read the signs of the landscape and how to decipher and interpret them.[73] In looking at landscapes, Desvigne aims at deducing the geomorphological, historical, and technical processes and constraints through which the landscape receives its forms. Desvigne's notion of form is therefore temporal and active—a notion of form that is close to the Goethean idea of morphology I referred to in chapter 4, to the idea that *form* can only be understood through *change*, through the processes by which it came to be.[74] Desvigne's work emphasizes an idea of landscape as immersed in a continuous process of *transformation* —"time-form," as Ronald Brady put it—[75] and participates in that transformation, by giving legibility to the transformative process itself. As Tiberghien explains, in Desvigne "the drawing plays a role that is at

[72] Gilles Tiberghien, "A Landscape Deferred," in Desvigne, *Intermediate Natures*, 151-157.

[73] Ibid.

[74] See chapter 4 of this dissertation, the section called "The Synthesis of Conjunction: the one and the many."

[75] Brady, "Form and Cause."

once descriptive and analytical—it is an instrument for visibility that makes it possible to understand how a landscape is made. But at the same time, it plays a "constructive" role since, in revealing this role, it creates the very thing that it unveils."[76] The logic of intervention on the river bank retraces the morphology of land subdivision inherited from the agricultural and industrial pasts of the area, projects it, as trees grow, from the planimetric to the volumetric, and repurposes it, in the form of elongated bosques and clearings that parcel out the landscape for new cultural processes to unfold in the future.

It is at this scale of development that the project relinquishes rigidity and embraces adaptability as a way to respond to the indeterminacy of the process by which different plots of land, with the different sizes and forms they inherited from history, become progressively empty and, potentially, incorporated into the proposal as individual fragments that begin to conform a comprehensive schema. Here is where the project unfolds opportunistically and adaptively. Using again Gleason's concept of the individualistic behavior of plants propagating across the landscape, each instance of the prototype will now need to fluctuate and locally respond to the equally fluctuating and contingent conditions of the environment.[77] But it is precisely because of the strict generative principles of the prototype, firmly rooted in the abstract logics of geometry and algebra, that the project is able to accommodate spatial variation while retaining, both at the small scale of the part and the large scale of the whole, a strong sense of formal identity. The right bank of the Garonne offers, in this sense, a notion of form that operates, as Anita Berrizbeitia has explained, at the interface between the exterior conditions that act upon it, and its own autonomy and its possibility of being apprehended as such.[78] It offers a notion of form that synthesizes, on the one hand, the internal logic that rules the structure of the prototype and, on the other, the inherited forms dictating the patterns of propagation of the prototype across the river bank, to produce a landscape aesthetic that is rustic and highly geometric at the same time, by which the project seeks to ultimately internalize the

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[76] Tiberghien, "A Landscape Deferred," 154.

[77] Gleason, "The Individualistic Concept," 8.

[78] Anita Berrizbeitia, "On the Limits of Process: The Case for Precision in Landscape," in *New Geographies 8: Island*, eds. Daniel Daou and Pablo Pérez-Ramos (Cambridge, Mass.: Harvard Graduate School of Design, 2016), 110-117.

environment that extends beyond the Bordeaux metropolitan region, that of the agronomic and silvicultural landscapes of the French countryside.

The Bordeaux right bank, and the work of Michel Desvigne in general, constitutes a clear expression of a modular understanding of landscape as a process of rapidly replicating form, where, as in agricultural landscapes, the recurrence of very specific gestures embedded at local scales creates the possibility that we can apprehend structure at large scale (*Figure 6.20*). The landscape architecture entity that is derived is not a positive one: there is no hard boundary condition that separates an allegedly "positive" designed form from a constitutive other. The distinction between inside and outside is not absolute but only a question of degree, a gradual transition between the proposed intervention and the existing context, which allows for an understanding of the landscape as a continuum. From this viewpoint, landscape architecture entities emerge as abrupt and deliberately induced intensifications in the matrix of interactions that exist between the constituent entities of the environment, so that a new kind of legibility of environment as a socially constructed medium becomes possible. Such an understanding of landscape architecture entities as legible structures yet open and continuous with their environment implies that landscape architecture internalizes, at least to some degree, the environment. Landscape architecture entities engage the environment; they are not *placed in* it but rather *continuous with* it. The environment does not transcend landscape architecture, but is rather immanent within it.

CHAPTER 7

Tension and Equilibrium

Tension and Equilibrium

Chapter 5 and chapter 6 have examined the capacity of landscape architecture to engage ideas of discreteness and continuity and of transcendence and immanence, and have established analogies with the ways in which ecological theory has tackled those same concepts. In this last chapter I shall use landscape architecture design projects and built works to focus more explicitly on notions of process and time, that is, those that lie at the core of what I have referred to in chapter 4 as the synthesis of becoming. The discussion will revolve around the dialectical relationships that exist between the concepts of "tension" and "equilibrium."

The chapter departs from the idea of equilibrium as the state of a system where no further change is likely to occur. This notion of equilibrium—used, as we have seen, by Clements—is borrowed from thermodynamics, the branch of physics that arose as the study of energy and its capacity to do work, and for which a system is in equilibrium when the energy originally available has been already dissipated or has exerted all its potential to do work. I revise different ecological approaches to the notion of equilibrium and discuss the influence that thermodynamics had in ecological theory during the twentieth century, to then also develop an explanation of some of the concepts—entropy, order, disorder, dissipation, creativity, destruction, and process, among others—that emerged around the notion of equilibrium as thermodynamics transcended, in the mid nineteenth century, its original boundaries within the scope of technology and incorporated cosmological implications.

In so doing, in this chapter I emphasize the idea that every work of landscape architecture demands and constitutes in itself an input of energy, and that, therefore, every work of landscape architecture implies a change in the existing order of a site, be it in equilibrium, or not. Looking at both productive landscapes and examples of landscape architecture I argue that no matter what the site conditions are, landscape architecture has the capacity to change existing orders into new ones, and that for these new orders to persist (to be maintained), a continuous input of energy (of maintenance) is often necessary; otherwise the landscape will eventually move back to a zone that is closer to equilibrium—to an order that offers higher resistance to be changed.

Through the figures of Ian McHarg and Lawrence Halprin, the two major exponents of landscape architecture during the central years of the rise of environmentalism and of the irruption of ecology into the cultural spheres, I shall explain some of the different theoretical approaches that 1960s landscape architecture adopted when dealing with equilibrium and some of its associated concepts. I then turn to a discussion on agronomic and productive landscapes to elaborate on the formal and managerial implications of the transformation of found orders into designed ones. Towards the end of the chapter, I focus on a series of contemporary practices, including the New York based landscape architecture firm Scape, led by Kate Orff, the work of the Spanish agronomic engineer Teresa Galí-Izard, and that of the Swiss landscape architect Georges Descombes. More particularly, I discuss the "Living Breakwaters" competition project by Scape as an example of designed landscape that works at the same time with processes of energy accumulation and dissipation before I turn to a discussion of Teresa Galí-Izard's Central Park in Valencia, Spain, as a project of extremely intense management regimes that results in a landscape condition continuously far from equilibrium. I conclude with a provocative exercise by Georges Descombes for the re-naturalization of the river Aire, near Geneva, where the absence of any sort of maintenance in a landscape of artificially induced tension becomes a celebration of the processes by which new forms of landscape equilibrium are achieved.

Thermodynamic Equilibrium and Ecological Equilibrium

In chapter 4, when examining the notions of homeostasis and stochasticity in the theory of ecology, I discussed how, in the hands of Eugene and Howard Odum, the ecosystem became the fundamental unit of ecological inquiry. I also explained how the Odums borrowed the ecosystem from Arthur Tansley, who proposed the concept in 1935 as part of his efforts to move ecology apart from the life sciences and bring it closer to the mechanical and materialist tradition of physics. The Odums, and before them Raymond Lindeman, used the ecosystem to translate Charles Elton's functionalist notions of food chain and trophic levels into an image of environment characterized by flows of energy across and within ecosystems. I have also explained how, according to the Odums' systems ecology, ecosystems were supposed to follow a strategy of development whose final stage would be a state of balance, a closing state of equilibrium.

As it becomes clear, the ecosystemic reading of the environment puts at the forefront the concepts of system, energy, and equilibrium. These are also central concepts, as I explained in chapter 3, for the field of thermodynamics, the branch of physics that has been primarily concerned with energy and the capacity to carry out work. Beginning with Tansley's original interest in physics and energy, thermodynamics progressively permeated the field of ecology to the point where thermodynamic principles became a sort of basis for ecosystem theory. I have already alluded to the interest of Eugene and Howard Odum in the work of the biophysicist Alfred Lotka, who had been working in the early twentieth century on the translation of Darwin's theory of natural selection into thermodynamic principles.[1] Lotka's conclusion, which he synthesized in what he called the fourth law of thermodynamics, was that the Darwinian selective principle of evolution favored those species that were able to transform larger quantities of energy available in the environment. Eugene Odum's definition of the strategy of development of the ecosystem shows strong resonances with Lotka's principle, when he suggests that it is "directed toward achieving as large and diverse organic structure as is possible within the limits set by the available energy input and the prevailing physical conditions of existence (soil, water, climate, and so on)."[2] But even stronger are the resonances it had on Howard T. Odum's work, who translated Lotka's principle into his own "maximum power principle," which he stated like this: "During self-organization, system designs develop and prevail that maximize power intake, energy transformation, and those uses that reinforce production and efficiency."[3]

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[1] See Alfred J. Lotka, "Contribution to the Energetics of Evolution," *Proc. Natl. Acad. Sci.*, 8 (1922), 147-151, and "Natural Selection as a Physical Principle," *Proc. Natl. Acad. Sci.*, 8 (1922), 151-154.

[2] Eugene P. Odum, "The Strategy of Ecosystem Development," *Science* 164 (1969), 266.

[3] Howard T. Odum, "Self-Organization and Maximum Empower," in *Maximum Power: The Ideas and Applications of H. T. Odum*, ed. C.A.S. Hall (Colorado: Colorado University Press, 1995).

At the end of these thermodynamically-informed ecological processes of energy dissipation, the Odums found an equally thermodynamically-informed ecological state of balance. The closing state of balance that every undisrupted ecosystem would naturally move towards—an idea that the Odums borrowed almost literally from Clements' notion of *climax*—was a translation into ecological terms of the idea of equilibrium in classical thermodynamics, that is, the attractor that every thermodynamic system inevitably tends to through the mutual and progressive cancellation of the forces at stake. Although there is no single mention of the field of thermodynamics in Clements' book on the theory of plant succession, he describes the process of succession and climax through a notion of equilibrium that clearly draws upon thermodynamics; an equilibrium, in this case, where the tensions between habitat and populations have been dissipated:

> The essence of succession lies in the interaction of three factors, namely, habitat, life-forms, and species, in the progressive development of a formation. In this development, habitat and population act and react upon each other, alternating as cause and effect until a state of *equilibrium* is reached."[4]

In thermodynamics, equilibrium is the internal state of a system where the energy originally available in the system has been already dissipated or has exerted its potential to produce work, so that there are no more flows of matter or energy. In equilibrium, therefore, no more change can occur.[5] In accordance to the second law of thermodynamics, as I shall explain with more detail below, equilibrium acts as an attractor for any given closed system, where potential for work is progressively minimized and entropy is maximized. The passage of a thermodynamic system from any initial state to this final state of equilibrium is a thermodynamic process.

But the kind of equilibrium that Clements' climax or Odum's ecosystems move towards is far from being a state of maximum entropy. As in thermodynamics, ecological equilibrium certainly entails the resistance to further change, but this resistance is not exerted through maximum entropy but, instead, through maximum order. Ecological climax allegedly reaches equilibrium instead through the achievement of high

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[4] Clements, "Concept and Causes of Succession," in *Plant Succession*. Emphasis mine.

[5] In physics, energy is the property of a system that accounts for the capacity of that system to perform work. Work is defined as the capacity of a system to impact and have an effect on its environment.

levels of organization and high levels of complexity. The theories of the plant association and the ecosystem claimed that successional processes would progressively grow organic diversity towards the achievement of higher levels of order. The reason for that is the fundamental openness of ecological systems. Ecological systems are living systems, systems that contain life. If, during the first half of the nineteenth century and for the first time in the history of science, Sadi Carnot's theory of thermodynamics introduced the arrow of time in physics, and presented it as an irreversible vector that moved towards lower levels of order, Charles Darwin's theory of natural evolution came to fundamentally challenge this axiom in the second half of the nineteenth century, by suggesting that time was, indeed, an irreversible vector, but one that moved, instead, towards more and more complex organizations.

In 1824, the French military engineer and physicist Sadi Carnot was the first author to use the notion of system with its contemporary mechanistic meaning in his book *Reflections on the Motive Power of Fire*, which is considered the founding text in the field of thermodynamics.[6] In the midst of the Industrial Revolution, Carnot's study was devoted to the improvement of the efficiency of steam engines, which transformed heat into energy—the capacity to do work. The theoretical models developed by Carnot, such as the cycle that is named after him, served to prove that there is a constant loss of heat in any thermodynamic system—such as in the steam engine—and that such dissipated heat has no capacity to produce any mechanical work and the dissipation of that heat was irreversible. Carnot's work set the basis for the work of others scientists, such as the German physicist Rudolf Clausius and the British physicist William Thomson, Lord Kelvin, who grasped the ontological implications that existed in some of the more strictly technological developments of early thermodynamics. They both represent, as the Belgian physicist and major exponent of non-equilibrium thermodynamics Ilya Prigogine notes, a jump from technology to cosmology in thermodynamics.[7] Concepts and principles about the design of efficient machines that were free of frictions and other ways of dissipating energy in the form of heat, acquired a

[6] Sadi Carnot's 1824 book *Reflections on the Motive Power of Fire* is considered the founding text in the field of thermodynamics. It is essentially devoted to the study of the capacity of heat to produce work, and to the efficient use of that capacity. Sadi Carnot, *Réflexions sur la puissance motrice du feu et sur les machines propres à développer cette puissance* (Paris 1824).

[7] Prigogine and Stengers, *Order Out of Chaos*, 115.

new universalizing dimension in the way Clausius and Thomson enunciated them. Clausius was the first to state the first law of thermodynamics, the law of conservation of energy, according to which the total energy of an isolated system is constant: it might be transformed from one form to another, but can be neither created nor destroyed.[8] In 1852, drawing upon previous work by both Carnot and Clausius, Thomson was the first to formulate an even more fundamental principle, the second law of thermodynamics, as "the existence of a *universal tendency* toward the degradation of mechanical energy."[9] Even if the energy on a system is conserved, the capacity of that energy to produce mechanical work is continuously reduced. For the first time in physics, time was interpreted as something more than just a measure against which certain mechanical processes could be measured, as in Newtonian physics. Thermodynamics introduced an idea of time as an actual property of matter, as an irreversible arrow, an inevitable and universal tendency towards homogeneity and death. This tendency was reformulated by the German physicist Rudolf Clausius in 1865 as *entropy*, the physical measure of the ever-increasing degree of degradation of the energy in a given system.[10]

Parallel to the development of classical thermodynamics was the development of the evolutionary conception of life, which Darwin introduced, almost coinciding with Thomson and Clausius' landmark publications, in his *On the Origin of Species*, published in 1859. The theory of evolution came to fundamentally challenge the theory of classical or equilibrium thermodynamics. Evolution, as formulated by Darwin, is far from pointing toward reduced organization and diversity, as the universality of

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[8] Rudolf Clausius, "Ueber die bewegende Kraft der Wärme und die Gesetze, welche sich daraus für die Wärmelehre selbst ableiten lassen," *Annalen der Physik*, 79 (1850), 368–397, 500–524. See English translation, "On the Moving Force of Heat, and the Laws regarding the Nature of Heat itself which are deducible therefrom," *Phil. Mag.,* series 4, no. 2 (1851), 1–21, 102–119.

[9] Thomson's first formulation of the second law of thermodynamics read: "It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects," in William Thomson, "On the Dynamical Theory of Heat, with numerical results deduced from Mr Joule's equivalent of a Thermal Unit, and M. Regnault's Observations on Steam," in *Philosophy Magazine* Vol. 4 No. IV (1852): 13. The formulation quoted in the text belongs to Ilya Prigogine's interpretation of Thomson's work on the second law, and is taken from Prigogine and Stengers, *Order Out of Chaos*, 115.

[10] Rudolf Clausius, *The Mechanical Theory of Heat – with its Applications to the Steam Engine and to Physical Properties of Bodies* (London: John van Voorst, 1856).

Thomson's second law of thermodynamics argued. Evolution proceeds, instead, from the simple to the complex, from the undifferentiated, the degraded, to the differentiated, the elaborated. Evolution could be then interpreted as the very opposite of what the second law of thermodynamics described as the course of the universe.

Who was right, then, Carnot or Darwin? The first answer to this conundrum, which constitutes the very base of modern non-equilibrium thermodynamics, came from the field of biology and, more precisely, from Ludwig von Bertalanffy's systems theory. Bertalanffy suggested that living systems—and landscapes are also living systems for, as Richard Forman reminds us, they contain life—[11] cannot be described by classic thermodynamics, for they are open systems. Open systems, such as living organisms, need, in order to remain alive, a constant flow of matter and energy that comes from their immediate surroundings. "A living organism," suggests Bertalanffy:

> is a system consisting of a large number of different parts, organized in hierarchic order, in which a large number of processes are ordered in such a way that, through their continuous interactions within wide borders, with a continuous change of substances and energies, the system stays, even when disturbed from outside, in its own state, or it builds up that state, or these processes lead to the generation of similar systems.[12]

The dissipation of energy, therefore, does not necessarily imply degradation. Sometimes it drives, instead, to the emergence of order. The possibility of such order is the key of self-organizing beings, that is, those which are able to sustain their form by consuming energy from their surroundings and by exporting entropy to them. As Erwin Schrödinger beautifully put it in *What is Life?* in 1944:

> What is the characteristic feature of life? When is a piece of matter said to be alive? When it goes on 'doing something,' moving, exchanging material with its environment, and so forth, and that for a much longer period than we would expect an inanimate piece of matter to 'keep going' under similar circumstances. When a system that is not alive is isolated or placed in a uniform environment, all motion usually comes to a standstill very soon as a result of various kinds of friction; differences of electric or chemical potential are equalized, substances which tend to form a chemical compound do so; temperature becomes uniform by heat conduction. After that the whole system fades away into a dead, inert lump of matter. A permanent state is reached, in which

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[11] Forman, *Land Mosaics*, 5.

[12] Ludwig von Bertalanffy, *Theoretische Biologie, Band I: Allgemeine Theorie, Physikochemie, Aufbau und Entwicklung des Organismus*. (Berlin: Gebrüder Borntraeger, 1932), 83. Quoted in Manfred Drack, "Ludwig von Bertalanffy's Organismic View on the Theory of Evolution," *Journal of Experimental Zoology* 324, no. 2 (2015): 77-90.

> no observable events occur. The physicist calls this the state of thermodynamical equilibrium, or of 'maximum entropy.'[13]

The processes through which life resists the universal tendency towards degradation implicit in the second law of thermodynamics are called anabolic processes. In anabolic processes, the available of energy is invested in the construction of molecules from smaller units, in the construction of organs and tissues, and in the production of growth and differentiation of cells. And, conversely, the set of processes by which molecules are broken down into smaller pieces, releasing energy, are called catabolic processes. Anabolism and catabolism counteract and power each other in the development of any biological organism.

According to recent ecological theory on complex adaptive systems, ecological systems also unfold in accordance to this tension between anabolism and catabolism, between creative and destructive forces.[14] As I explained in chapter 4 while discussing C. S. Holling's theory of adaptive cycles in ecology, complex adaptive systems follow trajectories that are cyclical, which begin with long periods of transformation and accumulation of available energy—processes analogous to the anabolism of the organism—followed by shorter phases of energy release and reorganization—analogous to the catabolism of the organism.[15] At the end of each period of accumulation, ecological systems (i.e., a mature forest) arrive at forms of complex organization. However, the accumulation of energy that produces these organizations implies a movement of the system far from its zone of equilibrium, so that it presents great potential for a new transformation, and great attraction towards new forms of equilibrium. That potential is executed through the release of the energy accumulated in the complex organization of the system: biomass and nutrients become an easy target for new agents of disturbance—fires, diseases, pests, and so on—that will

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[13] Erwin Schrödinger, *What is Life? The Physical Aspect of the Living Cell* (Cambridge UK: Cambridge University Press, 2014), 69.

[14] For a good account of the engagement between thermodynamics and recent ecological theory, see Eric D. Schneider and James J. Kay, "Complexity and Thermodynamics: Towards a New Ecology," in *Futures* 26, no. 6 (1994), 626-647.

[15] Holling, "Understanding the Complexity."

eventually induce a drastic release of that energy, a destructive process that will drive the system back into a state of lower complexity, from which a new anabolic phase will begin.

These are the two tendencies imposed by the passing of time—processes where energy is progressively consumed and dissipated into states closer to equilibrium, and processes where energy is progressively accumulated into states of order that are further from equilibrium. For systems that are exposed and open to steady supplies of energy, both processes are possible and act simultaneously. Ecological systems, landscapes, and the Earth as a whole, fall within this category: they receive a continuous input of energy in the form of radiation from the sun. And because they are living systems, because they contain life, the energy supplied by the sun is constantly transformed into orders of higher levels of organization, which are often reduced to simplicity by forces of destruction. The structures and forms we perceive in the landscape are the result of the simultaneous action of those processes which make for order, and of those that tend to upset it.

Order and Disorder in 1960s Landscape Architecture. McHarg's Equilibrium and Halprin's Tension

Among the first landscape architects that understood that systems were essentially open to the influence of energetic inputs from their environments, was Ian McHarg. McHarg also understood that the environment was saturated with feedback loops between forces that make for complexity and those that tend to upset it. And although McHarg is often discussed, also in earlier chapters of this work, as the main promoter of a deterministic and science-driven agenda for landscape architecture, the point of departure of his problem-solving strategies for landscape planning and design was a very detailed attention to the different kinds of processes by which the environment is formed. As part of this understanding, references to notions derived from or, at times, explicitly grounded in thermodynamics and evolutionary thinking permeate his writings and thinking.

In his 1976 lecture “The Theory of Creative Fitness,” he opens by noting that the first principle of such theory is the recognition of “something called creativity, which can be defined as the employment of energy and matter to raise matter and energy of high levels of order,”[16] and the recognition of an antithesis to creativity, “reduction: the movement from higher to lower levels of order.”[17] He explains these two different conditions through the example of the mature forest, and by asking the audience to think of the before and after of such ecological formation in the event of a fire. Mentioning the first law of thermodynamics, according to which no matter or energy would have been created nor destroyed during the fire, McHarg arrives at the conclusion that the successional process through which the forest is formed is an example of creativity, and the fire is an example of reduction, for, after the fire, the forest has gone from a higher to a lower level of order. He goes on to say that there are criteria by which we can identify directionality and specific attributes in both kinds of processes:

> Creativity, according to this definition, only shows the tendency to move from a greater to a lesser randomness, from simplicity to complexity, from uniformity to diversity, from instability toward dynamic equilibrium, from a low to a higher number of species, from a low to a higher number of symbioses. These tendencies can be subsumed under two terms: in the left-hand column, the tendency toward entropy, or disorder; on the positive side of the balance sheet, the tendency toward negentropy, or a higher level of order. The theory allows us to see the state of any process and its directionality. Is the process creative and evolving, or is it retrogressing? If we can see the directionality, we have a very useful model. If one sees anything that goes from complexity to simplicity, presumably it is reductive and retrogressing. If we see a process move from instability to a stability or to dynamic equilibrium, presumably it is evolving and creative.[18]

This paragraph constitutes a great synthesis of much of McHarg’s previous writing in *Design with Nature,* where, despite the limited number of explicit mentions to the field of thermodynamics, long stretches are invested in the discussion of this dialectical tension between creative and reductive processes.[19] In these discussions, there are frequent allusions to Clausius’ concept of *entropy*, as we have seen, but also to the notion of *negentropy*, which is a shortening of the expression *negative entropy* introduced by Erwin Schrödinger, precisely, in *What is Life?* to denote the capacity of living systems to organize matter and

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[16] Ian McHarg, “The Theory of Creative Fitness,” in *Ian McHarg: Conversations with Students*, eds. Lynn Margulis, James Corner and Brian Hawthorne (New York: Princeton Architectural Press, 2007), 19-62, 21.

[17] Ibid., 21.

[18] Ibid., 22.

[19] See, for example, McHarg, “The Naturalists,” in *Design with Nature*, 117-125.

export entropy to their surroundings.[20] In McHarg's view, creative processes were desirable, and reductive processes should be avoided in the work of landscape architecture. And he sustained this argument on Darwin's idea of adaptive evolution and, more vigorously, on the work of the American physiologist and chemist Lawrence Henderson. Henderson had expanded Darwin's idea of the organism's fitness to its environment, and had suggested that the environment should not be considered, as most naturalist had been doing since Darwin, as an independent variable in processes of biological adaptation, but that, instead, they should consider fitness as a universal law that ruled the whole environment, and not only organisms.[21] This theory had an immense impact on McHarg, who took this universal law of fitness as a fundamental principle that the work of landscape architecture should not disrupt (*Figure 7.1*). In McHarg's mind:

> evolution then consists of a tendency towards increasing fitness whereby the organism adapts the environment to make it more fitting and, through mutation and natural selection, adapts itself towards the same end. As the process of fitting exhibits the direction from simplicity to complexity … it corresponds to the most basic creative processes in the earth. Fitting and the movement towards fitness were thus creative. The failure to accomplish a fitting, the misfit, is not creative. Processes whereby the system reverts from complexity to simplicity and so on are therefore entropic and destructive. There are two polar conditions, the first creative fitting and the other a destructive unfitting. The measure of fitness and fitting is evolutionary survival, success of the species or ecosystem, and, in the short run, health.[22]

McHarg's message in favor of creative processes is clear (*Figure 7.2*). Creative processes build order, they build fitness, and order and fitness are desirable.

There are, however, some biased associations in the language he uses that need clarification. In the excerpts just quoted we read a tendency to establish synonymic connections between *entropy*, *disorder*, *unfitness*, *instability*, *destruction*, and *reduction*, on the one hand, and *negentropy*, *order*, *fitness*, *equilibrium*, *creation*, and *creativity*, on the other. These associations promote a dogmatic dualism in the tension that exists between processes that build complexity and those which favor simpler forms of matter

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[20] The expression *negentropy* was coined in Leon Brillouin, "Negentropy Principle of Information", *Journal of Applied Physics*, Vol. 24, No. 9, (1953), 1152–1163. *Negative entropy* was firstly used in Schrödinger, *What is Life*.

[21] Lawrence Henderson, *The Fitness of the Environment* (New York: MacMillan, 1913).

[22] McHarg, *Design with Nature*, 120.

and energy. This dualism was far from being exclusive of McHarg: it was a general tendency in those years, where not only the establishment of ecosystems' ecology, as I have previously explained, but also cybernetics and information theory played an important influential role.[23]

These dogmatic associations are derived from the simplification of some of the concepts that participate in the definition of entropy. Originally defined, in very specific scientific terms, as the physical measure that served to quantify the degree of degradation of the energy in a given system, entropy soon acquired connotations that were something close to the degree of disorder that exists on a given system. Gestalt psychologist and art theorist Rudolf Arnheim, looking at the question of entropy from a stance that was not restrained by scientific bias, offered in his 1971 work *Entropy and Art* a careful analysis of the different terms that participate in this discussion to prove that the same words are often attached to different meanings or that, conversely, words with opposite meanings are used to denote the same condition.[24] In his elaborations, Arnheim includes detailed discussions on the ideas of order, disorder, degradation, tension, equilibrium, entropy, probability, structure, constraints, and information.[25] As part of these, he describes an experiment with liquids in conditions of zero gravity, where a transparent tank is filled with oil and colored water—liquids of equal density and incapable of mixing. If an input of energy is applied to the tank—let's say, it is vigorously agitated—the segregating surface that separates both liquids adopts all kinds of accidental shapes (*Figure 7.3*). In the lack of any further input of energy, according to the second law of thermodynamics, the useful energy in the system will be progressively reduced—i.e. the forces between both liquid agents will progressively even out—and, at the end of the process, the entropy in the system will be maximum. Once the forces have been cancelled, the resulting

[23] For a good account on the influence of cybernetics on Ian McHarg, see Margot Lystra, "McHarg's Entropy, Halprin's Chance: Representations of Cybernetic Change in 1960s Landscape Architecture," in *Studies in the History of gardens & Designed Landscapes* 34, no. 1 (2014), 71-84.

[24] Rudolf Arnheim, *Entropy and Art: An Essay on Order and Disorder* (Berkeley: University of California Press, 2011). The book was first published in 1971.

[25] Information theory and cybernetics were very influential fields by the time that McHarg and Arnheim published these books, and were fields that were providing expanded interpretations of entropy. If the degradation of energy implied an increase of entropy in thermodynamics, the degradation of information produced noise in information theory and cybernetics.

shape of the surface between both liquids is, of course, a perfect sphere, the overall state of equilibrium, the state of minimum tension, the simplest shape available under the given conditions.[26]

Arnheim's elaborations claim that, contrary to what McHarg's language suggests, situations of maximum entropy are, in fact, situations of maximum equilibrium, and often lead to final forms that are far from being "disordered." The forces constituting a physical field, Arnheim writes:

> have no alternative. They cannot cease to rearrange themselves, until they block each other's movement by attaining a state of balance. The state of balance is the only one in which the system remains at rest, and balance makes for order because it represents the simplest possible configuration of the system's components. A proper version of order, however, is also a prerequisite of good functioning and is aspired to for this reason also by organic nature and by man.[27]

For Arnheim, therefore, order is relative, and not absolute. Order is continuously built and rebuilt in accordance to the forces that act upon a system at any moment in time. In the input of a new force, a new tension emerges, and a new order is produced. The process through which that tension is progressively dissipated constructs a new order, a different order. And once the force has disappeared, and the tension introduced by it has been completely dissipated, the system arrives at new state of balance or equilibrium that might be different from that which existed prior to the action of the force. Each of these two potentially different states of equilibrium is, yet, a new and different kind of order.

This understanding of order as relative is close to that of another landscape architect contemporary of McHarg—Lawrence Halprin. Halprin's book *The RSVP Cycles*, published in the same year of McHarg's *Design with Nature*, puts the notion of "creative process" at the forefront.[28] Unlike McHarg, however, Halprin's interest on "creative processes" had less to do with the affirmation of the alleged stability, order, and equilibrium they were meant to build, than with the introduction of chance, choice, and accident in their course of action. Drawing upon his collaborations with musicians, choreographers, dancers, and so

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[26] Arnheim, *Entropy and Art*, 6.

[27] Ibid., 7.

[28] Halprin's *The RSVP Cycles* includes the expression "creative process" in the subtitle. Lawrence Halprin, *The RSVP Cycles: Creative Processes in the Human Environment* (New York: George Braziller, 1969).

on, Halprin departs from a definition of "creative processes" as something close to the set of actions and procedures that participate in the realization of an artistic performance.[29] Also central in Halprin's work is the representation of these creative processes in notational "scores," which he also derives from the performative arts, and defines as *symbolizations of processes* which extend over time,[30] an abstract and generic definition that allows for the expansion of the concept of the musical or choreographic score and applies it to a process-based idea of landscape architecture.

In transposing these ideas from the arts, Halprin assigns to earth and life processes the value of models for creative processes in landscape architecture.[31] As part of these earth processes, he discusses Clements' notions of succession and climax, and even reproduces the diagram of the trends of succession of a climax forest that appeared in Clement's 1906 book *Plant Succession*.[32] Through these, Halprin shares with McHarg an understanding of the tendency of these creative environmental processes to produce complexity and stability. Through the influence of the performative arts on his work, however, Halprin emphasizes notions of chance in the development of creative processes, and, accordingly, accepts processes of erosion and forces such as earthquakes and wind as creative ones in the construction of the landscape. In this work, scores are left intentionally open and unfinished, so that, as in music or dance, chance and choice in the course of actions can play a role in their completion. As he noted in *The RSVP Cycles*:

> we are searching for … open-ended scoring devices which will act as guides not dictators. These kinds of scores have the built-in possibilities for interaction between what is perceived beforehand and what emerges during the act. They allow the activity itself to generate its own results in process. They communicate but do not control. They energize and guide, they encourage, they evoke responses, they do not impose.[33]

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[29] Ibid., 2.

[30] Ibid., 1.

[31] Ibid., 3.

[32] Ibid., 102-103.

[33] Ibid., 19.

From a position also heavily influenced by cybernetics, which, as I have already said, enjoyed great prominence in the decade of the 1960s, Halprin engaged an idea of the creative process where the notion of feedback played a complementary role to that of the score in the consummation of the work of art.[34] In terms of landscape architecture, he coined the term "ecoscore" to refer to processual notations of environmental processes and formations (*Figure 7.4*).[35] The score as an open-endedness representation of process, and its translation into the creative process of landscape architecture, implied the acceptance of chance and uncertainty in the understanding of the processes through which landscapes are formed. As Halprin declared:

> nature has many lessons for us, but to me, as a designer, these two are most important. The first of these is that order, natural order, is overwhelmingly clear and that I relate to it easily and organically and my own sense of order derives from it … This order has to do with process—it has to do with natural rhythms, of qualities of relationships between objects; of lightness and heaviness; of the sense of gravity and density of rock, of energy and force. Second is process. Here is clearly seen the way in which our sense of nature arises. Process and product become synonymous and the sequence of events is absolutely clear. Art is here evolved, by the inevitability that natural chance brings … In the design of our environment we can strive for the same sense of inevitability through processes which can use chance and accident selectively.[36]

Forces and processes that would be considered "destructive" by other environmental frameworks are incorporated in Halprin's conception of landscape as generative of an expanded notion of order that accepts disturbance and chance. A conception of landscape that is effectively expressed in the windbreaks that exist on the Sea Ranch, a ten-mile-long development on the coast of northern California for which Halprin did a master plan in the early 1960s (*Figure 7.5*). The most salient aspect of this coastal landscape is a series of cypress windbreaks, planted in the early twentieth century, where the creative impulse of the growth of the trees collides with the "reductive" and entropizing action of the wind. The appearance of a

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[34] In the texts and the graphic work of Halprin it is evident a influence of the work of early cyberneticians as Norbert Wiener, Margaret Mead, and Gregory Bateson. For a detailed account on the influence on cybernetics upon Halprin's work, see Lystra, "McHarg's Entropy, Halprin's Chance." Although these authors are not explicitly referenced in *The RSVP Cycles*, there are multiple references to the American minimalist musician John Cage who, as Kathleen John-Alder has recently noted, recommended Wiener's books on cybernetics to his students. See Kathleen John-Alder, "Processing Natural Time: Lawrence Halprin and the Sea Ranch Ecoscore," in *Studies in the History of gardens & Designed Landscapes* 34, no. 1 (2014), 52-70.

[35] Halprin, *RSVP Cycles*, 98.

[36] Quoted from excerpts of Lawrence Halprin, *Landscape*, Winter, 1961-62, reproduced in Halprin, *RSVP Cycles*, 104.

windbreak implies, as the very term notes, a *break*, a disturbance on a force, that of the wind, which, over the course of the years, has participated in the production a particular landscape order, that of the meadow, that might be said to rest in some sort of equilibrium. But the windbreak does not simply appear, by chance. The windbreak needs to be introduced, and its introduction demands an input of energy, large enough to be able to compete with the energy supplied by the wind, and not just be annulled by it. The introduction of the windbreak is, then, the introduction of an accident, a new tension into the preceding equilibrium of the meadow. And, as in the oil and water experiment described by Arnheim, the new tension triggers, inevitably, a process where both forces will be progressively evened out towards the generation of a new landscape, a new order, that of the deformed trees, that is nothing more than a new different expression of equilibrium (*Figure 7.6*). The windbreak in the meadow is, therefore, as in Halprin's open-ended understanding of the score, an insertion of chance in the creative process of landscape architecture, so that the movement from tension to equilibrium emphasizes landscape as bounded process. It is, as in Arnheim, a resistance to simply associate the concept of entropy to its negative connotations—as in catabolism—that gives way to an engagement of the notion of degradation as a generative—anabolic—force in landscape architecture. The degradation of tension, the process of tension reduction, to use Arnheim's words, lead to new orders, to new relative notions of order.

Tension in Landscape Architecture and in Productive Landscapes. Galí-Izard and the 365 Parks

From the previous section, it is derived that, in order to transform a given order, be it close to its zone of equilibrium or far from it, into a different one, an input of energy is necessary. And as a way to preserve—to maintain—that new order, a sustained input of energy—of maintenance—is also required. The farther a system is moved from its zone of equilibrium, the higher the potential for energy loss in the system is. In other words, the farther a system is from its state of equilibrium, the more powerfully attracted towards that zone of equilibrium the system is, the higher the tension is. Therefore, in order to maintain a system far from equilibrium, inputs of energy are constantly required, so that the tension can be maintained. Systems far from equilibrium are expensive. As Sanford Kwinter put it:

> the phrase far from equilibrium is borrowed from the field of thermodynamics where, especially in the last four decades, it has come to refer to the special states of a system in which it is most

> likely to produce radical, productive and unforeseeable behaviors. When close to equilibrium, the disturbances, anomalies and events passing through a system are easily absorbed and damped out; but as a system is moved further from its rest places, it becomes increasingly ordered and differentiated. The more ordered and differentiated, however, the more unstable and expensive (in terms of energy required to sustain it) the system becomes. Instability, it turns out, is the precondition of creativity. But because of its cost—in terms both of the energy required to produce and sustain it as well as in terms of the damage to the status quo that must invariably be repaired following every transformation—instability and invention are rare.[37]

Tension is, therefore, more expensive than equilibrium.

This spectrum between tension and equilibrium, between orders that are close to equilibrium and orders that are far from it, is the medium where landscape architecture operates. In order to transform a given landscape order, wherever it is along the tension-equilibrium spectrum, into a different one, an input of energy is necessary. And, again, as a way to preserve—to maintain—that new order, a sustained input of energy—of maintenance—is also required (*Figures 7.7 and 7.8*). That is why orders that are far from equilibrium are expensive, as Kwinter notes, but also fragile. In the absence of the input that sustains the tension, the order will spontaneously move towards a different order that is closer to its zone of equilibrium. In this sense, every landscape architecture work consists of either a transformation or a maintenance of a specific landscape order, and, in most cases, the orders that landscape architecture introduces or maintains in the landscape are orders that are far from equilibrium. But tension is necessary in landscape architecture, as tension exists in the public realm where landscape architecture operates.

As a way to begin to more clearly translate these notions of equilibrium and tension into landscape architecture, we might draw upon the image of a manicured grass lawn as an illustrative example. Grass lawns never simply emerge out of the passage of time. They are landscape conditions that are deliberately created and that are very far from a state of equilibrium. Any portion of the land requires great inputs of energy to be transformed into a grass lawn and also to be maintained as such. These inputs of energy include money and human labor, the careful selection of grass seeds of the same species, the deliberately homogeneous distribution of those seeds over a portion of the land, the adequate chemical treatment of

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[37] Sanford Kwinter, "Introduction: De l'Audace," in *Far from Equilibrium: Essays in Technology and Design Culture* (Barcelona: Actar, 2008), 16-8.

the substrate for the adequate growth of the vegetation, the introduction of drainage systems for episodes of high precipitation, the provision of irrigation systems for episodes of lack of precipitation, the continuous mowing of the grass to preserve the desired appearance, and so on. In some portions of the land, however, the necessary inputs of energy to create and maintain a grass lawn are greater than in others. We only need to think about how difficult it is to maintain a lawn of grass in a dry temperate climate such as the Mediterranean to understand how expensive and fragile that order is, how it needs to be continuously "restored." The same applies for a humid climate, where new grass species continuously try to get over and need to be kept out. Each of the operations that participates in the maintenance of that order constitutes an input of energy.

These are ideas that are splendidly put forward by a project by the Spanish agronomic engineer and landscape architect Teresa Galí-Izard, a competition entry for the design of a large urban in the center of Valencia, of a city in the east of Spain. The project presents a radical approach that essentially seeks to keep the landscape continuously in a zone that is far from equilibrium, in a continuous state of tension. Galí-izard usually introduces the project by discussing the establishment of a new general order on the site that is described as a "framework" or "infrastructure," concepts that are very recurrent, as I already referred to in chapter 2, in landscape architecture projects that engage ideas of design adaptation to indeterminacy (*Figure 7.9*). But, instead of letting the design "go by itself," Galí-Izard aims at doing exactly the opposite. She aims at a project that consists primarily of a very meticulous and intense management regime. The framework is one of high precision, one whose modularity and dimensions are defined by the trusses of the irrigation system and the tractors that will be used in the maintenance of the park (*Figure 7.10*). These machine-derived modules create a system of lines and paths that define the structure of the framework, which is used to incorporate a calendar of a total of 365 different events, one for each day of the year. Flower mats, special pruning, opening of new walking paths, fall foliage, contact with aromatics, flowering of arching pergolas, sprinklers' rain, creative mowing, butterflies attraction, and so on (*Figure 7.11*), every new event implies a new variation of the order established by the framework; each of them finds its own expression within the degrees of liberty opened by the framework while remaining also linked to its constraints in one way or another (*Figure 7.12*). The park adopts, in other words, 365 different configurations during the course of a year.

And, of course, each of these reconfigurations demands a new input of energy—of maintenance: from mowing the grass to open new paths, pruning the shrubs in order to achieve specific shapes, to the planting of bulbs to flower the following season, irrigating the fields, burning the fields, etc (*Figure 7.13*). When discussing this project, Galí-Izard explains that the investment required for the implementation of the elements that are part of the infrastructure of the park (grading, irrigation trusses, pavement, tractors, trees, and grasses) is minimum when compared to projects of a similar scale and budget. The goal here is to save more than half of the budget assigned for the construction of the park and reinvest it instead in labor and maintenance during the first five years: the punctual input of energy that is necessary in the beginning to induce the transformation of the site into a new order is relatively small, and the energy invested in the maintenance of that new order on the site over time, as a continuous reconfiguration of it, is higher.

Galí-Izard's Central Park in Valencia is, in this sense, a brilliant example of the transformation that every work of landscape architecture implies in the existing order on a site. And, even more, of the need for continuous and specific inputs of energy (of *maintenance*) that are necessary if the intended order is to be kept (*maintained*). The environment is, nevertheless, a space-time continuum saturated with energy. And, as Galí-Izard reminds us, "thinking about landscape projects in energy terms enables new management systems to be introduced, new processes for transforming and taking advantage of natural energy flows in different ways to be invented."[38] The energy available in the environment is continuously redirected by landscape architecture in order to achieve landscape organizations that are different from equilibrium.

A clear example of this is the oasis, a landscape structure that "emerges" from natural energy flows that have been redirected, transformed by the creation of irrigation networks, so that agricultural production

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[38] Teresa Galí-Izard, *Los Mismos Paisajes: Ideas e Interpretaciones* (Barcelona: Gustavo Gili, 2005).

can exist in a land condition where it would not otherwise be possible—that of the equilibrium of the desert. The re-distribution and maintenance of the natural flows of energy acting on the land—water precipitation, water flowing down, growth of large palm trees that provide shelter from the sun—constitute a displacement of the desert landscape condition away from its zone of equilibrium and the production of a new landscape order.

As landscapes are transformed into orders that are "far away" from their zone of equilibrium, higher inputs of energy are progressively required for those orders to be sustained over time. Landscapes become, again, more "expensive." In the absence of those new inputs of energy, the new orders fail and give way to different ones. This is the case, following Hargreaves' discussion on his essay in *Large Parks*, of Golden State Park in San Francisco and Centennial Parklands in Sydney, where the introduction of the parks erased, in both cases, the existing conditions (sand dunes in San Francisco, swamplands in Sydney) in pursuit of allegedly "public park imagery" based on the lawns and deciduous trees that had been recurrently used to design parks elsewhere.[39] In places like London and New York, the regions which offered those precedents, designing with green lawns and deciduous trees certainly implies the introduction of a new order in places where that order did not exist: think for example of the derelict land conditions upon which Central Park in New York was implemented. However, the new order introduced in Central Park was not "too far away" from the zone of equilibrium of that land; if left alone for a process of ecological succession with no human input, deciduous trees and grasses with similar needs to those that were eventually planted would have "naturally" grown on that area. The energy available simply in the environment would have simply pushed the area upon which Central Park was established towards an order that would have presented a palette of vegetal species that does not differ extraordinarily from the palette that was introduced by the design. That is not to say, of course, that Central Park is just a successional landscape. It is obviously not. That is to say that Central Park design introduces a new order that is different from the landscape state of equilibrium but "not too far"—not too different—from it.

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[39] Georges Hargreaves, "Large Parks: A Designer's Perspective," in *Large Parks*, ed. Julia Czerniak and Georges Hargreaves (New York: Princeton Architectural Press, 2007), 121-174.

If the palette of species that is introduced in a landscape is too narrow, as in the grass lawn, or in a monoculture agricultural crop, the tendency towards equilibrium will continuously introduce new species that might not be desired in the design, and the maintenance of the design will basically consist of the removal of those "invaders." If the palette introduced is too wide, the tendency of the landscape will be to simplify the palette by removing those species that are less "adapted" to the new order introduced, and the maintenance of the design will consist, then, in supplying energy to favor the conditions needed by those less adapted species. In seeking high levels of complexity and biodiversity, some landscape architecture designs introduce very large arrays of species which can be too expensive to maintain over time, for some of the species might not be able to adapt well enough in the new environment and thus disappear. In some other cases, the recommendation might better be the opposite—to enlarge the palette, especially in those cases where the design suggests too optimistic a successional process in the landscape, according to which a very narrow set of species will simply evolve into a rich and complex palette.

So, if design introduces orders on the land that work with palettes that would never emerge by themselves in those lands, the order introduced might be "too far away" from equilibrium, and the input of energy needed to preserve it might be too high. In this sense, coming back to the example of the Golden Gate Park in San Francisco, the restorative pastoral scenery model that was being promoted in the landscape architecture literature at the time that Golden Gate Park was conceived demanded oaks and maples that were not suitable for the underlying conditions of the dunes.[40] The trees planted in the first attempt failed. The second attempt introduced eucalyptus, conifers from nearby Californian landscapes, and acacias, which eventually succeeded and offered the park a look that today hybridizes quite interestingly the pastoral scenery model originally intended with a canopy more attuned to the Californian landscape. In the 1980s and 1990s, about one hundred years after its construction, a new wave of plantation came in, with new species that are intended to better succeed in the park. Golden Gate Park is, in sum, a one-hundred-and-fifty year progressive move from the introduction of landscape order, that of the pastoral landscape, that was very far from equilibrium in this particular region of the world, towards an order that

[40] Ibid., 139.

is closer to the zone equilibrium upon which this land rested before the erasure of the dunes in the nineteenth century.[41]

The transformation and maintenance of landscape into an order which is away from equilibrium is also what every agricultural practice seeks. Irrigated landscapes, for example, make a very clear point, in this sense. In arid landscapes, the scarcity of water limits the growth of vegetation. In order to grow certain crops in arid landscapes, an input of energy is required in the beginning, to create an irrigation infrastructure that will distribute water in accordance to an order that is different from the drainage patterns that simply emerge from the combination of precipitation regimes and physiography. But there is also a need for a continuous regime of maintenance: maintenance of the infrastructure itself, and of the conditions on the cropping areas, in order to preserve the functional capacities of the agronomic system.

Most agricultural practices introduced since the modern age have been based on the monoculture, which, as the manicured lawn, constitutes a landscape order of extraordinary tension. In the monoculture, the palette is reduced to one single species. The distance from equilibrium is maximum. Very few landscape orders of equilibrium in the world offer palettes of one single species. One of Humboldt's fascinations were in fact these landscapes, those which he described as the "limits of plant life." Landscapes inhabited by very simple and reductive plant populations, he observed, are the icy and rocky peaks of the mountains above the clouds, and the interior of mines and undergrounds caves, conditions in which only a very limited numbers of species have adapted to survive, those areas where equilibrium unfolds in the form of

[41] The Bos Park in Amsterdam, built in the 1930s, by Cornelis van Eesteren and Jakoba Mulder, and the Parc du Sausset, by Michel and Claire Corajoud, built in the 1980s in the outskirts of Paris, are two interesting examples of parks where different regimes of maintenance keep different areas of the park at different distances from equilibrium, at different orders of landscape "tension." These two projects are discussed with detail, respectively, in Anita Berrizbeitia, "The Amsterdam Bos: The Modern Public Park and the Construction of Collective Experience," in *Recovering Landscape: Essays in Contemporary Landscape Architecture*, ed. James Corner (New York: Princeton Architectural Press, 1999), 187-205, and in Hargreaves, "Large Parks."

an extraordinarily restricted palette.[42] The lands where cultivation normally takes place are, on the contrary, very far from those limits of plant existence. In most cases they are, instead, in areas where many different species would grow without any human input. Monoculture is a cancellation of the diversity in favor of the maximization of production of one single species, which brings orders to the land that are very far from equilibrium, an idea eloquently expressed in a simple diagram by the American animal ecologists Victor Shelford in his 1913 book *Animal Communities in Temperate America* (*Figure 7.14*).[43] A huge input of energy is demanded, the tension is maximum, and the fragility—the risk of failure—is maximum as well. As Donald Worster puts it:

> The vulnerabilities inherent in modern monoculture … include an unprecedented degree of susceptibility to disease, predation, and pest population explosions; a heightened overall instability in the system; a constant tendency of the human manager to take risks for short-term profit, including mining the soil … ; an increasing reliance on technological substitutes for natural plant and animal services; a reliance on chemical inputs that have often been highly toxic to humans and other organisms; a dependence on imports from distant regions to keep the local system functioning; and finally, a demand for capital and expertise that fewer and fewer individual farmers could meet.[44]

Each of these operations constitutes a new input of energy invested in the perpetuation of an order in the landscape that is extremely far from its zone of equilibrium and which is being strongly attracted towards it.

For a few years now, environmental historians and cultural geographers have been looking to premodern agronomic systems, emphasizing the idea that their endurance is derived from their resilience and aptitude to minimize environmental risks, and emphasizing as well their capacity to create landscape orders of higher complexity that allow for better mediation of the demands of agricultural production with other

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[42] Humboldt in fact declares his fascination that the palette was actually very similar in all those limits of plant life, despite the very different constraints (cold temperatures, lack of sun light, etc) that each of them imposed. Alexander von Humboldt and Aimé Bonpland, *Essay on the Geography of Plants*, Stephen T. Jackson, ed., and Sylvie Romanowski, trans. (Chicago: University of Chicago Press, 2009), 64.

[43] Victor E. Shelford, *Animal Communities in Temperate America* (Chicago: The University of Chicago Press, 1913), 13. I want to thanks Harvard GSD assistant professor Danielle Choi for this reference.

[44] Donald Worster, "Transformations of the Earth: Toward and Agroecological Perspective in History," *The Journal of American History*, Vol. 76, No. 4 (Mar., 1990), 1087-1106.

ecological processes unfolding on the land.[45] Some of these vernacular agronomic practices—tillage conservation, intercropping, crop rotation, and targeted grazing among many others—long regarded as archaic—are today increasingly recognized as appropriate and sophisticated by recent work in environmental engineering. What all of them seem to share is, according to Worster, an interest in strategies of land transformation that do not impose orders that are very different from those that precede the implementation of agriculture. Instead they are based on the close observation and imitation of the orders found on the land as a way to restrain the tension agricultural production inevitably brings with it. In calibrating the tension, these practices seek the construction of complex landscape orders that are at once the product of non-human factors and human intelligence working towards a mutual accommodation.[46] An understanding of the productive landscape that resonates with John Brinckerhoff Jackson's memorable definitions of landscape in *Discovering the Vernacular Landscape*, where he writes that "a landscape is not a natural feature of the environment but a *synthetic* space, a man-made system of spaces superimposed on the face of the land, functioning and evolving not according to natural laws but to serve a community; [it] is this a space deliberately created to speed up or slow down the process of nature."[47] Jackson claims that natural laws—orders close to equilibrium—need to be changed for the land to serve a community. However, he does not suggest a radical transformation of those laws but a recalibration, a change that either speeds up or slows down their effects; for the introduction of orders on the land that are too close to equilibrium—no tension at all—might cause a transformation that does not fulfill the service it was intended for; but moving the land too far away from its equilibrium, introducing, in other words, too much tension might cause those new orders to be unsustainable and eventually fail.

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[45] The work of the cultural geographer and ecologist Karl Butzer, who has studied various agronomic traditions, is particularly relevant in this regard. See for example, Karl Butzer, "The Classical Tradition of Agronomic Science: Perspectives on Carolingian Agriculture and Agronomy," in *Science in Western and Eastern Civilization in Carolingian Times*, eds. Paul Leo Butzer and Dietrich Lohrmann (Basel: Birkhauser Verlag, 1993), 539-598, Karl Butzer, "The Islamic Traditions of Agroecology: Cross-cultural Experience, Ideas and Innovations," in *Ecumene* Vol. 1, No. 1 (January 1994), 7-50, or Karl Butzer, "Ecology in the Long View: Settlement Histories, Agrosystemic Strategies, and Ecological Performance," in Journal of Field Archaeology, Vol. 23, No. 2 (Summer 1996), 141-150.

[46] Worster, "Transformations of the Earth."

[47] John Brinckerhoff Jackson, "The Word Itself," in *Discovering the Vernacular Landscape* (New Haven: Yale University Press, 1984), 1-8.

Matter Accumulation and Energy Dissipation; Scape and Living Breakwaters

As a way to begin to more clearly illustrate some of these ideas around tension and equilibrium discussed in the previous sections, I want to use the American landscape architecture firm Scape and their Living Breakwaters project, of 2014, in State Island. This is a project that introduces tension to the landscape by accumulating matter in the form of a system of breakwaters that, as in the windbreaks at Halprin's Sea Ranch, aim at the dissipation of specific forms of energy that exist in the environment—in this case water currents on New York's lower bay. The main value of the project derives from its prototypical ambition, from the idea that the strategies developed in the project could be replicated in many other coastal regions. The exercise originates around the question of the agency of landscape architecture in the development of coastal protection strategies in the event of major storms. But the proposal unfolds within the recent paradigm of resilience, which is more interested in the examination of the role of natural landscapes in reducing coastal risk than it is in the development of barriers of coastal resistance that seek to keep risks encapsulated. The intention here, therefore, is to attenuate and dissipate the energy continued in the agents that pose the risk rather than to create a hermetic perimeter that bounces that energy back.

Kate Orff, the principal at Scape, addresses three primary goals in the development of the proposal: risk reduction, ecological regeneration, and the fostering of social resilience.[48] In terms of risk reduction, the proposal begins by rejecting the coastal protection strategy based on the levee. Widely used in coastal engineering projects throughout the world during the twentieth century, a levee's linear and continuous embankments is built to prevent overflow of rivers and marine waters. They are singular elements consisting of an extraordinary accumulation of mass (a form of energy). Their implementation drastically changes found coastal conditions, introducing new orders intended to trigger new forms of equilibrium, that is, new coastal conditions that should remain essentially stable and unchanged, by virtue of the levee's mass, when subject to external forces of disturbance. They are hard and closed systems of coastal protection designed, not to absorb, attenuate, or dissipate forces, but, instead, to repel them, to bounce

[48] Kate Orff, in Scape's "Living Breakwaters Rebuild By Design Competition" internet video, 00:30. Posted by Scape Studio, https://www.scapestudio.com/projects/living-breakwaters-competition/. Accessed on March 1, 2018.

them back. But a levee's capacity to repel those forces is derived from the extraordinary tension that their sharp, linear, and continuous order introduces on the softer and blurrier orders that characterize most untreated coastal conditions. The energy is not distributed but accurately accumulated in one single element, which assumes all the burden of protection (*Figure 7.15*).

But, as Orff points out, elements of protection can fail. No matter how intensive the accumulation of energy in the levee might be, the risk of failure always exists, and if the protection relies on one single element, the results of failure can be catastrophic.[49] If, on the contrary, the strategy of protection is unfolded on a gradual and distributed system of different elements and agents developing different aspects of the same function, the resulting order will be less tense and closer to the zone of equilibrium of the coastal landscape and, therefore, more resilient (*Figure 7.16*). It seeks to induce some sort of homeostasis in the marine system as a way to protect the community that inhabits the area. In this sense, Scape proposes the creation of a multilayered landscape system designed to progressively absorb and dissipate oceanic forces, consisting of a sequence of constructed breakwaters, tidal flats, constructed reefs, salt marshes, and so on, which are studied and incorporated in different areas of the project by virtue of the different protective benefits that they can bring about. It is a softer and more open system than the levee, a system that requires a lower investment of energy (less mass), for the change of order that it introduces on the coastal configuration is smaller than that introduced by the levees. Scape uses the sloped walls of the breakwaters to "drastically dissipate," to use Kate Orff's own words, "destructive wave energy."[50] Some of them are sub-tidal beds, longer and shorter, which allow for slow inundation to approach the coast in areas that are not inhabited by people, and some others go above the high water level, higher and shorter (*Figure 7.17*). The morphology of these last ones is closer to that of the levee; they still dissipate part of the energy of the waves, but also bounce back some of it, allowing less inundation to come in, which is a more adequate strategy for coastal zones with human settlements.

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[49] Philip Orton, ibid., 3:00

[50] Orff, ibid., 01:30.

The new order created on the coast also offers potential for ecological regeneration. The new sub-tidal structures generate a new kind of tension in the marine environment. The introduction of the breakwaters into the aquatic environment marks the point of initiation of a new adaptive cycle, as explained in chapter 3: the appearance of the new boulders constitutes a sudden release of energy devoid of life into an environment that is essentially saturated with different life forms, and triggers a new successional process in which different marine species, just by chance, will progressively take over the newly introduced elements (*Figure 7.18*). The initial tension that exists in an environment in which just a few patches are empty of life is progressively reduced into a state closer to equilibrium, where the distribution of life is eventually evened. But in order for those empty patches—the boulders—to engender life, they need to offer the environmental conditions to do so. In this sense, Scape's proposal maximizes the diversity of conditions offered by the sloped and submarine rocky structures of the breakwaters by using rocks and concrete boulders of various forms, materialities, and textures; the more mixed the structure is, the higher the diversity of life forms it will be able to engender, and the more complex the resulting environment will be.[51]

The presence of life constitutes an accumulation of energy itself that will be able to offer its own resistance in the event that an external climatic force impacts the system. And it is also complemented by the accumulation of sand in the form of sedimentation. The breakwaters are, in this sense, not only the seed for life processes to take over, but also the point of departure of new processes of sand sedimentation which, over time, will spontaneously accumulate enough matter to conform yet another layer in the designed landscape sequence. Each of these layers—the breakwaters themselves, the sand sedimented by their presence, and the different life forms taking over the designed submarine landscape—adds a new potential for energy dissipation in the event of a storm. A project, in sum, where the human manipulation

[51] Sella, ibid., 05:00.

of the environment by using small amounts of supplementary energy is intended to trigger processes in which the main energy drives are still coming from non-human sources.[52]

Landscapes Close to Equilibrium: Energy Dissipation and Formal Tension Reduction. Descombes and The River Aire

As I have discussed before, Rudolf Arnheim in *Entropy and Art* resists the association of the concept of entropy only with its negative connotations and claims instead that the degradation of order can also have creative potential. This is a premise that has been recently explored in landscape architecture. An illustrative example is the “Stock Pile” temporal experiment that Stoss, the American landscape architecture firm led by Chris Reed, actualized at the Radcliffe Institute for Advanced Study in Cambridge, Massachusetts, in 2009. “Stock Pile” consisted of a series of mounds which shared initially a conic structure, and which were left to evolve and “degrade” over a period of several months, resulting in different formal outcomes, which depended on the materiality of the pile and the presence or absence of living matter. Another exercise, more ambitious but also based on processes of “tension relaxation,” is the work of Swiss landscape architect Georges Descombes in “Superpositions,” the renaturalization of the River Aire, in Geneva, Switzerland.

The premise of the River Aire renaturalization is the generation of a “naturally” meandering river from a situation where such a river does not exist. All rivers on the earth exhibit a rather limited range of structures—normally described as branching and meandering patterns—[53] which are the result of a long process of reduction of the tension existing between various forces at play. These forces can be reduced to the two that have the highest agency in the formation of a river: on the one hand the force that results from the attraction that gravity exerts upon the water of precipitation, and on the other the resistance offered by the crust of the earth. Because of gravity, water has a natural tendency to flow downward, and

52 This is an idea that is close to Howard T. Odum’s definition of ecological engineering, in Howard T. Odum, *Man in the Ecosystem*, *Proceedings of Lockwood Conference on the Suburban Forest and Ecology, Bulletin of the Connecticut Agricultural Station* 652: 57-75.

53 See Peter S. Stevens, *Patterns in Nature* (Boston: Little, Brown & Co, 1974).

the material condition of the soil presents a sequence of obstructions. The negotiation between those two primary conditions eventually produces some sort of equilibrium that, following Arnheim's notes on entropy again, is far from being disordered but, instead, exhibits regularity, complexity, symmetry. The potential energy contained in the water upstream is released and, in its process of degradation, forms an ordered structure, that of the branching and meandering patterns of the river. This is just one example of what the Belgian physicist and Nobel Prize Ilya Prigogine referred to as "dissipative structures," both of them different ways of expressing the cosmic principle according to which the dissipation of energy, as Arnheim had also claimed, often leads to an increase in the orderliness of a system.[54]

The interest and provocation of this exercise of the renaturalization of a river lies in its ambition to very legibly enact this cosmic principle—cosmic, therefore, with no conscious intention—in a work of landscape architecture—which is necessarily conscious and intentional. Natural processes—that is, those that unfold indifferently to us—have two things going for that landscape architecture does not normally have: great scales of time and great scales of land. It takes a great deal of time and territory for water to establish the meandering patter of a river. If such a pattern is to be produced in a time and to an extent that satisfies the constraints of a specific landscape architecture work, the process needs to be sped up by design. The project, becomes, in other words, a compression of time.

The River, outside of Geneva, flows through valleys historically devoted to farming. Beginning in the late nineteenth century, it was progressively canalized, and in 2001 the city of Geneva opened a competition with the idea of restoring the river to its original shape—its state of equilibrium—by destroying its canals. Instead of destroying the canal, Descombes proposed combining the canal with a vast divagation space for the river. In so doing, the canal is preserved as yet another layer of history in the comprehension of the valley's cultural landscape, but it also becomes the place of transformation, a point of reference offering the opportunity to understand the before and after established with the new operation (*Figure 7.19*).

[54] Prigogine and Stengers, *Order out of Chaos*.

The device that is created in order to accelerate that renaturalization of the river is a network of channels excavated in the area where the new river is meant to flow. A highly erodible landscape is constructed: its materiality is basically that of the sandy and gravelly substrate, and the form assigned to it is that of a regular pattern of diamond-shaped volumes (*Figure 7.20*). The introduced order is one that is very far from equilibrium. As I have explained earlier, the way in which thermodynamic theory measures the proximity of a system to its state of equilibrium is by calculating the probability of the structure to come about simply by chance. And, of course, the probability of such a Euclidean pattern of diamonds to emerge in the course of river is simply none. Such is not an emergent pattern. Instead, it is the result of an intentional input of energy over the original *tabula rasa* condition of the river bed, which derives from industrial processes of excavation and their associated formal logics. It is also possible to get a sense of the move away from the equilibrium of such a landscape order by accounting for the level of maintenance —inputs of energy—that such a pattern would require in order to resist and be restored against the entropizing tendency it will adopt once the force of the water is flowing across it. Once the water is released, the pattern will be easily degraded into a new order derived from the accompanying processes of sedimentation. Following the metaphor that the French philosopher and scholar of complexity Michel Serres uses to explain the concepts of time and entropy: the very force of the river's flow is what will cause it eventually to silt up (*Figure 7.21*).[55]

Despite the ironic attitude that Descombes uses to describe the constructed pattern—he often claims he was inspired by the lozenges of a Swiss chocolate bar—the structure proposed is very far from being arbitrary and shows a consciously calibrated degree of formal tension. The diamonds are, of course, designed to erode over time, but the aperture of the angle that generates the pattern is carefully calculated, so that it accommodates the flow of water without producing a major disturbance during the initial stages, which would result in the erosion of the diamonds before the intended meandering pattern is established. In other words, Descombes carefully measures the degree of friction in the system, the magnitudes of

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55 See Michel Serres, "The Origin of Language: Biology, Information Theory, and Thermodynamics," in *Hermes: Literature, Science, Philosophy*, eds. Josué V. Harari and David F. Bell (Baltimore: The Johns Hopkins University Press, 1982), 71-83.

resistance and movement that are to be introduced into the system. Different degrees of friction in the initial conditions of design will ultimately construct different orders in the river bed.[56] And the design exhibits, in this sense, a delicate balance between the movement that is induced along the channels, and the resistance offered by the material that builds the diamonds.

Among the ambitions of the renaturalization of the river there is, as in the case of Scape's Living Breakwaters, a program of flood control. The friction seeks a progressive process of sedimentation carried out by the dissipation of the energy contained in the daily course of the river. The sediments will be randomly distributed across the river bed, and the flowing water will establish a meandering pattern through it. The river will have found a state of dynamic equilibrium through the area of divagation established for it to do so. This new form of equilibrium is the one sought by the flood control program of the river, for it is the one that will offer the necessary friction to absorb and neutralize the larger flow of water carried during flood events. As I have explained before, when close to equilibrium, the disturbances, anomalies and events passing through a system are easily absorbed and damped out; when far from equilibrium, on the contrary, systems are unstable and likely to adopt unpredictable behaviors.

This approach to flood control through friction, soft systems, and equilibrium, contrasts, as in the case of coastal protection strategies discussed in the Living Waters project by Scape, with those that became the norm in civil engineering projects during the twentieth century. For many decades, river flood control has been primarily dealt with by constructing monofunctional concrete infrastructures, particularly in urban environments, where pressures of urbanization have progressively constrained the spaces for divagation

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[56] While explaining the process of degradation involved in the degradation of the gravel diamonds, Georges Descombes makes reference to Ilya Prigogine's dissipative structures, and to notions of stochasticity derived from chaos theory and percolation theory. See Georges Descombes "Designing a River Garden," YouTube video, 34:50, of a lecture on November 15, 2016, at the Harvard University Graduate School of Design. Posted by the Harvard University Graduate School of Design, November 17, 2016,https://www.youtube.com/watch?v=Jw9zRake7lU, accessed January 25th, 2018. Minute 34:50.

of rivers—the Los Angeles River perhaps being among the most paradigmatic examples of all.[57] The section of these channels is dimensioned in accordance with the volume of water that is expected to flow downstream in the event of a five-year, ten-year, fifty-year, one-hundred-year, or five-hundred-year flood, and the directrix of their courses is designed to offer the least possible resistance to the water. Compared to the earth moving works of the River Aire renaturalization project, the initial input of energy required in the construction of these hard infrastructures is very large: vast amounts of concrete and steel need to be organized for the engineered system of the channel to adequately respond to the program it is intended for. A huge amount of energy is accumulated in the steel and concrete of the channel, so that it will be able to contain, even in its most violent expressions, the force carried by the water. Rather than dissipated, the force of the river is encased within the hard boundaries of the channel's bed and banks and transported downstream with no major loss. The main goal is to minimize friction, to expel water out as fast as possible, and, in sum, to send the problem of flooding elsewhere downstream.

During the past two or three decades, these infrastructures of extraordinary tension have been giving way to other models where, like in the River Aire, larger areas are devoted to the dissipation of the energy of the water. These edge-softening strategies require, comparatively, a much lower initial input of energy, for, again, they accept and seek landscape conditions that are closer to equilibrium—conditions in which the energy contained in the water is progressively absorbed by the course of the river, rather than just exported somewhere else. In so doing, they allow water to stay longer on the site and unfold recreational and ecological functions. This approach not only offers civic value of the expansion of the interface between the river system and its environment, especially in cases where these strategies are developed in urban contexts but also the ecological value implied in the reintroduction of vegetal and animal species. As the river bed is eroded into a meandering pattern, the substrate on the banks becomes more and more stable, allowing for the growth of vegetation and the establishment of a process of ecological succession which, in turn, will increase the stability of the overall system. In a vegetated river, not only sediments but

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57 The River Aire is just another example of this paradigm: it was channelized in the 1920s, and the competition opened by the city of Geneva to restore the river to its original shape considered the destruction of the canal. The preservation of the channel and the introduction of historical and symbolic content into it as part of a recreational project is another chapter of Descombes' proposal.

also vegetation itself, becomes an agent of friction that dissipates the energy of the water in the event of a flood (*Figure 7.22*).

Now that a few years have passed since this process of degradation and stabilization began to operate, the river today presents a different kind of tension from that of the Euclidean order of the clear-cut diamonds. This new tension is what Arnheim refers to as “disorder,” which is not the absence of order, “but rather the clash of uncoordinated orders”:[58] the clash, in this case, of the tension originally imposed by the Euclidean order of the field of diamonds, on the one hand, and, on the other, the meandering pattern that is emerging as the river seeks its path towards equilibrium. But it is precisely through this disorder that the project reveals its intentionality, that the project holds a strong representational value, where form is used as a synecdoche of a process of formation, where the course of a process is read in the image of a form, where form internalizes process.

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[58] Rudolf Arnheim, “Order and Complexity in Landscape Design,” in *Towards a Psychology of Art* (Berkeley: University of California Press, 1966), 123-135,

CONCLUSION

Towards an Ecologically Expanded Field of Landscape Architecture

Conclusion. Towards an Ecologically Expanded Field of Landscape Architecture

As it is derived from its title and subtitle—Forms of Ecology: Towards New Epistemological Binds between Landscape Architecture and Ecology—the fundamental aim of this dissertation has been the formulation of a new set of relationships between landscape architecture and ecology. These relationships have been forged through the examination of some of the key concepts and principles in the theory and the philosophy of ecology across a period of time that extends from the embryonic stages of the field during the first half of the nineteenth century till the present day. The establishment of these new relationships between landscape architecture and ecology is, nonetheless, at the service of a larger and more ambitious goal to which this dissertation hopes to be making a small contribution, and which is no other than the expansion, through ecology, of the agency of landscape architecture as a cultural project.

If ecology is, as I have explained in the earlier chapters of this work, the science that studies the matrix of interactions and the evolutionary unfolding of the environment, landscape architecture is, in its broadest sense, the design field that deals with the transformation of those environmental interactions and processes. The environment is the fundamental object of study of ecology, as much as it is, in Elizabeth Meyer's words, the canvas, medium, and subject of landscape architecture.[1] The whole dissertation is, in this sense, a reflection on the possibility of landscape architecture forms to be looked at and deciphered as representations of the different modes of interaction and processes of evolution that comprise the environment, and an attempt to demonstrate that, through form, landscape architecture also has the capacity to establish specific modes of interaction with the environment and to legibly accelerate or decelerate the course of the processes through which the environment is formed.

The emphasis that the dissertation puts on the *formal* aims at counterbalancing the prevalence of the *systemic* and the *processual* in landscape architecture's discourses for about two decades now. This prevalence has been derived, as I explained in chapter 2, from the deep yet often narrow influence of ecology over landscape architecture. The dissertation resists, in this sense, a dominant and mainly

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[1] Elizabeth Meyer, "Post-Earth Day Conundrum," 191.

operational theoretical paradigm in contemporary landscape architecture, which I have earlier referred to as a shift from *form* to *performance* and *adaptation*. As I also referred to in chapter 2, in this shift "performance" invokes the capacity of landscape architecture to carry out work and have an impact on the material world, "adaptation" refers to landscape's requisite to be able to change in order to endure, and "form" refers to both physical manifestation of meaning and appearance towards aesthetic experience. The recovery of the formal implies, in this sense, a recovery of both the linguistic and the aesthetic in landscape architecture, which have been largely marginalized in favor of more purely instrumental and materialist dimensions of the discipline. Since ecology remains the central narrative of this work, in recovering the linguistic and the aesthetic, the ultimate signified and the ultimate object of aesthetic appreciation of the landscape architecture projects that I have discussed here are the ways through which ecology has attempted to decipher the constitution of the environment.

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These have been the central ideas in the development of chapters 5, 6, and 7, those more explicitly devoted to the interpretation of specific landscape architecture case studies. The titles of these three chapters are, as we have seen, formed by the association of two antithetical concepts, namely, "Discreteness and Continuity," "Transcendence and Immanence," and "Tension an Equilibrium." These binary formulas parallel, on the one hand, three different dialectics through which, as explained in chapter 3, ecological theory has developed some of its various definitions of environment, and, on the other, point to different formal operations by which landscape architecture might be said to act as an epistemological project in approaching such definitions.

In this sense, Chapter 5, under the title "Discreteness and Continuity," has reviewed various scientific and aesthetic codes of botanic gardens during the modern age, and the role that landscape gardening played in the maturation of botany as a formal science. Drawing upon Linnaeus' *Systema Naturae* as the first universal system of plant classification derived from the explosion in the number of known species brought about in the Age of Explorations, I have discussed the formal parallelisms that exist between the arithmetic regularity of some systems of classification and the spatial regularity of some contemporary botanic gardens. I have also explained how by the turn of the nineteenth century, these systems of classification were criticized for their essentialism and their artificially induced discreteness, and soon contested by the so-called natural methods of plant classification, more interested in morphological connections between different organisms. The Linnaean grid gave way to more complex networks of relationships, coinciding, interestingly, with the rise of the theory of the picturesque in landscape gardening and new aesthetic sympathies towards intricacy and continuity. I have discussed the work of the English gardener John Loudon as an early landscape architecture formal practice that synthesized these lineages of scientific and aesthetic principles in garden design, and I have argued that his post-picturesque proposition of the gardenesque, and his abundant discussions around the specific aesthetic effects of different plant arrangements, are particularly illustrative positions of how landscape architecture has historically internalized and helped advance conversations around discreteness and continuity in the natural order. In the last section of the chapter, I have examined with detail a contemporary example, the Bordeaux botanic garden by Catherine Mosbach, as a way to recapitulate and update these conversations in an exercise that introduces more explicitly social and ecological programs into the botanic garden. I have focused, in this sense, in Mosbach's conception of the garden as an ethnobotanical representation of the different cultural roles of plants across different geographies and historic periods, as well as ecological microcosm, insofar as it puts the accent not on the natural objects or phenomena themselves but on the interactions and combined evolutionary processes that exist between them.

Chapter 6 has taken the dialectic between transcendence and immanence as a way to investigate modes by which landscape architecture deals with the mutual influence between design and context. In this chapter I have worked on the construction of a conceptual and formal analogy between the apparently elemental enclosure of the biological organism and that of the landscape's fundamental archetype, the walled garden. Leaving symbolic and cosmological connotations aside, I have emphasized the pragmatic origins of the garden, that is, the deliberate transformation of the order found on the land as a way to better serve specific demands through different design strategies, such as the slowing down of water flows, the redistribution of water through irrigation, the introduction and growth of edible plants, the organization of other species to protect from the sun, etc. The goal here was to provide the reader a new reading of the garden's enclosing wall as an architectural membrane that is constructed, as in biological organisms, not only to preserve the new order from the exterior forces that tend to upset it but also to conjoin the inside and the outside. The goal was to see the work of landscape architecture, therefore, as both a thing-in-itself, with its own ordering principles, and an interface through which the environment that lies beyond that order is rendered legible. It is through the garden, as I argued, that we comprehend the desert.

I have used these ideas on internal versus external relations to revisit some of the key landscape architecture projects of the late nineteenth century—such Olmsted's Central Park and, especially, Charles Eliot's Boston Metropolitan Park System—where some ecological ideas of interdependence began to be implicitly formulated. And then I have turned, as in the previous chapter, to a contemporary landscape architecture project, in this case, the right river bank by Michel Desvigne, also in Bordeaux. The project has been presented as a rather open-ended and individualistic developmental strategy, responsive to the uncertainties of the market-driven process by which the post-industrial land upon which it intervenes is being progressively decommissioned. I have used its prototypical approach to emphasize the idea of landscape prototype as system, that is, as a number of elements that are integrated into some sort of unified structure by means of a set of geometric and algebraic generative rules. I have also discussed the irregular, loose, open-ended succession of spaces that derives from the replication of the prototype as a clear expression of a modular understanding of landscape, where the recurrence of specific formal gestures at the local scale creates the possibility that we can apprehend structure at the large scale. I have argued that the resulting design entity is, as in ecology, not a positive one separated from its constitutive other by means of a hard boundary condition but instead an entity that emerges as an abrupt and deliberately induced intensification in the environmental matrix of interactions—a synthetic landscape architecture entity, in sum, that engages the environment, one that is not placed in it but, rather, continuous with it. One for which the environment is not transcendental but, rather, immanent.

The last chapter, chapter 7, has focused on the relationship between tension and equilibrium, departing from the idea of equilibrium as the state of a system where no further change is likely to occur. The notion of equilibrium has been discussed in both thermodynamic and ecological terms, emphasizing the organismic idea that plant associations simply exist in equilibrium with climate and will not change unless there is a new input—a disturbance—that changes those conditions. In this chapter I have emphasized the idea that every work of landscape architecture entails an input of energy, the idea that every work of landscape architecture implies a change in the existing order of a site, be it in equilibrium or not, and the idea that, for the introduced orders to persist (to be maintained), a continuous input of energy (of maintenance) is often necessary, otherwise landscapes will eventually move back to a zone that is closer to equilibrium, to an order that offers higher resistance to be changed (*Figure c.1*). I have looked at the decade of the 1960s, where ecology was for the first time consciously engaged in landscape architecture, and I have revised notions of equilibrium in the work of McHarg and notions of chance and tension in Halprin before focusing, as in previous chapters, on contemporary practices. I have looked at Kate Orff's Scape "Living Breakwaters" competition in New York to then turn to the comparison of Teresa Galí-Izard's Central Park in Valencia as a project of extremely intense management regimes that seek to produce a landscape condition continuously far from equilibrium, vis-à-vis Georges Descombes' provocative exercise for the renaturalization of the river Aire, in Geneva, a radically different approach where the processes of dissipation of the energy contained in the flowing water are celebrated in the absence of any form of maintenance, thereby emphasizing a reading of the resulting landscape as a temporal synecdoche, as just one phase in the longer duration of a continuous process of change.

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As this schematic overview makes clear, each of these three chapters offers an extended commentary about different periods in the history of western landscape architecture, before they conclude with one or two examples of contemporary design. Chapter 5, in this sense, has focused in botanic gardens during the modern era and up to the turn of the nineteenth century; chapter 6 has looked at projects of the second half of the nineteenth century; and chapter 7 has focused on ecologically-informed landscape architecture of the mid-late-twentieth century. In trying to counterbalance the already mentioned shift towards the instrumental and the operational in landscape architecture—primarily motivated from the North American academia—the contemporary practices discussed are practices that, although certainly acquainted with the leading practices and theoretical discourses that have motivated such shift, remain relatively indifferent—and sometimes even cynical—to them. Of the examples that I have looked at in detail, one of them is in fact North American—Kate Orff's competition in Staten Island, New York—but the rest are European; Mosbach's botanic garden and Desvigne's right river bank are both in Bordeaux, France; Galí-Izard's park is in Spain, and Descombes' project is in Geneva, Switzerland. The dissertation might be read, in this sense, as an implicit opposition between contemporary landscape architecture practices on both sides of the North Atlantic.

I want to clarify, in this sense, that the sampling is informed by the modes of practice that I have been more exposed to because of my personal trajectory, but, more importantly by the fact that these European projects constitute representative examples of other modes of landscape architecture practice that have developed less explicit connections with the field of ecology, and which have remained, in many respects, less susceptible to the various forms of ecological cooptation that are observed in the United States context—and which I have explained with detail in chapter 2. This is partially due to the fact that, since the early decades of the twentieth century, the development of ecology both as a science and a worldview has primarily taken place in North America, and, as a result, American landscape architects have been long exposed to ecological ideas and concepts put forward in the interpretation of an environment polarized between vast wilderness and highly industrialized landscapes. In most European practices, on the contrary, ecology is more often invoked as just one other factor in the equation that seeks to explain relationships and evolutionary processes in a landscape that is rather seen as a thick palimpsest made of millennia of heavy management and agronomic culture. References to agriculture and forestry are, in this sense, much more frequent than those to ecology in Mosbach and Desvigne, for example, whose work often seeks to internalize agricultural aesthetics in the design of public spaces; not to mention Galí-Izard, who enters the practice of landscape architecture with a highly technical background in agronomic engineering.

Although the dissertation has implicitly built this dualism between North American and European case studies, the exploration of contemporary examples of landscape architecture from other latitudes and geographic locations, particularly from South America and East Asia, remains, of course, a potential ramification of the work, which I would be willing to work on in the near future as part of a long term and more ambitious project—an ecological atlas of contemporary landscape architecture. And not only geographically, I am also aware of the potential of expansion of this work in historic terms, for which I have attempted to anticipate some preliminary steps.

In the sense, although at the end of chapters 5, 6, and 7 I concentrate, as I have just explained, on contemporary practices and their formal engagement of ecological ideas, the wide range of projects that I touch upon in the construction of these frameworks indicates that the vision of the dissertation is more panoramic than focal. A vision that I hope will constitute a contribution to the construction of a historiography of landscape architecture that brings environmental questions to the foreground. While contemporary landscape architecture theories today build upon arts and social sciences models as well as on environmental models, the scholarship on the history of landscape architecture still shows a remarkable lack of interest in ecology. Only recently has some interesting work focused on environmental history, cultural geography, and botany.[2] In this sense, Persian and Islamic studies have been particularly relevant for their role in the establishment of the landscape's fundamental archetype, the garden, and for the role that the great environmental pressures existing in these geographic contexts have played in the development of these landscape architecture traditions. If we look, on the contrary, to the history of Western landscape architecture we find that Italian, French and English gardens—those that have mobilized more scholarship on landscape architecture history than any other geographical areas or

[2] The work of James Wescoat deserves mention in this regard. See, for example, *Aga Khan Foundation, Sustainable Landscape Design in Arid Environments* (Geneva: Aga Khan Trust for Culture, 1996).

historical periods up to date—are largely empty of environmental or ecological content.[3] Particularly remarkable is, in this sense, the scarcity of ecological commentary in the study of the eighteenth century English pastoral landscape and, through it, in the theory of the picturesque. As I discussed in chapter 5, it is my contention that the picturesque affinity for ideas of intricacy and complexity can certainly play a mediating role between ecological and artistic endeavors in contemporary landscape architecture, a topic that I definitely intend to explore in depth in the near future.[4]

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Finally, I would also like to make a comment on the general content of the dissertation. I have consciously centered the discussion on the role of landscape architecture as a cognitive instrument to formally approach different ecological worldviews. There is, however, an underlying discourse throughout the whole dissertation that is less concerned with the organization of environmental systems and processes

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[3] For a detailed account in the historiography of Italian and French landscape architecture, see Mirka Benes and Dianne Harris, "Introduction," in *Villas and Gardens in Early Modern Italy and France*, ed. Mirka Benes and Diane Harris (Cambridge UK: Cambridge University Press, 2001), 1-25, where Benes discusses a rise of landscape design studies based on social, political, and, more recently, geographical theories, that came to complement the longtime prevailing art-historian approach. However, Benes does not mention any author that has explicitly worked with ecological or environmental concerns in Italian landscape history, neither as drivers, nor as consequences.

Also according to Benes, the scholarship on French historic landscapes feeds, chronologically, on four main traditions: artistic patrimony, art history, linguistic studies and literary stories, and territorial systems and their technology. The most recent of these is the one that touches more clearly upon the environmental dimension of landscape. We need to mention here the work of Antoine Picon, who has studied the impact of cartographical achievements and engineering technologies in the territorial configuration of seventeenth century France, opening a door for further exploration of the relationship between the French historical landscape design and its ecology. A more explicit connection can be found in Thierry Marriage's work on André Le Nôtre, where he claims that early seventeenth century agronomic treatises had an important influence in the layout strategies that Le Nôtre employed in most of his designs. See, for more information on environmental question in the history of French landscape gardening, Antoine Picon, "A Productive Countryside," in *French Architects and Engineers in the Age of the Enlightenment* (Cambridge, U.K.: Cambridge University Press, 1992), 211-255, Thierry Mariage, *The World of André Le Nôtre* (Philadelphia: University of Pennsylvania Press, 1999), and Franklin Hamilton Hazlehurst, *Jacques Boyceau and the French Formal Garden* (Doraville: University of Georgia Press, 1966).

[4] See, in this sense, Isis Brook, "Wildness in the English Garden Tradition: a Reassessment of the Picturesque from Environmental Philosophy," in *Ethics and the Environment* 13, no. 1 (Spring, 2008), 105-119.

than it is with the social and political significance that these formal operations entail. In trying to unveil the ways in which the environment is put together and in dealing with the human factor as just another organism in the environmental equation, ecology inevitably faces questions around the involvement of human actions in the very production of the conditions of existence for both human and non-human beings. Seen through this lens, as I discussed in chapter 1, ecology transcends its inaugural agenda of a science primarily invested in the understanding of the relationships between the organism and the environment and enters the even more complex area of inquiry about the extent to which the processes and relationships between different organisms should be affirmed, suppressed, manipulated, even defined, and for whose advantage or disadvantage. Ecology, it becomes evident, involves ethics and politics.

As I have already mentioned, the titles of chapters 5, 6, and 7, are formed through the association of two antithetical concepts, namely discreteness and continuity, transcendence and immanence, and tension and equilibrium. As I have explained only a few lines above, these are formulas that, on the one hand, parallel the dialectics through which ecological theory has approached the definition of the environment and, on the other, point to different formal operations by which landscape architecture might act as an epistemological project in approaching such definitions. As part of the affirmation of the inescapable ethical and political implications of ecological ideas, I would like to also acknowledge a third layer of meaning in the reading of these dual formulas that deals with their capacity to engage ideas of political agonism. While the dissertation clearly emphasizes the formal connotations of these words, they are also deliberately chosen for their political connotations, and it is my hope that the thoughtful reader will be able to recognize the subtext that underlies some stretches of the work and even recognize, in some cases, my personal preference towards certain positions.

Discreteness and continuity are, as it becomes clear in chapter 5, formal categories by which landscape gardening helped to give shape to different essentialist and nominalist conceptions of the natural order during the modern age—conceptions that, as some authors began to note during the eighteenth century also had moral connotations. At an age of great colonialist expansion, essentialist positions were extrapolated to the human species and served to sustain the theory of polygenism, according to which the different human races had different origins (polygenesis). Polygenism had its opposite in monogenism, which posited a common and single origin of humanity, and which is widely accepted today as a valid theory. Some of the arguments of monogenism were advanced, in spite of his contributions to the rampant scientific racism of the time, by the French naturalist Georges-Louis Leclerc, Comte de Buffon, whom I already alluded to in chapter 5 for being a key participant in the late eighteenth century transition towards nominalism in the natural sciences and the subsequent rejection of fundamental underlying essences in the definition of species.

It is clear, as well, that the discussion of transcendence and immanence in chapter 6 puts at its core the agonistic concepts of boundary, limit, and seclusion, and point directly to questions of what is inside, what is left outside, what is allowed to be continuous (and so on), which evidently have political connotations that go beyond the formal. I would also like to remind the reader that, as noted in the context of the discussion between tension and equilibrium in chapter 7, equilibrium is a general attractor for any system. As an attractor, I would like to remark here, equilibrium is just an unattainable illusion. Not only environmental or landscape systems but also social systems modulate across a tension-equilibrium spectrum, standing sometimes in zones relatively close to equilibrium and some other times in zones relatively far from it. All systems are continuously exposed to inputs of energy that induce different degrees of internal and external tension. These tensions are, therefore, inevitable yet necessary in any social system, as much as they are inevitable yet necessary in landscape architecture insofar as landscape architecture contributes to the construction of such systems.

I would argue, in this sense, that some of the most relevant questions that landscape architects might need to ask when facing a design project are: what is the degree of tension that is to be introduced in this portion of the environment? How far away from its zone of equilibrium is this landscape to be moved? And why? And for whom?

While asking these questions, I have very present, as I did when describing the spatial orders and agronomic landscapes in chapter 7, John Brinckerhoff Jackson's splendid definitions of landscape: "A landscape is not a natural feature of the environment but a synthetic space, a man-made system of spaces superimposed on the face of the land, functioning and evolving not according to natural laws but to serve a community; [it] is a space deliberately created to speed up or slow down the process of nature."[5] I have tried to use the word "nature" only where strictly necessary throughout the dissertation and, in this sense, I use "equilibrium" to refer to what Jackson's calls "natural laws." Following Jackson, I would also claim that orders of equilibrium need to be changed for the land to serve a community. But, again, following him, I would not suggest a radical transformation but a recalibration of those orders, a change that either speeds up or slows down their effects. Because the introduction of orders on the land that are too close to equilibrium—no tension at all—might cause those transformations to not fulfill the service they were intended for, but moving the land too far away from its zone of equilibrium—introducing, in other words, too much tension—might cause those new orders to eventually fail.

* * *

The ultimate aspiration of this work is to contribute to raise an awareness that different forms of ecological knowledge and different forms of landscape architecture adopt, consciously or not, specific positions across one or more of the spectrums defined by the extremes of discreteness and continuity, transcendence and immanence, and tension and equilibrium. And that, in so doing, both ecology and landscape architecture have the capacity and the responsibility of emphasizing different forms of reading and acting upon the environment. Both ecology and landscape architecture have, in conclusion, the capacity and the responsibility of revealing and transforming our different modes of interaction and evolution, as well as those of the entities which unfold independently from us but whose ground and fate we necessarily share.

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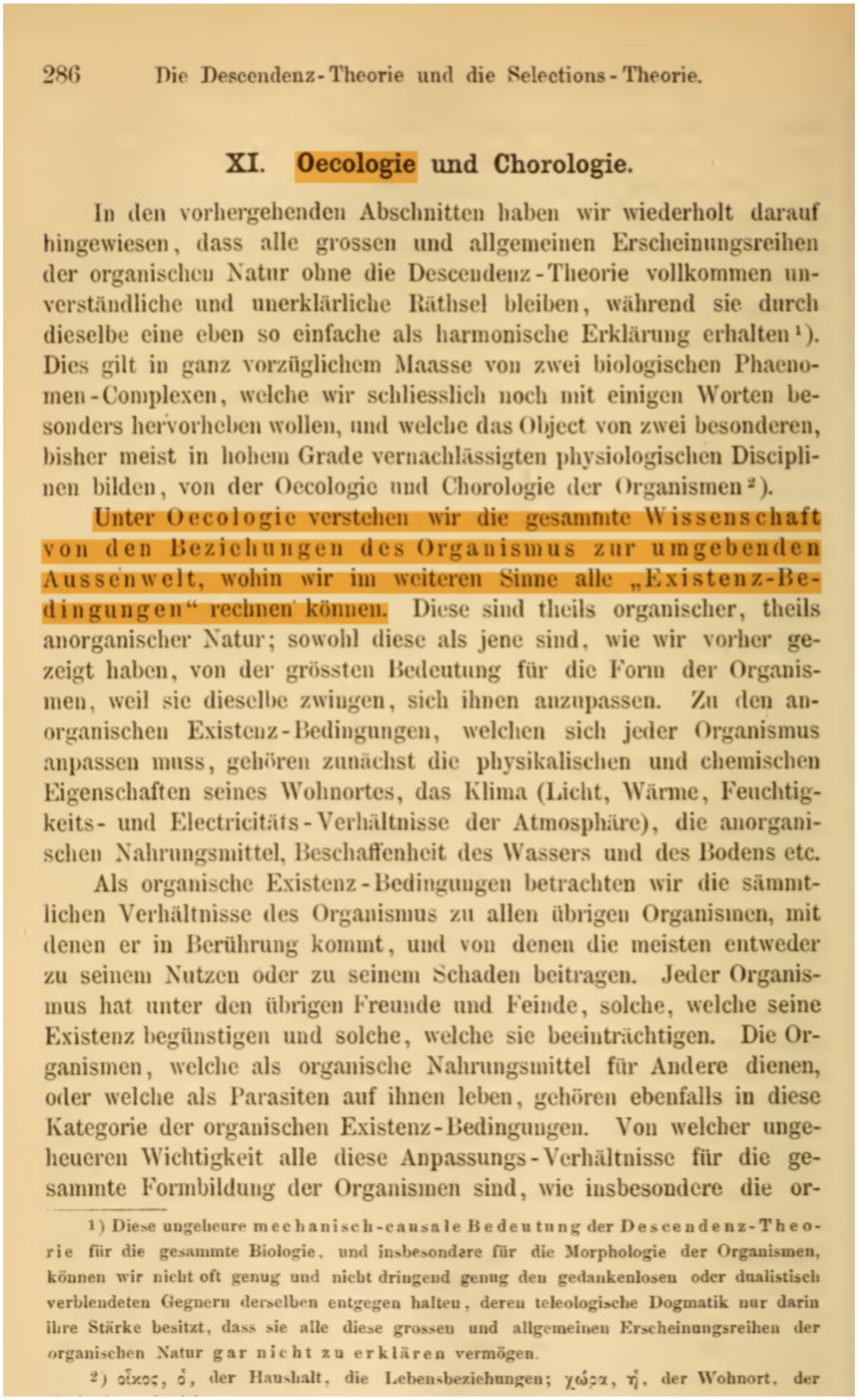
[5] John Brinckerhoff Jackson, "The Word Itself," in *Discovering the Vernacular Landscape* (New Haven: Yale University Press, 1984), 1-8.

APPENDIX

Illustrations

Figure i.1: Diagram of the structure of the dissertation.


286 Die Descendenz-Theorie und die Selections-Theorie.

XI. Oecologie und Chorologie.

In den vorhergehenden Abschnitten haben wir wiederholt darauf hingewiesen, dass alle grossen und allgemeinen Erscheinungsreihen der organischen Natur ohne die Descendenz-Theorie vollkommen unverständliche und unerklärliche Räthsel bleiben, während sie durch dieselbe eine eben so einfache als harmonische Erklärung erhalten [1]). Dies gilt in ganz vorzüglichem Maasse von zwei biologischen Phaenomen-Complexen, welche wir schliesslich noch mit einigen Worten besonders hervorheben wollen, und welche das Object von zwei besonderen, bisher meist in hohem Grade vernachlässigten physiologischen Disciplinen bilden, von der Oecologie und Chorologie der Organismen [2]).

Unter Oecologie verstehen wir die gesammte Wissenschaft von den Beziehungen des Organismus zur umgebenden Aussenwelt, wohin wir im weiteren Sinne alle „Existenz-Bedingungen" rechnen können. Diese sind theils organischer, theils anorganischer Natur; sowohl diese als jene sind, wie wir vorher gezeigt haben, von der grössten Bedeutung für die Form der Organismen, weil sie dieselbe zwingen, sich ihnen anzupassen. Zu den anorganischen Existenz-Bedingungen, welchen sich jeder Organismus anpassen muss, gehören zunächst die physikalischen und chemischen Eigenschaften seines Wohnortes, das Klima (Licht, Wärme, Feuchtigkeits- und Electricitäts-Verhältnisse der Atmosphäre), die anorganischen Nahrungsmittel, Beschaffenheit des Wassers und des Bodens etc.

Als organische Existenz-Bedingungen betrachten wir die sämmtlichen Verhältnisse des Organismus zu allen übrigen Organismen, mit denen er in Berührung kommt, und von denen die meisten entweder zu seinem Nutzen oder zu seinem Schaden beitragen. Jeder Organismus hat unter den übrigen Freunde und Feinde, solche, welche seine Existenz begünstigen und solche, welche sie beeinträchtigen. Die Organismen, welche als organische Nahrungsmittel für Andere dienen, oder welche als Parasiten auf ihnen leben, gehören ebenfalls in diese Kategorie der organischen Existenz-Bedingungen. Von welcher ungeheueren Wichtigkeit alle diese Anpassungs-Verhältnisse für die gesammte Formbildung der Organismen sind, wie insbesondere die or-

1) Diese ungeheure mechanisch-causale Bedeutung der Descendenz-Theorie für die gesammte Biologie, und insbesondere für die Morphologie der Organismen, können wir nicht oft genug und nicht dringend genug den gedankenlosen oder dualistisch verblendeten Gegnern derselben entgegen halten, deren teleologische Dogmatik nur darin ihre Stärke besitzt, dass sie alle diese grossen und allgemeinen Erscheinungsreihen der organischen Natur gar nicht zu erklären vermögen.

2) οἶκος, ὁ, der Haushalt, die Lebensbeziehungen; χώρα, ἡ, der Wohnort, der

Figure 1.1: Image of page 286 of the first edition in German of Ernst Haeckel's *General Morphology of Organisms*, where the word "ecology" was used and defined for the first time.

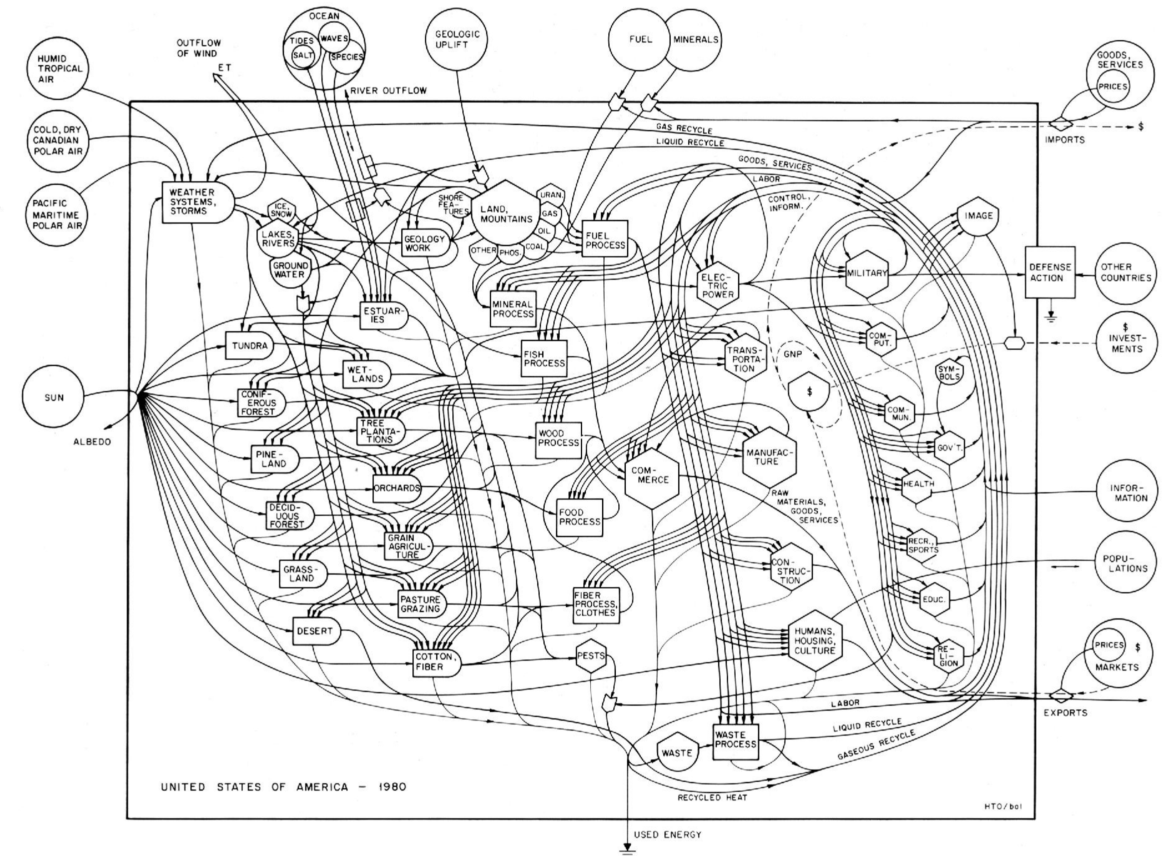


Figure 1.2: Aggregated model of the economy of the United States with sectors arranged in order of increasing energy quality from left to right, in Howard T. Odum, *Systems Ecology: An Introduction*, 1983.

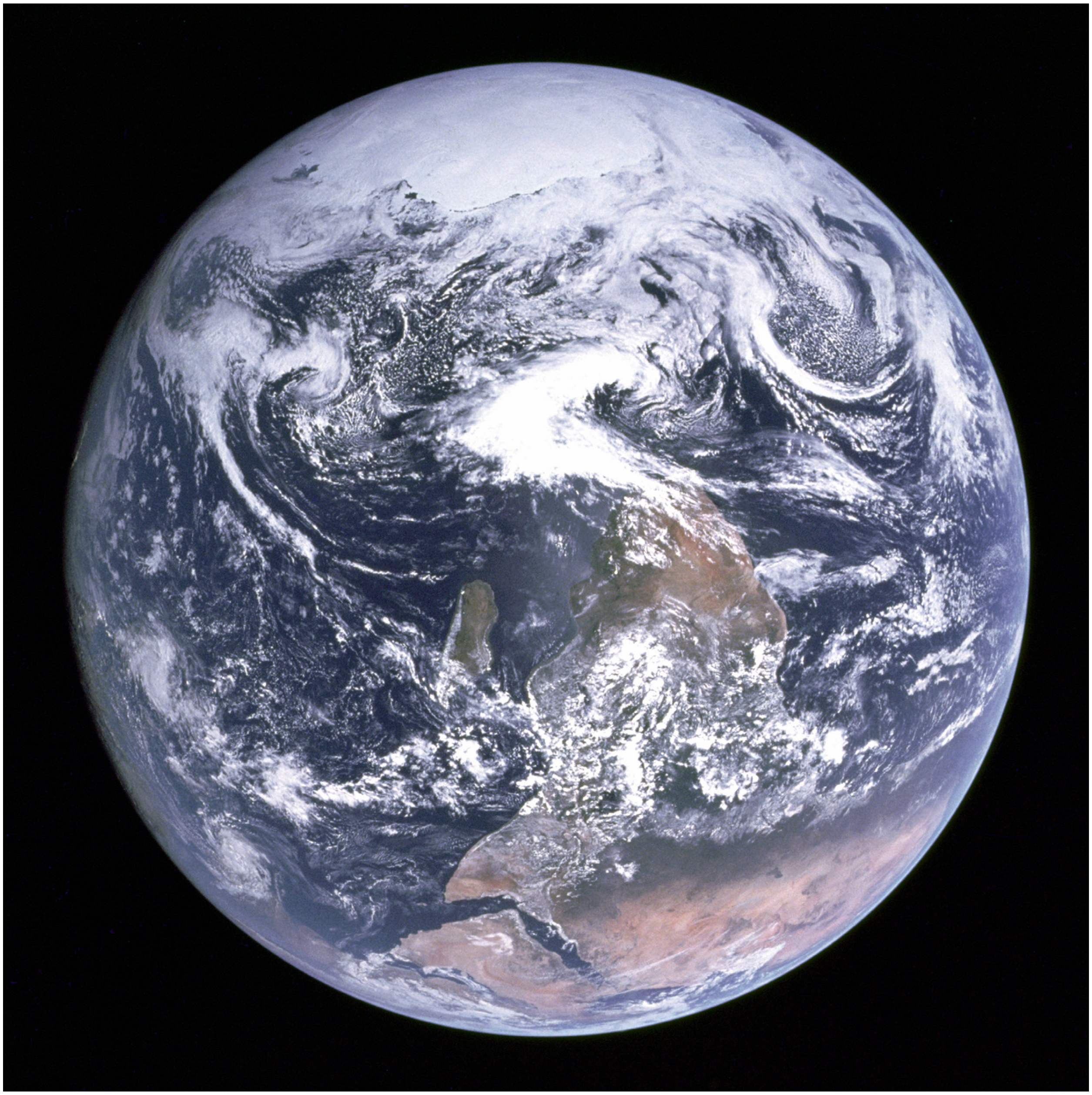


Figure 1.3: *The Blue Marble*, a photograph that became a symbol of the environmental movement, as it depicted the isolation and fragility of the planet in the immensity of space. It was captured on December 7, 1972, at 5:39 a.m. EST (10:39 UTC), from the Apollo 17 en route to the Moon at a distance of about 29,000 kilometers (18,000 mi), taken by either Harrison Schmitt or Ron Evans.

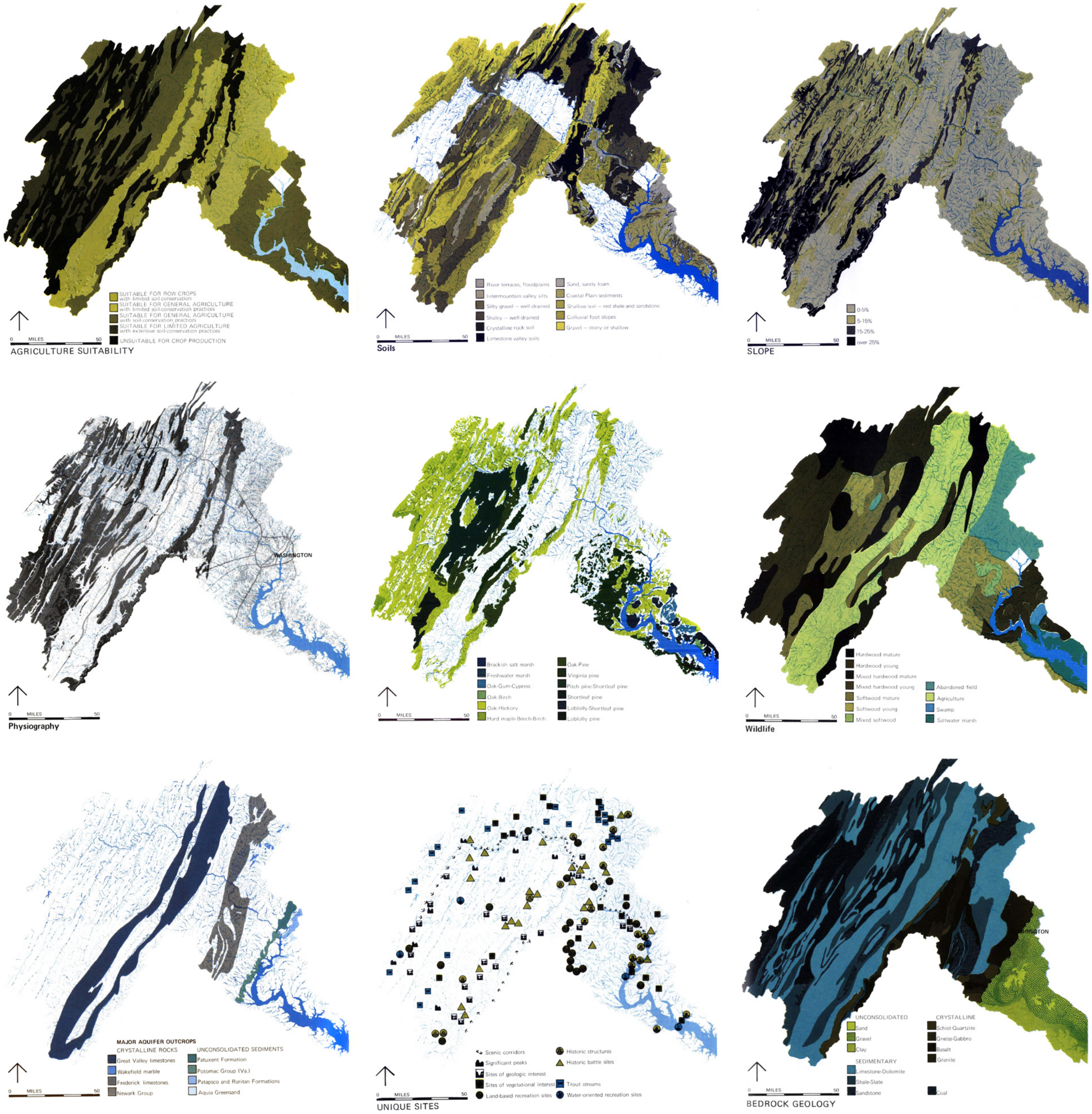


Figure 2.1: Ian McHarg, set of maps, *Potomac River Basin Study*, 1965-1966.

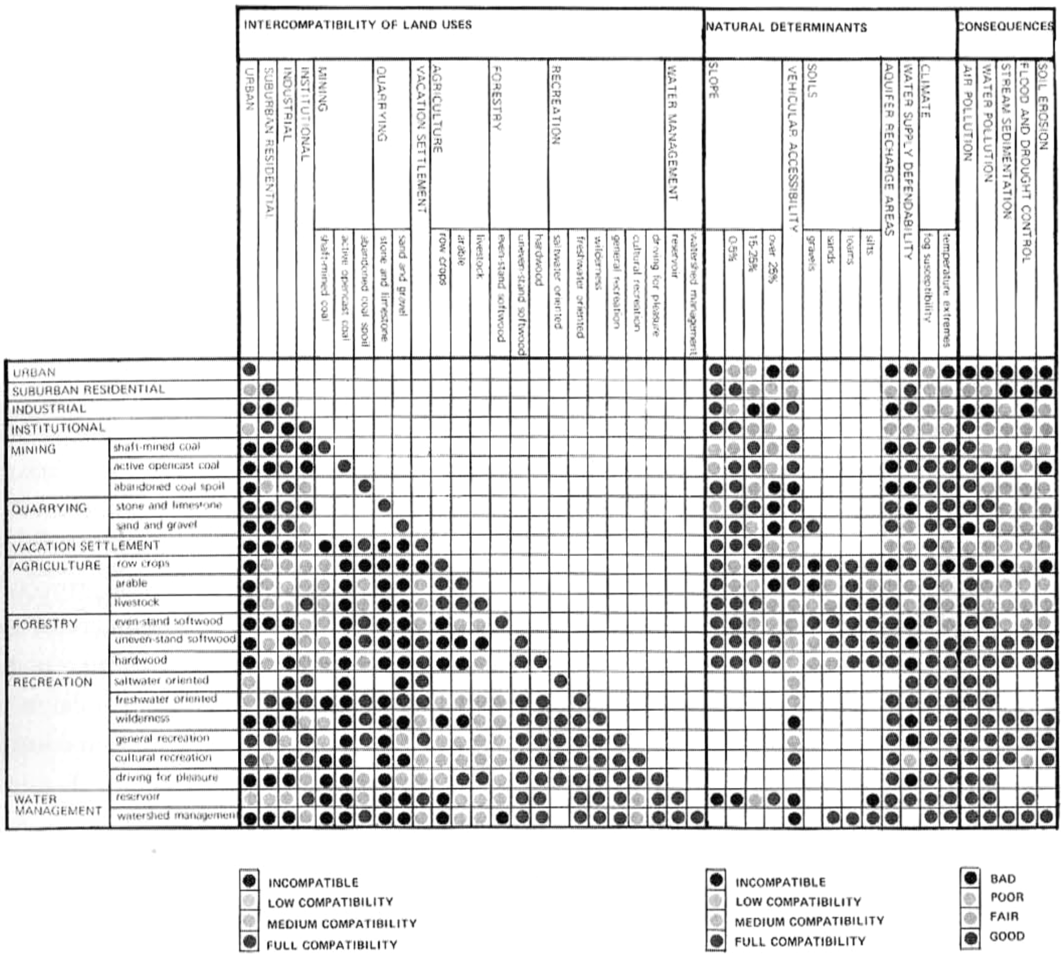


Figure 2.2: Ian McHarg, suitability matrix showing compatibility among land uses and various "natural determinants" and records the planners' assessment of potential conflicts and their consequences, *Potomac River Basin Study*, 1965-66.

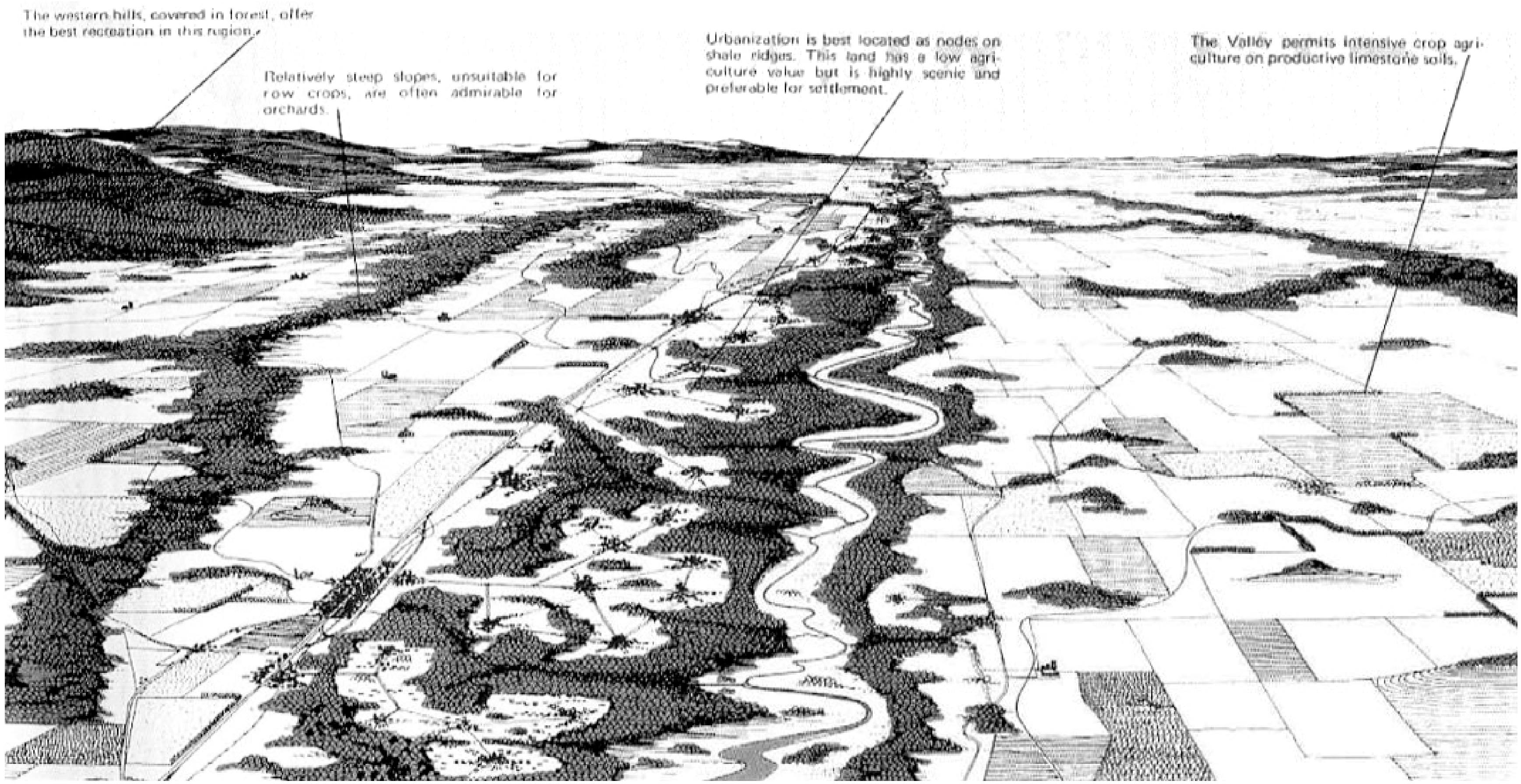


Figure 2.3: Ian McHarg, Great Valley physiographic region, *Potomac River Basin Study*, 1965-66.

Figure 2.4: Michael van Valkenburgh, *Radcliffe Ice Walls*, Harvard University, Cambridge, Massachusetts, USA, 1988.

Figure 2.5: Georges Hargreaves, *Candlestick Park*, San Francisco, California, USA, 1985-1993.

Figure 2.6: Richard Haag, *Moss Garden, Bloedel Reserve*, Bainbridge Island, Washington, USA, 1979.

Figure 2.7: Georges Descombes, cleaned glacial boulder, *The Swiss Way*, Uri Lake, Switzerland, 1987.

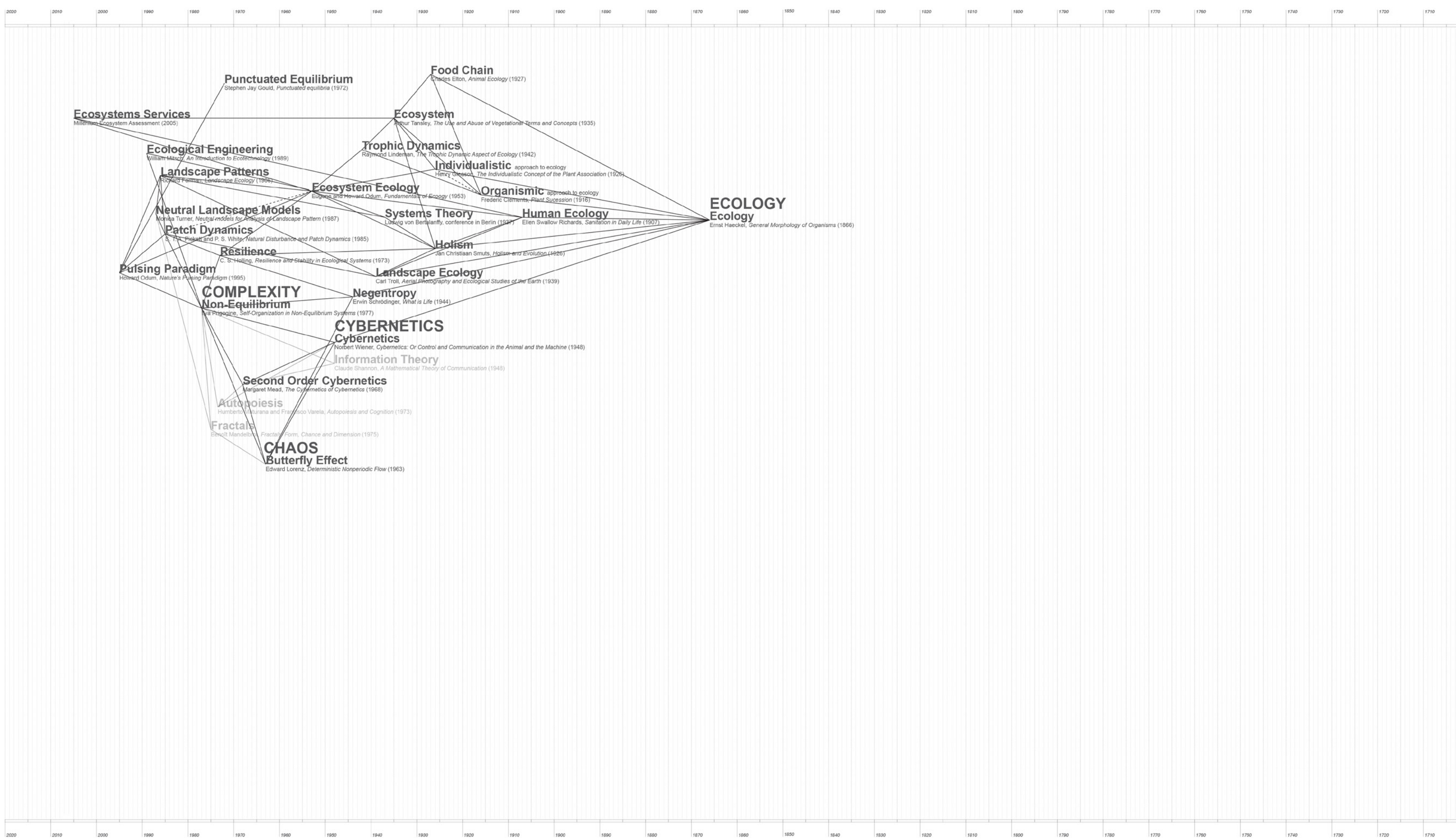


Figure 3.1: Reversed genealogy of ecological theory, twentieth century debates.

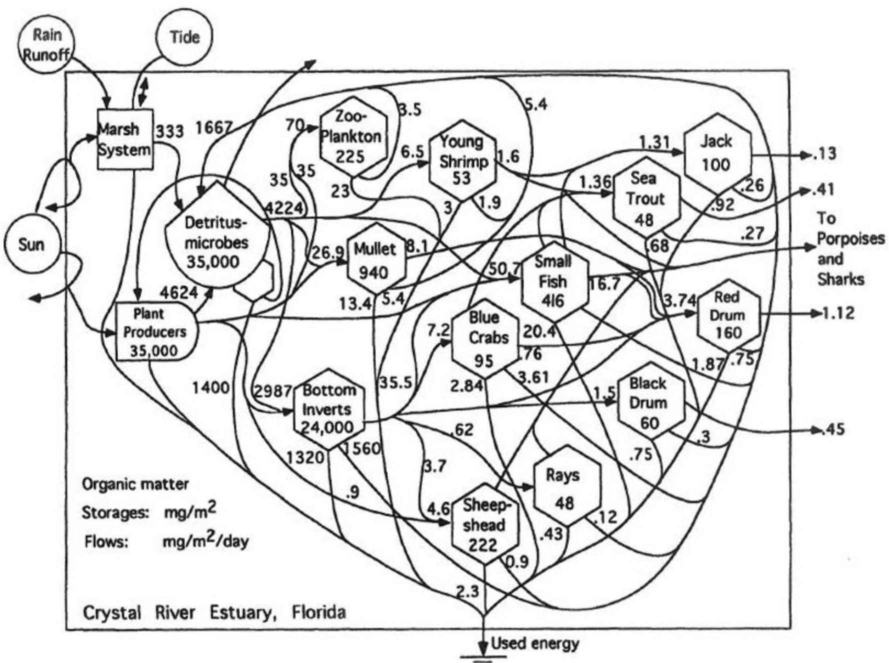
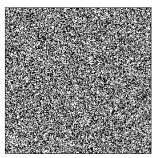
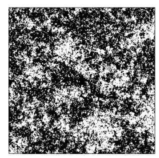
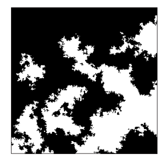


Figure 3.2: Howard T. Odum, diagram of the Crystal River Estuary, Florida, USA, 1998.

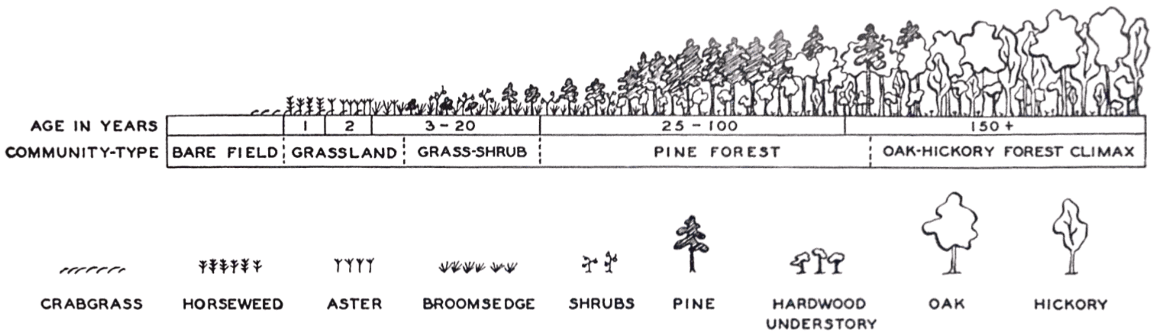
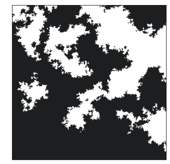
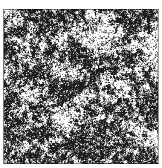
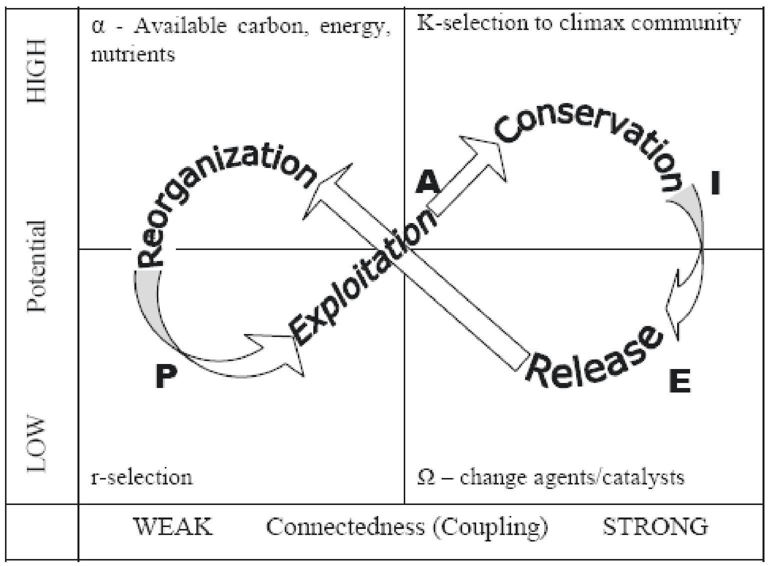


Figure 3.3: After Eugene P. Odum, diagram of secondary succession on the piedmont region of the southeastern United States, published in Eugene P. Odum, *Fundamentals of Ecology*, 1971.







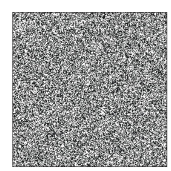


Figure 3.4: After C. S. Holling, diagram of the adaptive cycle, published in C. S. Holling, "Understanding the Complexity of Economic, Ecological, and Social Systems," 2001.

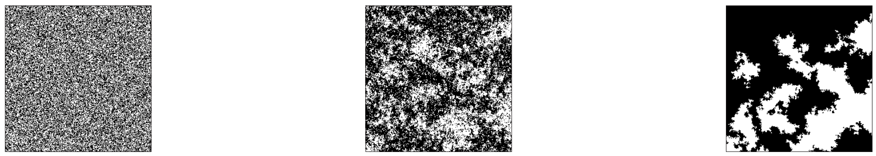


Figure 3.5: Deterministic versus probabilistic images of ecology, Blue Ridge Parkway in Pisgah National Forest in the Blue Ridge Mountains, North Carolina, USA.After David Oppenheimer.

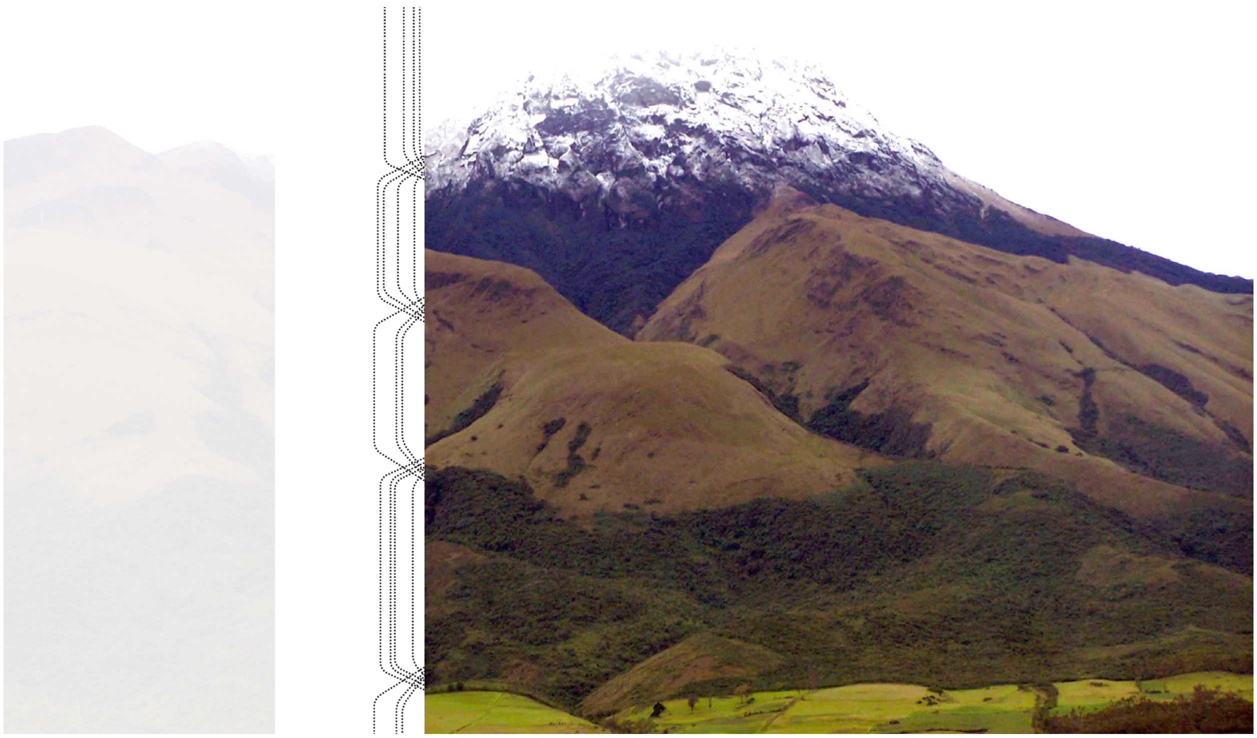


Figure 3.6: According to Frederic Clements' theory of the superorganism, the environment is organized in relatively discrete and uniform cognitive units, which he called plant formations or plant associations.

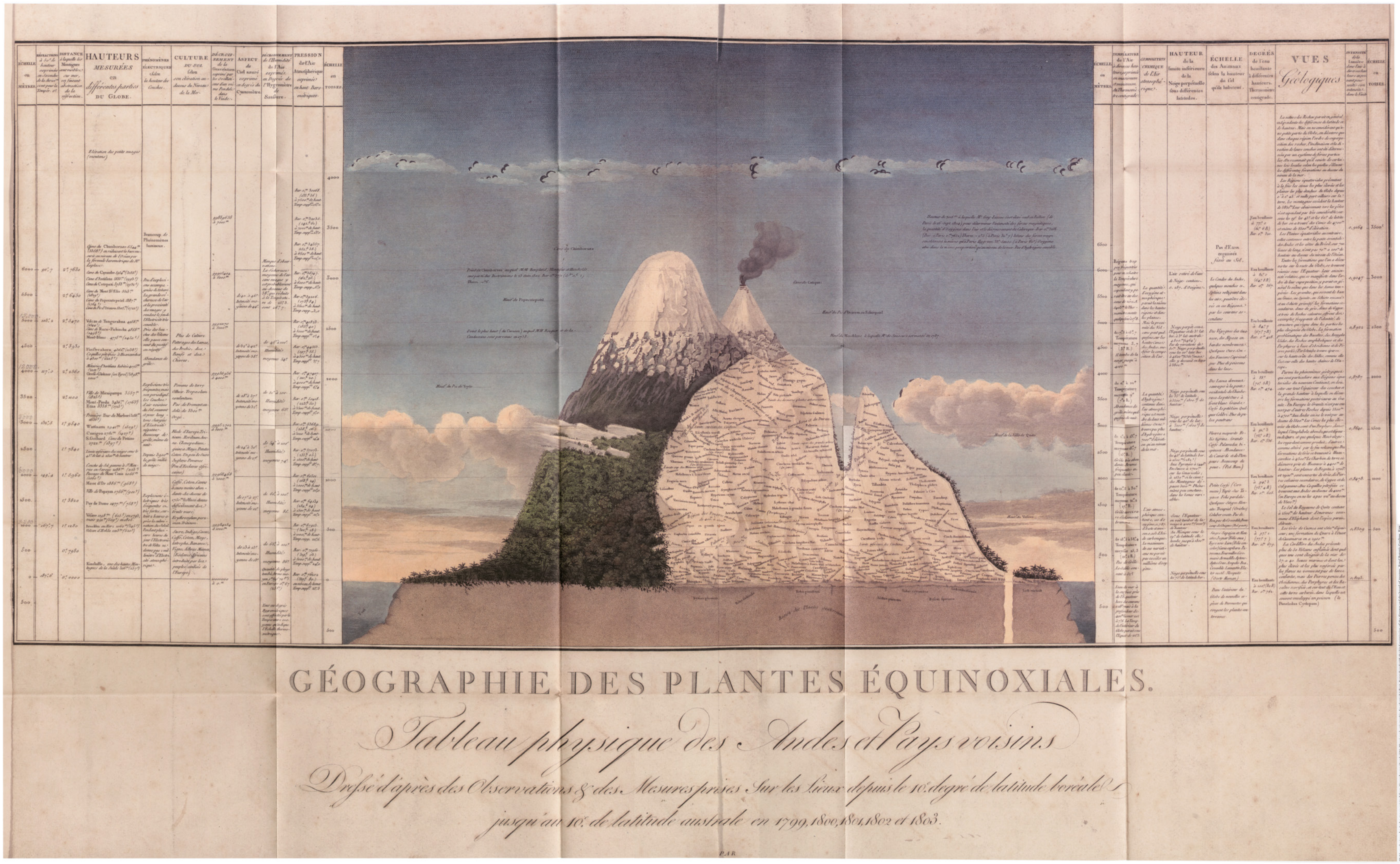


Figure 3.7: Alexander von Humboldt and Aimé Bonpland, "Géographie des Plantes Équinoxiales: Tableau Physique des Andes et Pays Voisins," table that accompanied their *Essay on the Geography of Plants*, published in Paris in 1807.

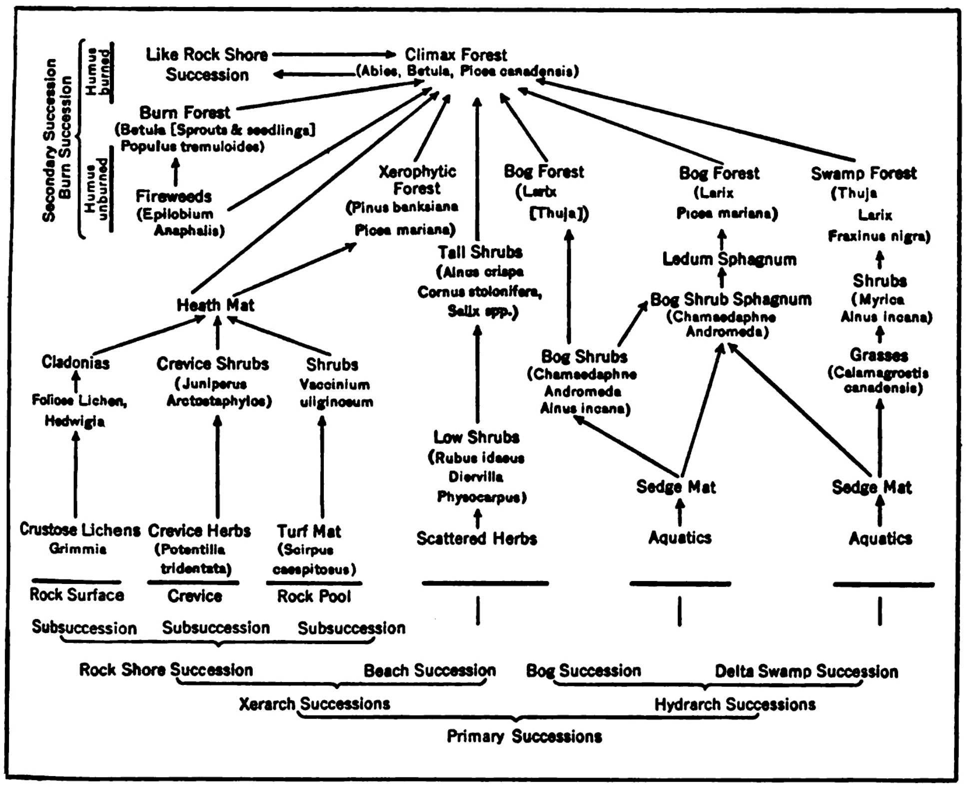


Figure 3.8: Frederic Clements, “Diagram of the development of climax forest on Isle Royale,” published in Frederic Clements, *Plant Succession*, 1916.

Figure 3.9: According to Henry Gleason, the vegetation growing on an area is the resulting combination of two different parameters, the fluctuating and contingent behavior of individual plants, responding to the equally fluctuating and contingent condition of the environment.

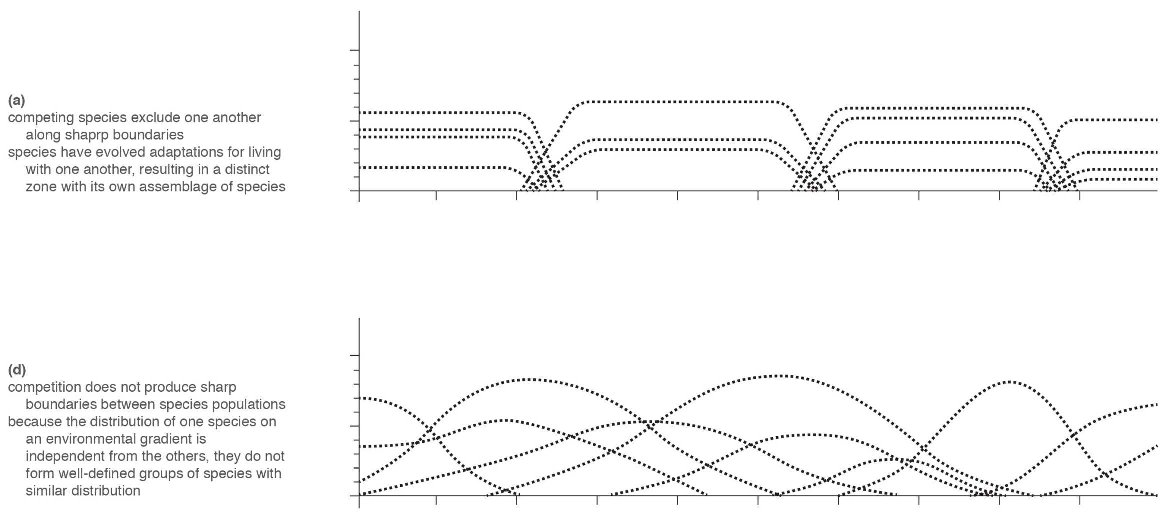


Figure 3.10: Plant associations versus individual organisms. Diagrams of species distribution along environmental gradients. After Robert Leo Smith, *Ecology and Field Biology*, 1996.

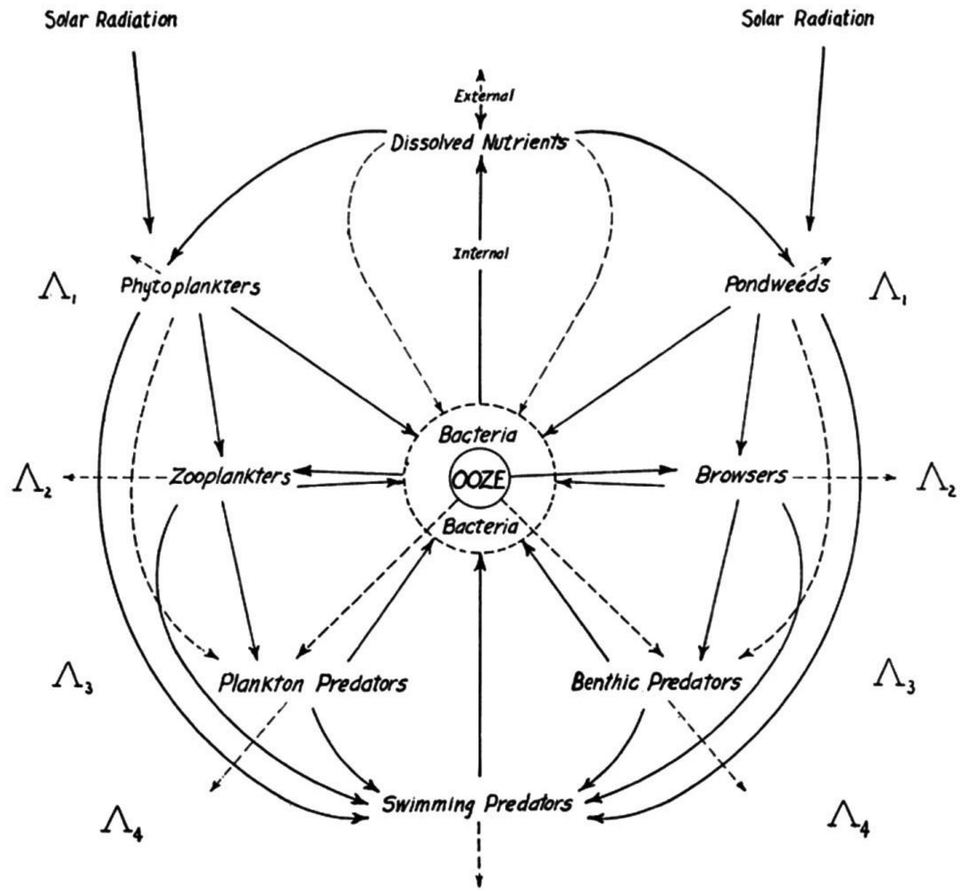


Figure 3.11: Raymond Lindeman, generalized lacustrine food-cycle relationships, published in Raymond Lindeman, “The Trophic-Dynamic Aspect of Ecology,” 1942.

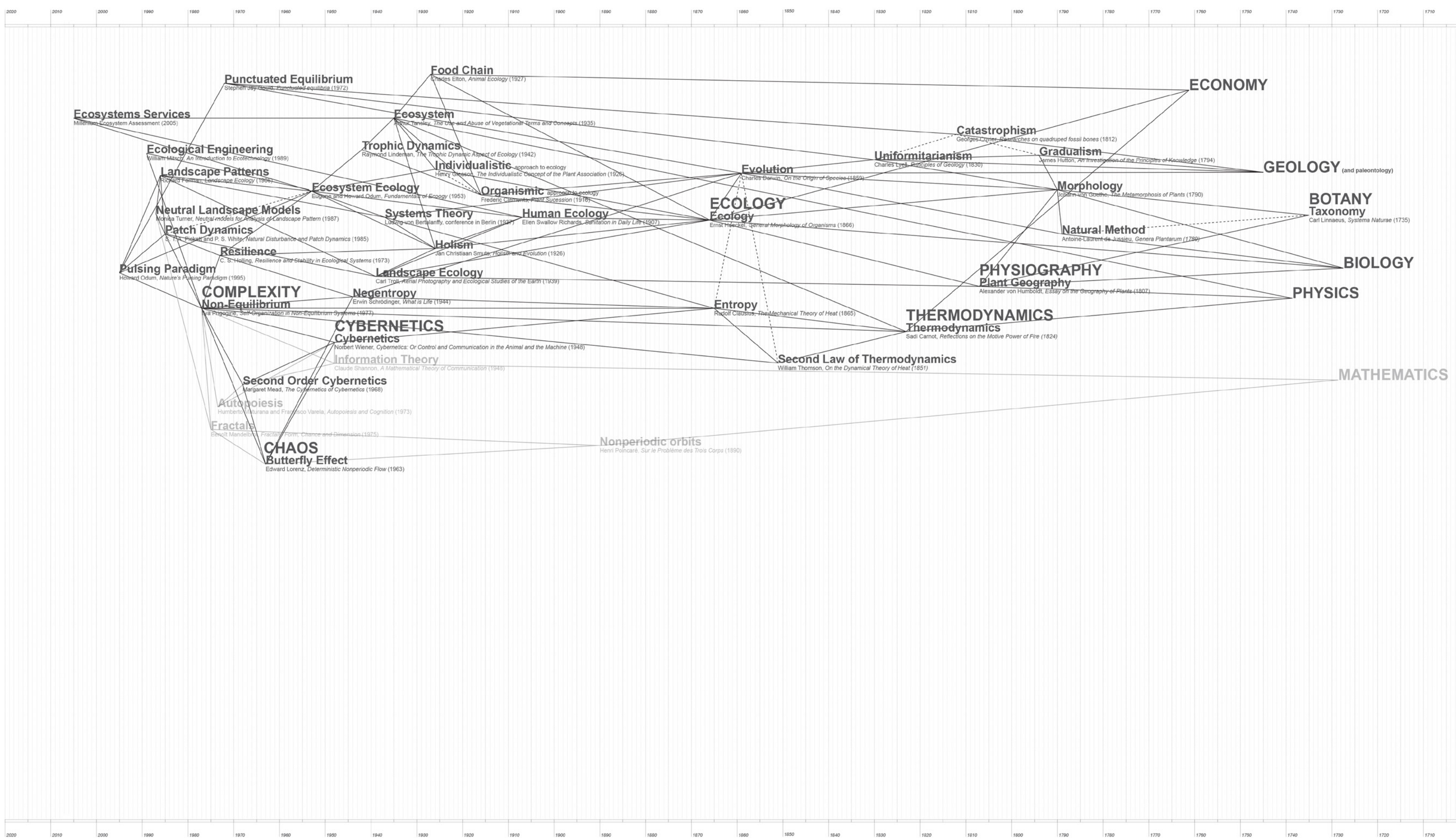


Figure 4.1: Reversed genealogy of ecological theory, nineteenth and twentieth century debates.

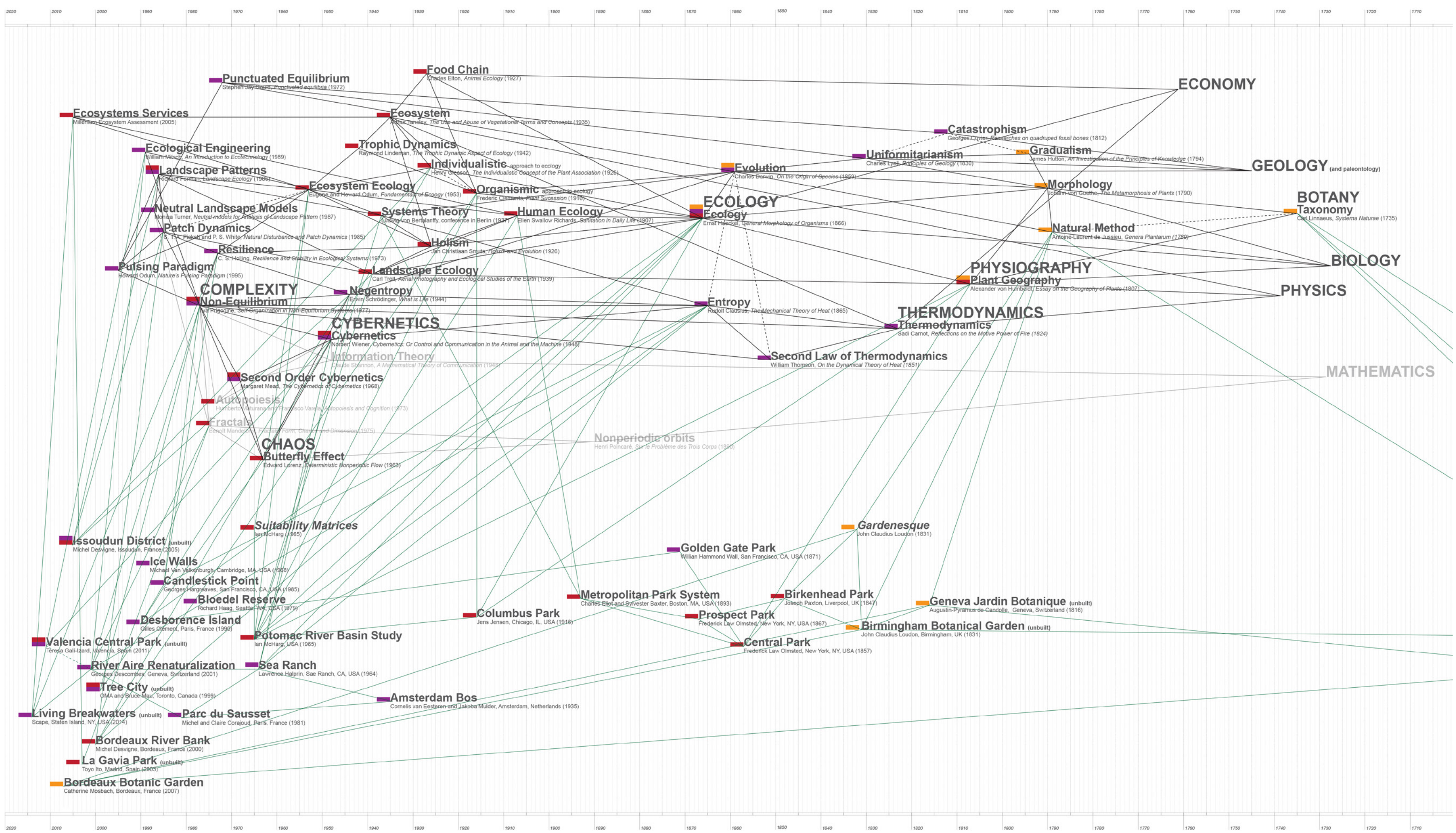


Figure 5.1: Reversed genealogy of ecological theory, nineteenth and twentieth century debates, and landscape architecture design case studies.

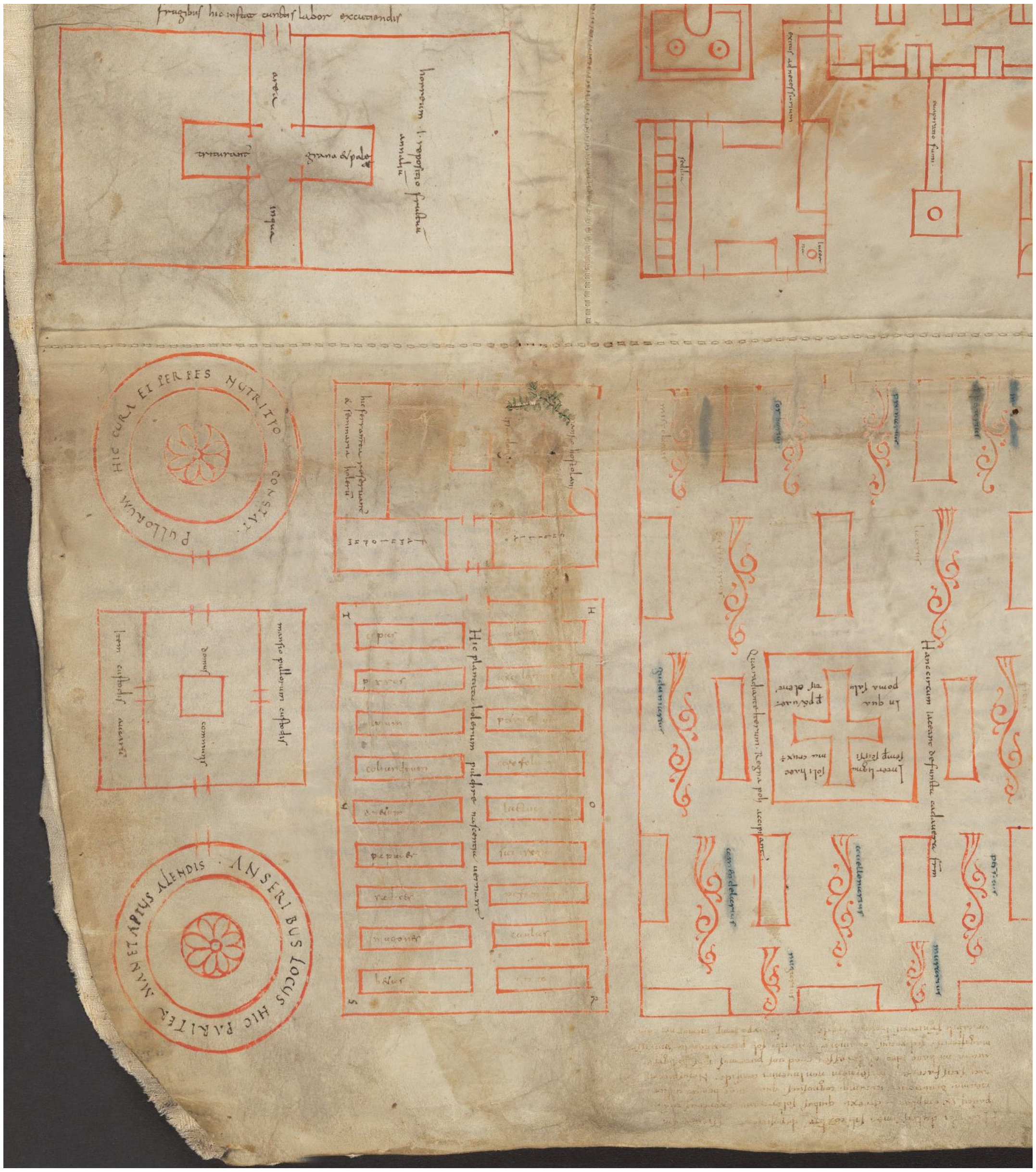


Figure 5.2: Fragment of the plan of Saint Gall Monastery, with detail of the medieval medicinal herb garden, *Codex Sangallensis*, 1092.

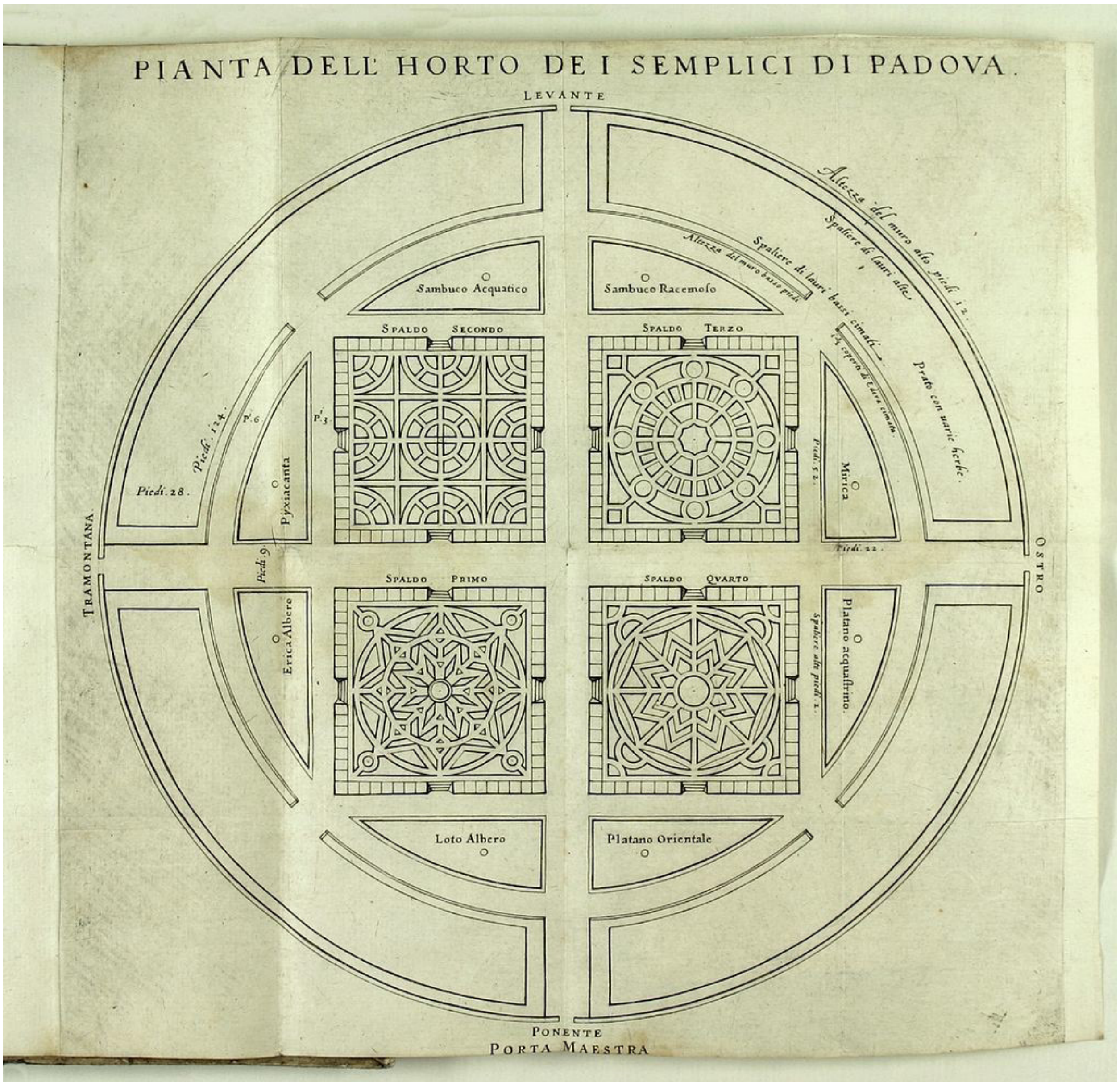


Figure 5.3: Plan of the Botanic Garden at Padua showing the exhaustive intricacy of the subdivision of the quadrants into the small planting beds. Girolamo Porro, *Plan of L'Horto de i Semplici di Padova*, 1592.

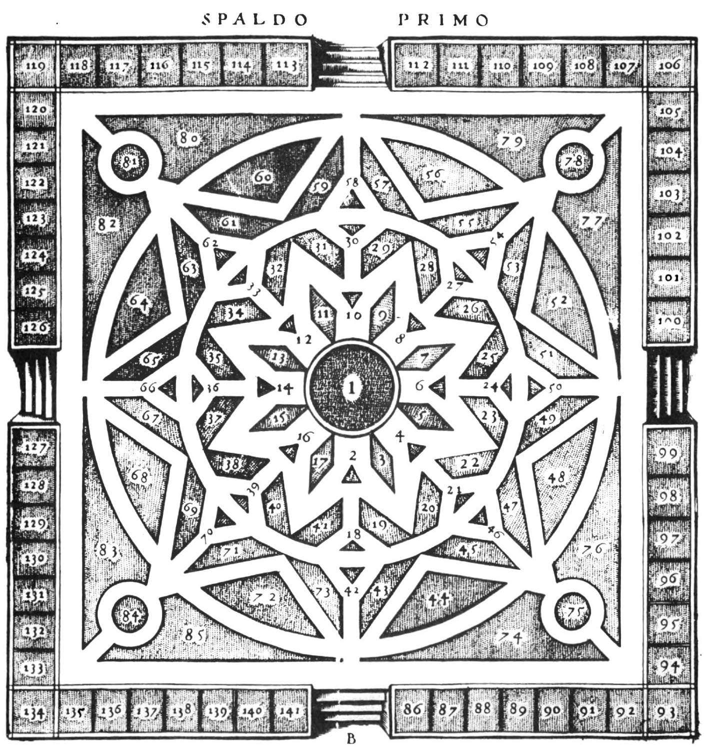


Figure 5.4: First quadrant of the Botanic Garden at Padua showing the numbering of the beds. Girolamo Porro, *Spaldo Primo de L'Horto de i Semplici di Padova*, 1591.

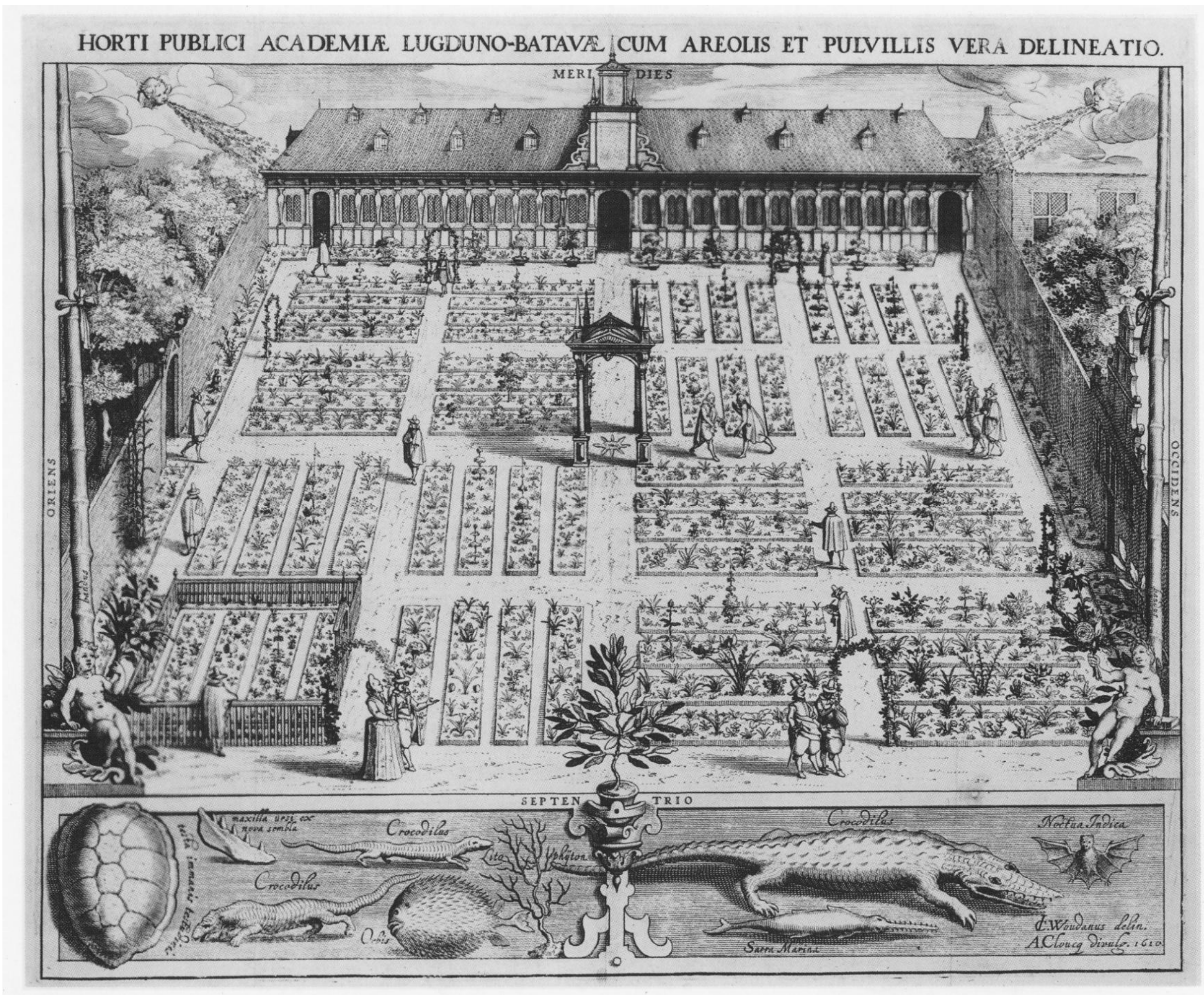


Figure 5.5: Plan of the *Hortus Botanicus* in Leiden, showing the regular and austere arrangement of the planting beds, reminiscent of the medieval *herbularia*. Engraving by Jan Cornelisz Woudanus, 1610.

Figure 5.6: *Hortus Upsaliensis* in 1745, after the changes introduced by Carl Hårleman and Carl Linnaeus. Illustration from Linnaeus' dissertation "*Hortus Upsaliensis*," of 1745.

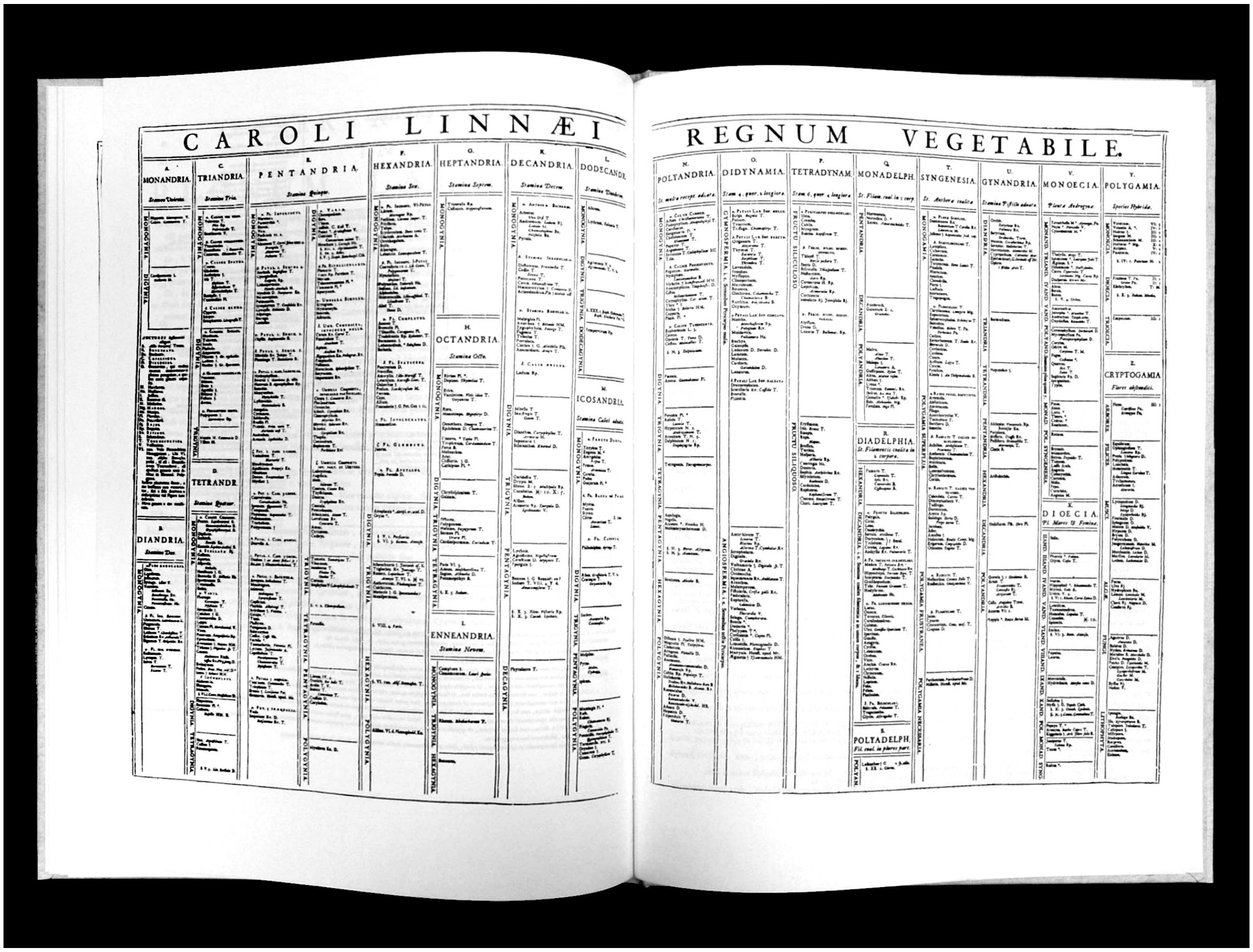


Figure 5.7: Table of the vegetal kingdom as conceived by Linnaeus. Carl Linnaeus, *Regnum Vegetabile*, published in “Systema Naturae,” 1735.

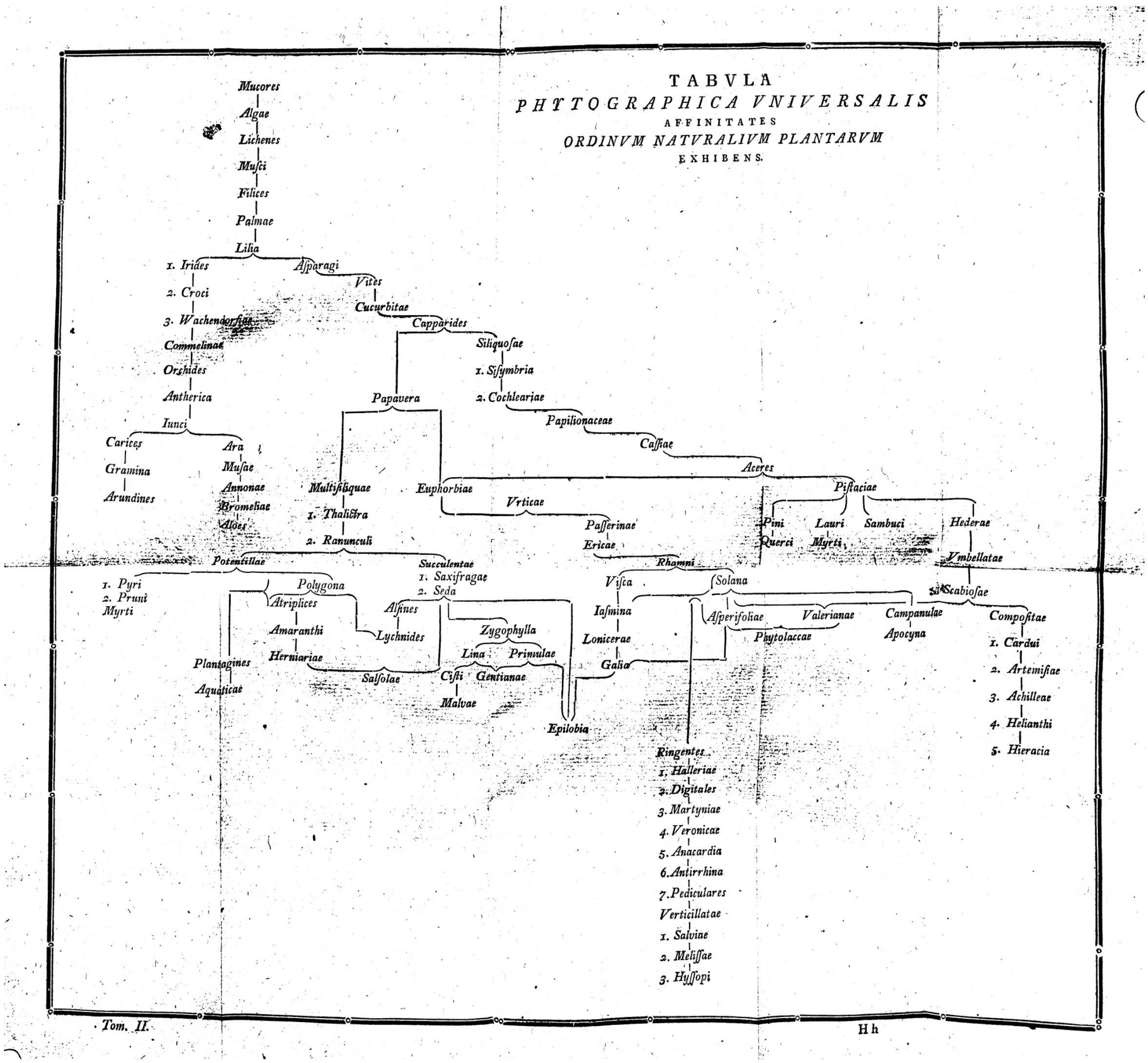


Figure 5.8: Johann Philipp Rüling, Complex Reticulae Relationships, 1793.

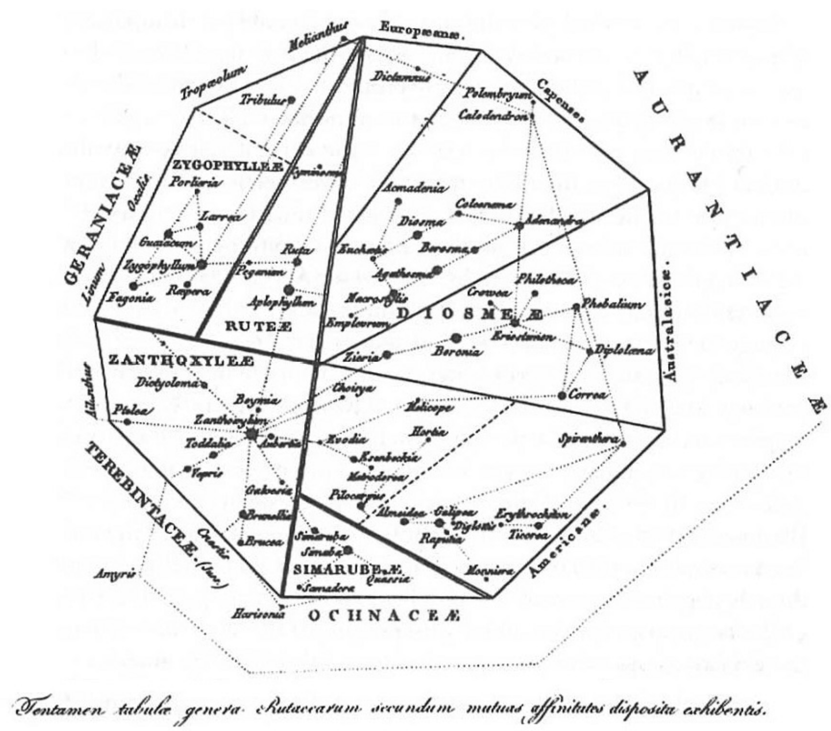


Figure 5.9: Adrien de Jussieu, Subdivision of a Reticulum in the Rutaceae, 1825.

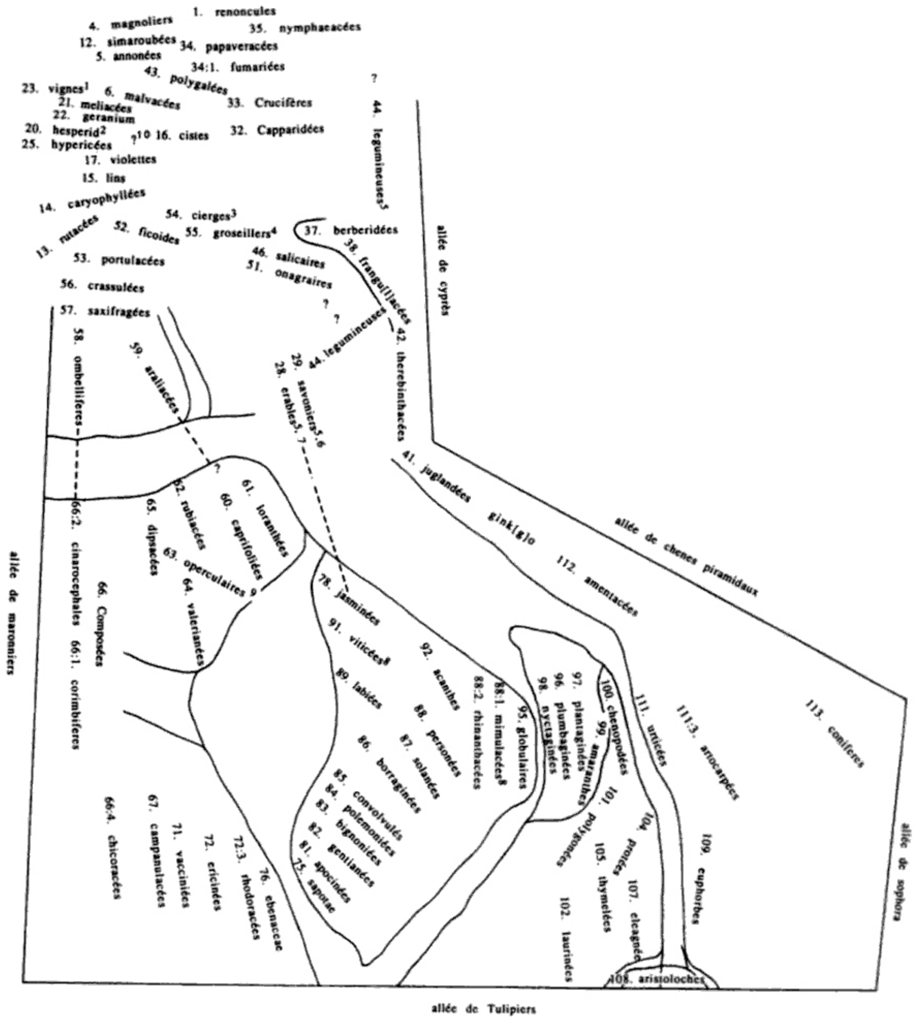


Figure 5.10: Augustin-Pyramus de Candolle, "Landscape of Nature," a Botanical Garden, 1816. Drawing elaborated by Peter F. Stevens from a copy at the Jardin botaniques, Genève, and published in Peter F. Stevens, *The Development of Biological Systematics: Antoine-Laurent de Jussieu, Nature, and the Natural System*, 1994.

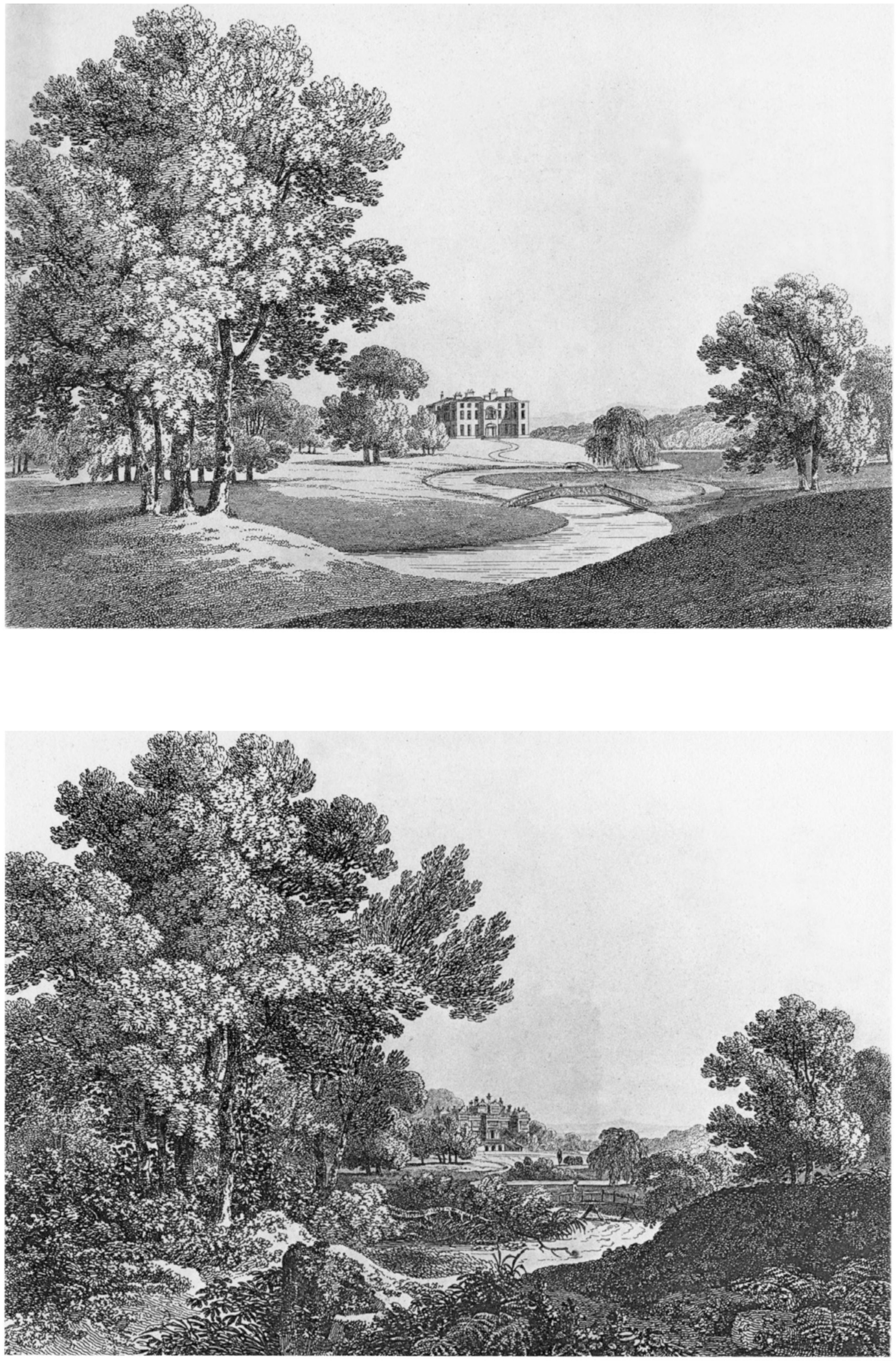


Figure 5.11: Comparative drawing of the pastoral landscape gardening canon (top) versus the picturesque one (bottom). Thomas Hearne and Benjamin Thomas Pouncy, engravings for Richard Payne Knight's poem "The Landscape," 1794.

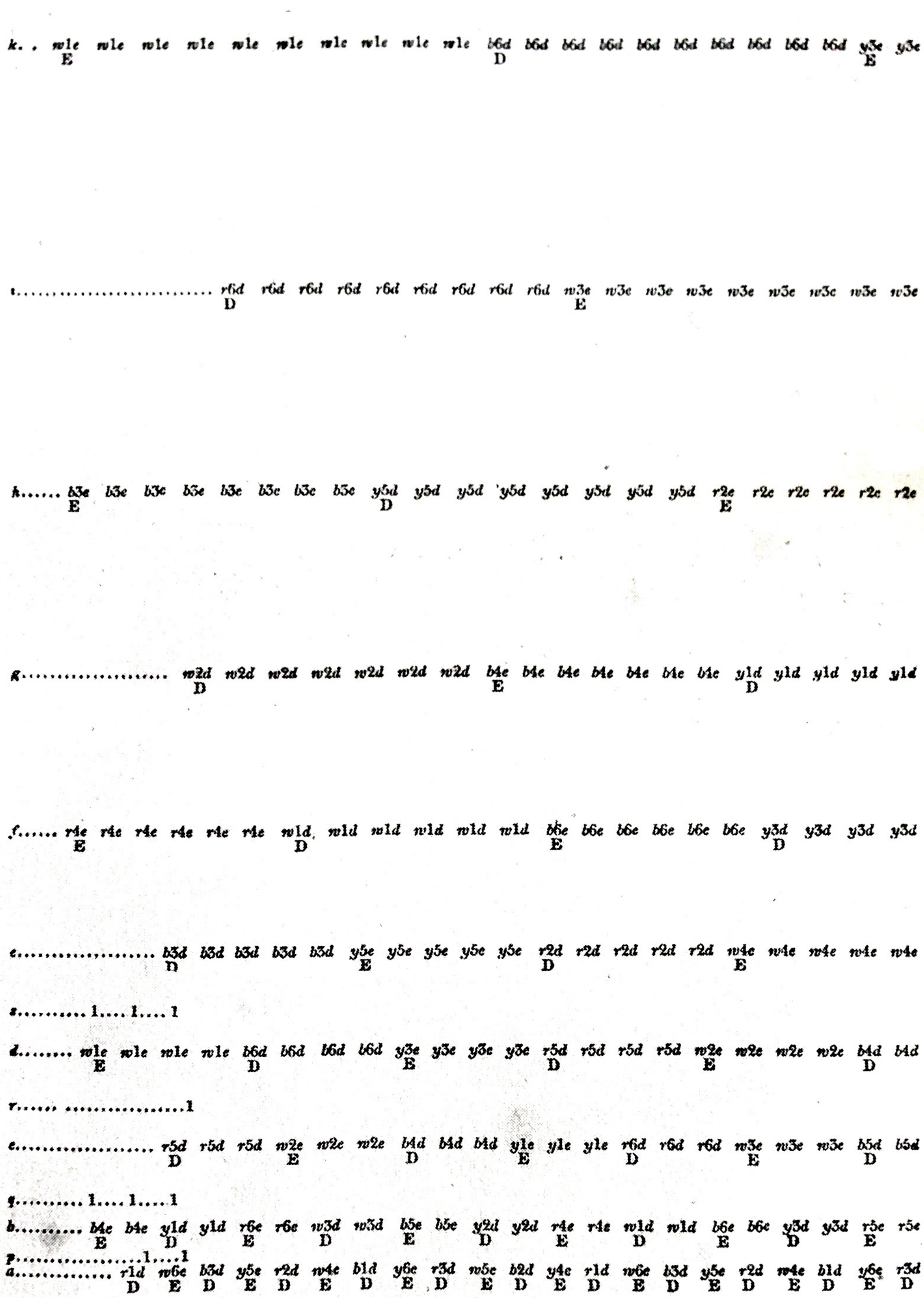


Figure 5.12: John Claudius Loudon, planting arrangement in the mingled manner, published in *An Encyclopaedia of Gardening*, 1824.

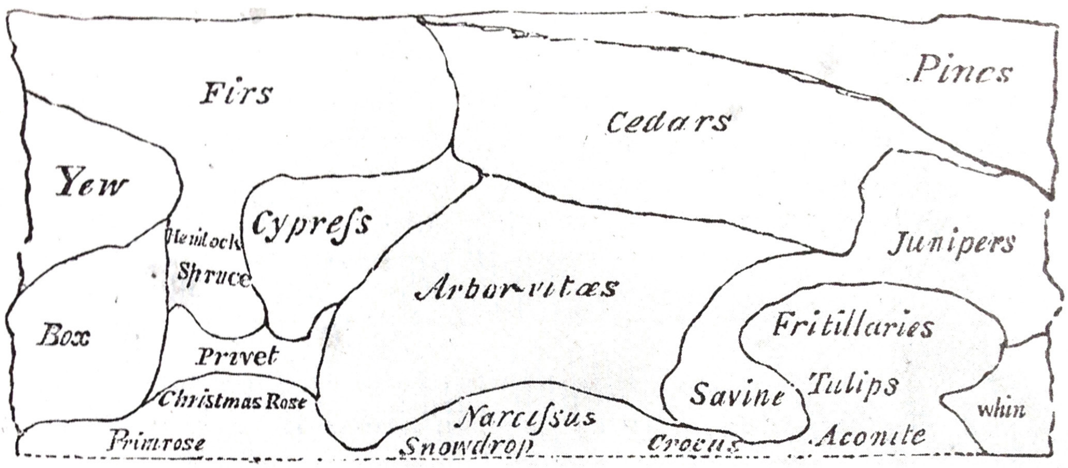


Figure 5.13: John Claudius Loudon, planting arrangement in the grouped manner, published in *An Encyclopaedia of Gardening*, 1824.

Figure 5.14: Satellite image of the Bordeaux Botanic Garden. Catherine Mosbach, *Bordeaux Botanic Garden*, Bordeaux, France. Source: Google Earth.

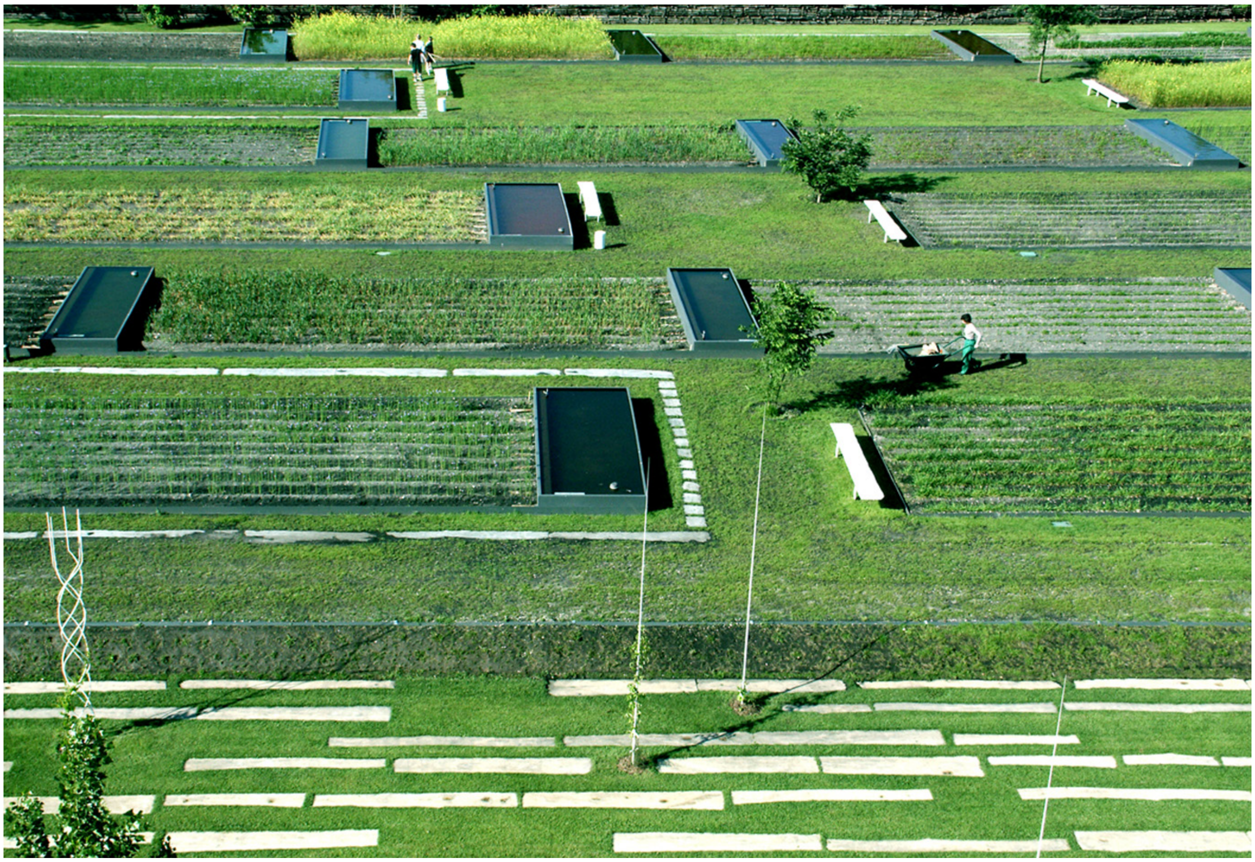


Figure 5.15: Detail of the *Champs de Culture*. Catherine Mosbach, *Bordeaux Botanic Garden*, Bordeaux, France, 2017.

Figure 5.16: Detail of the *Jardin Aquatique*. Catherine Mosbach, *Bordeaux Botanic Garden*, Bordeaux, France, 2017.

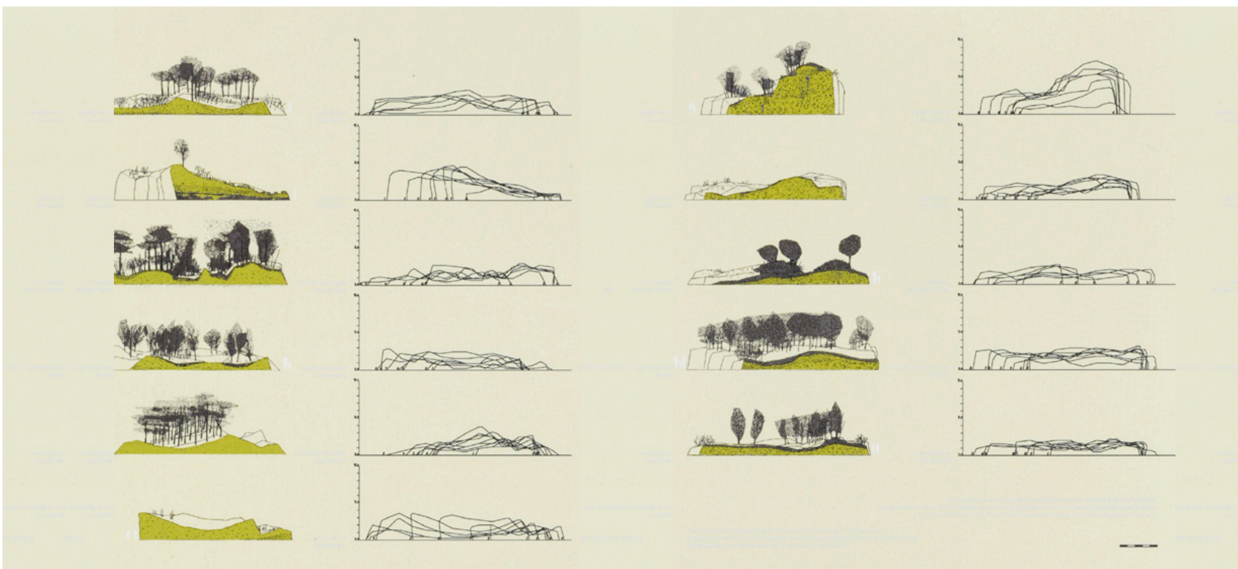


Figure 5.17: Section drawings of the promontories conforming the *Galerie des Milieux*. Catherine Mosbach, *Bordeaux Botanic Garden*, Bordeaux, France, 2017.

Figure 5.18: Successional landscapes on the promontories of the *Galerie des Milieux* as of 2017, Catherine Mosbach, *Bordeaux Botanic Garden*, Bordeaux, France, 2007.

Figure 5.19: Aerial view of the *Galerie des Milieux*, Catherine Mosbach, *Bordeaux Botanic Garden*, Bordeaux, France, 2007.

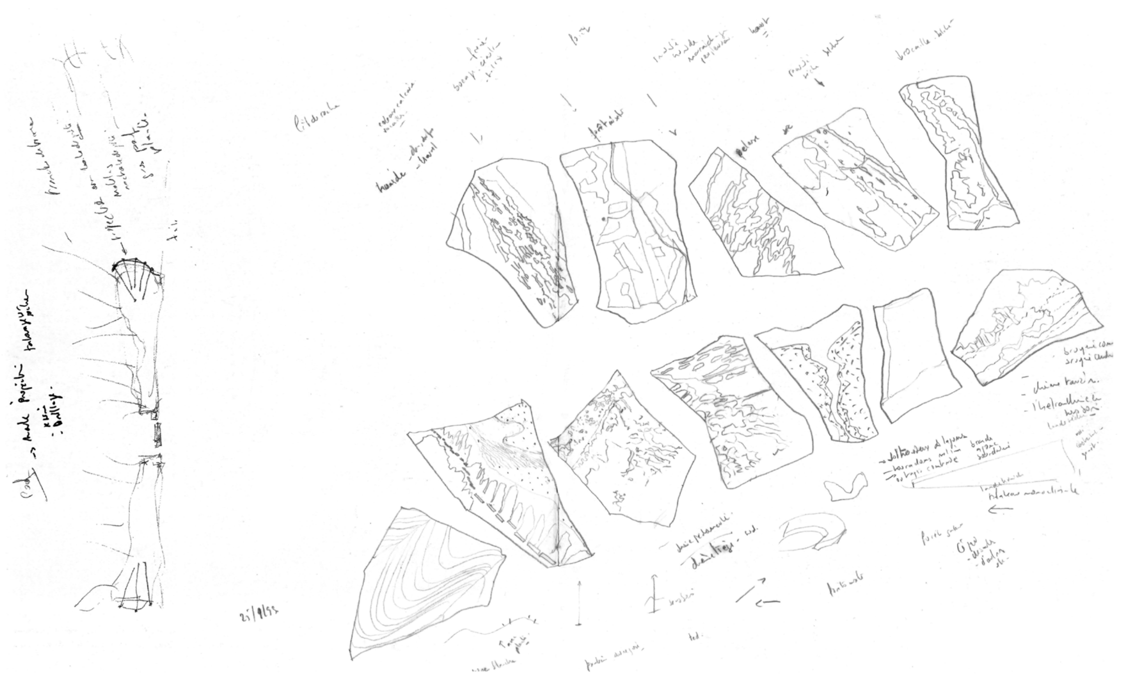


Figure 5.20: Sketch of the *Galerie des Milieux*. Catherine Mosbach, *Bordeaux Botanic Garden*, Bordeaux, France, 2007.

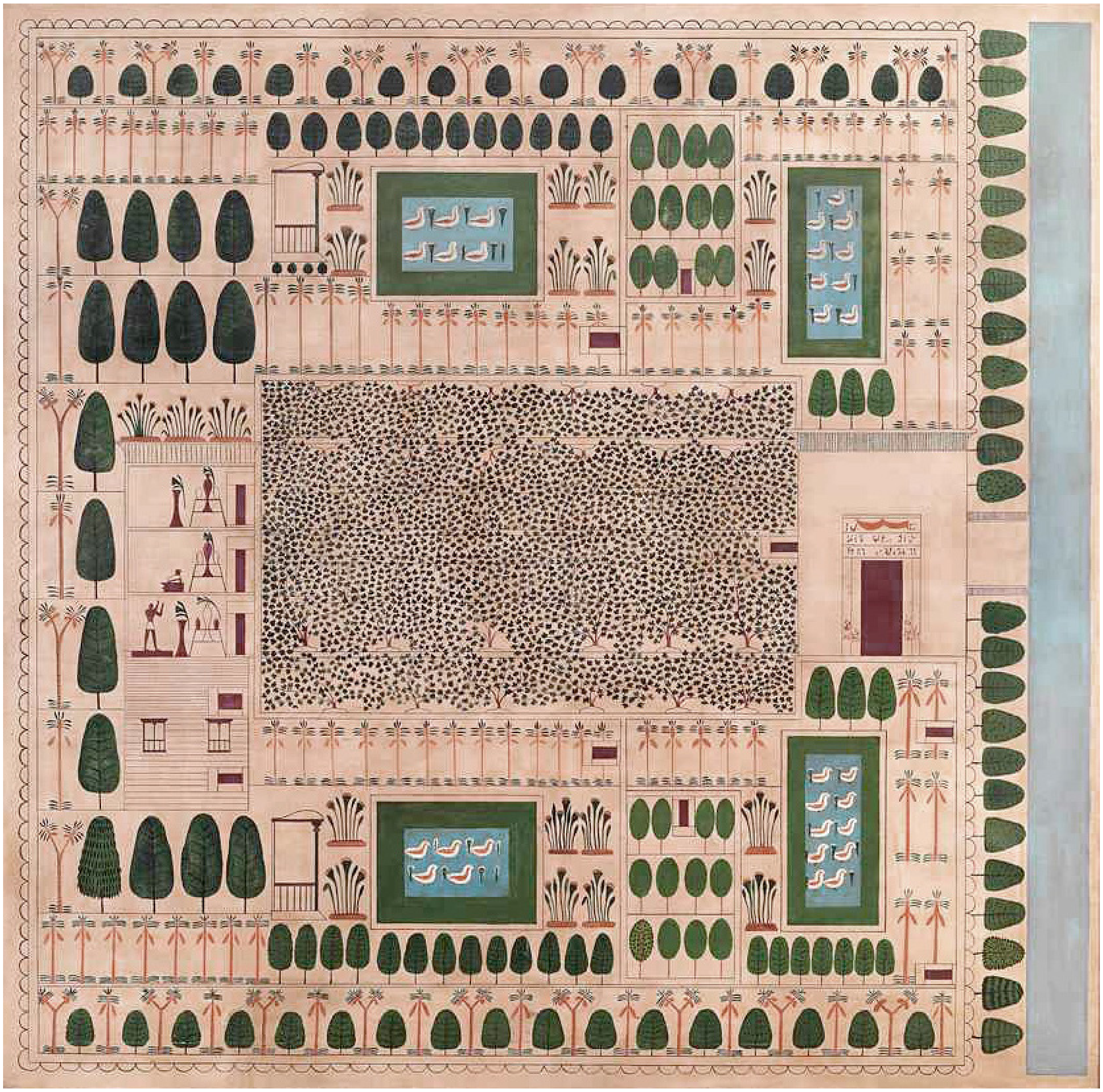


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Figure 6.2: Aerial view of Bagh-e Shahzadeh near Mahan, Kerman, Iran, late 19th century. Photograph by Georg Gerster.

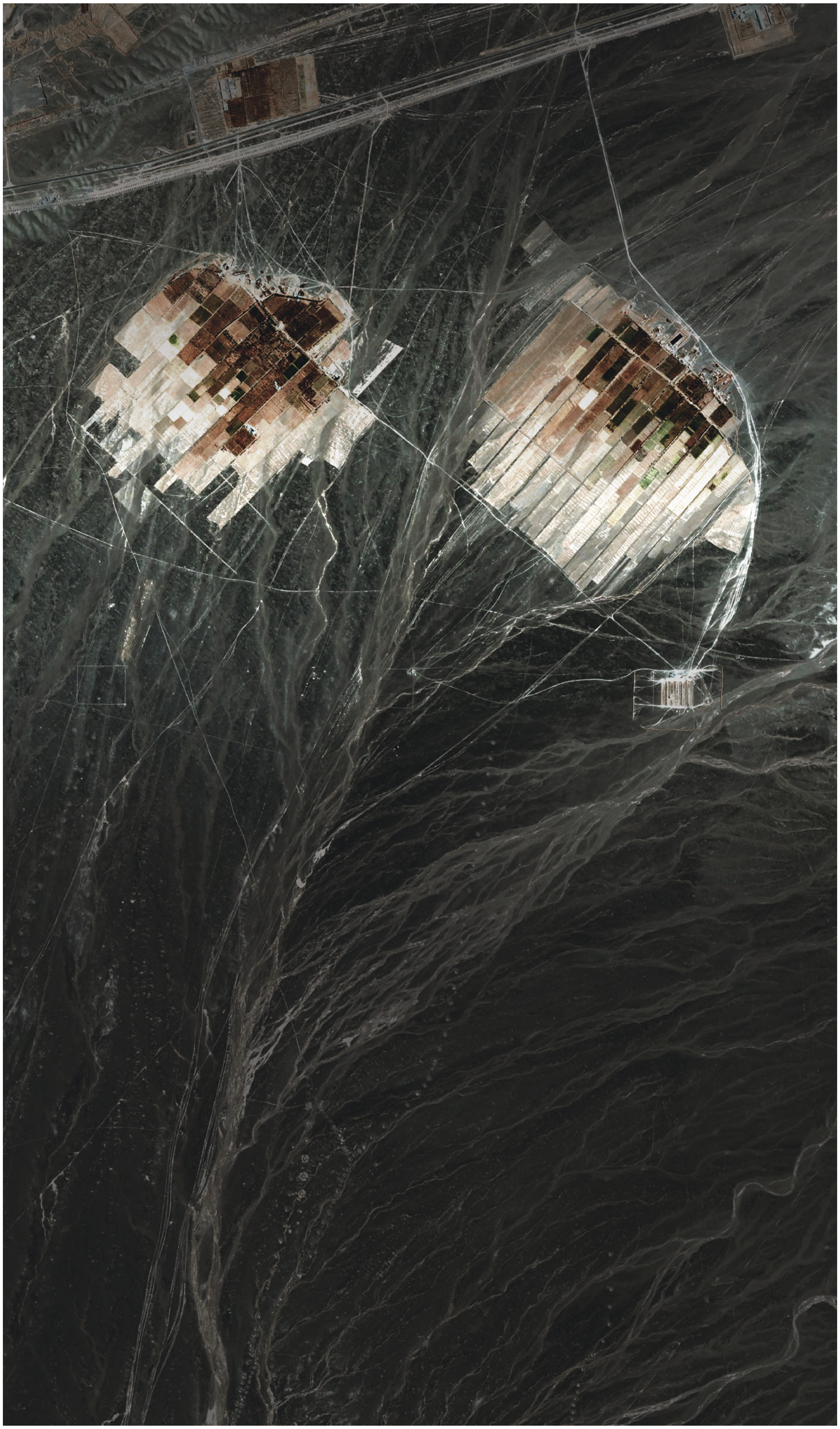


Figure 6.3: Agricultural fields near the village of Bahramjed, Kerman, Iran, 2011. Source: Google Earth.

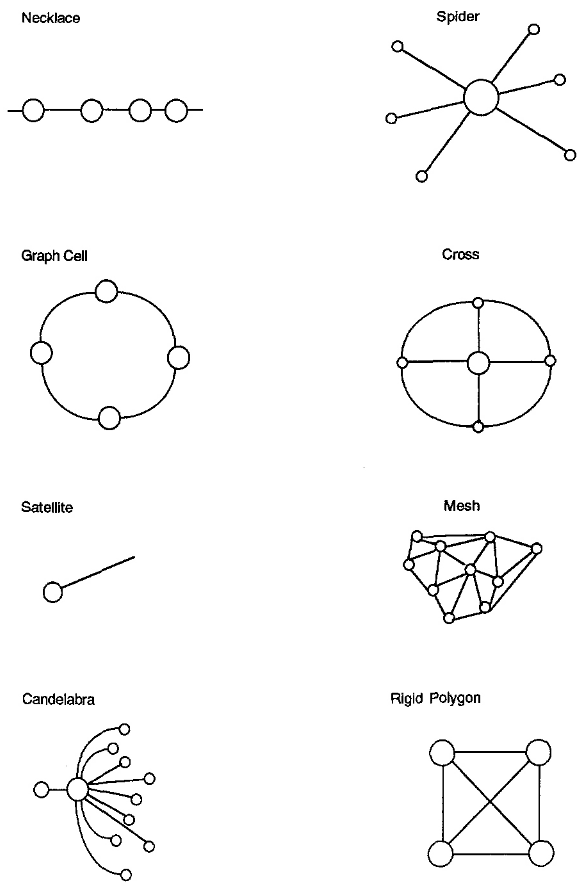


Figure 6.4: Common and uncommon graph patterns identified from twenty-five diverse landscapes. The first seven patterms (left to right, top to bottom) were common, by Margot D. Cantwell and Richard T. T. Forman, “Landscape Graphs: Ecological Modeling with Graph Theory to Detect Configurations Common to Diverse Landscapes,” 1993.

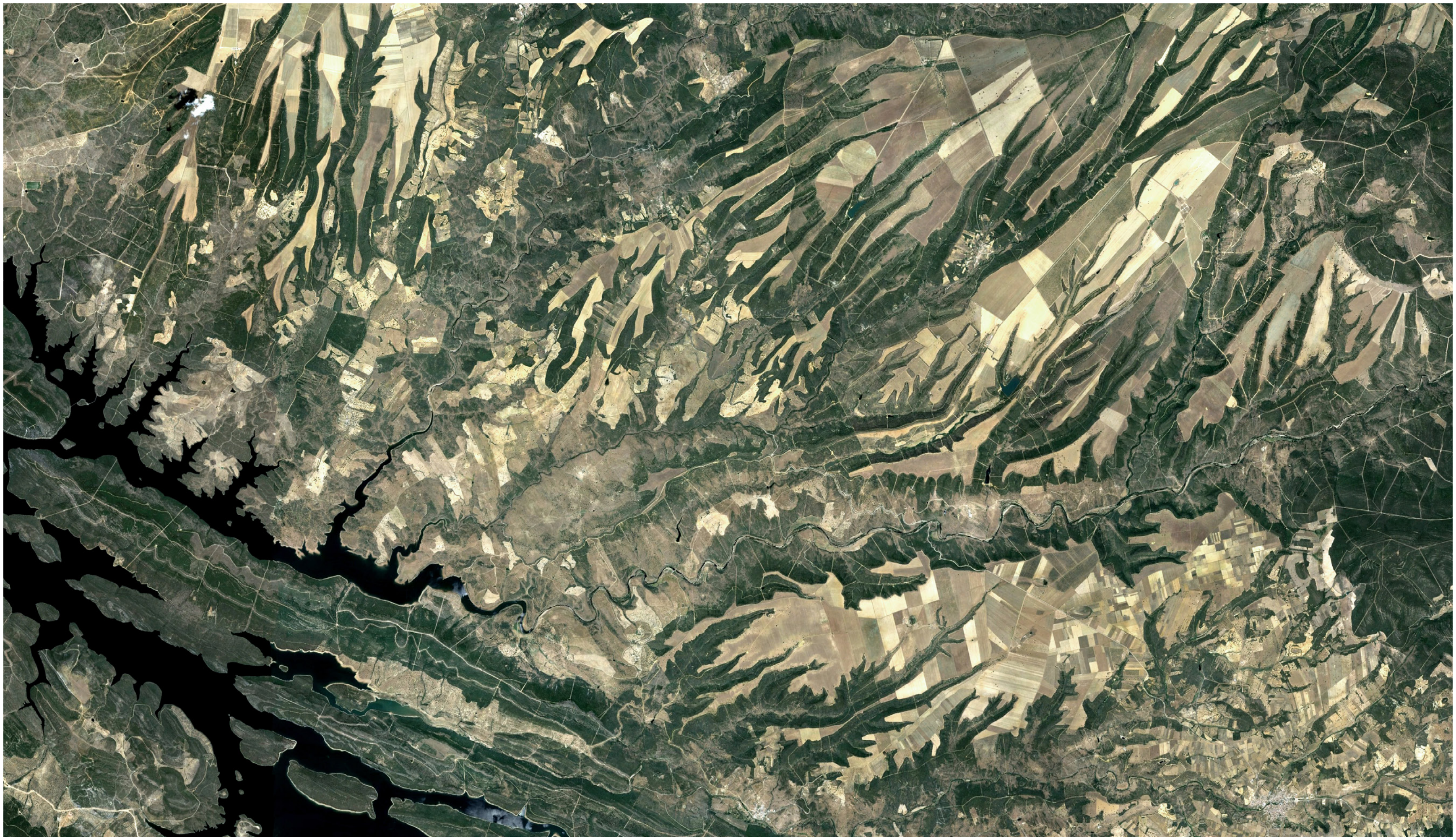


Figure 6.5: Landscape ecology's patches, corridors, and matrix, near Valdeazores, Toledo, Spain. Source: Google Earth.

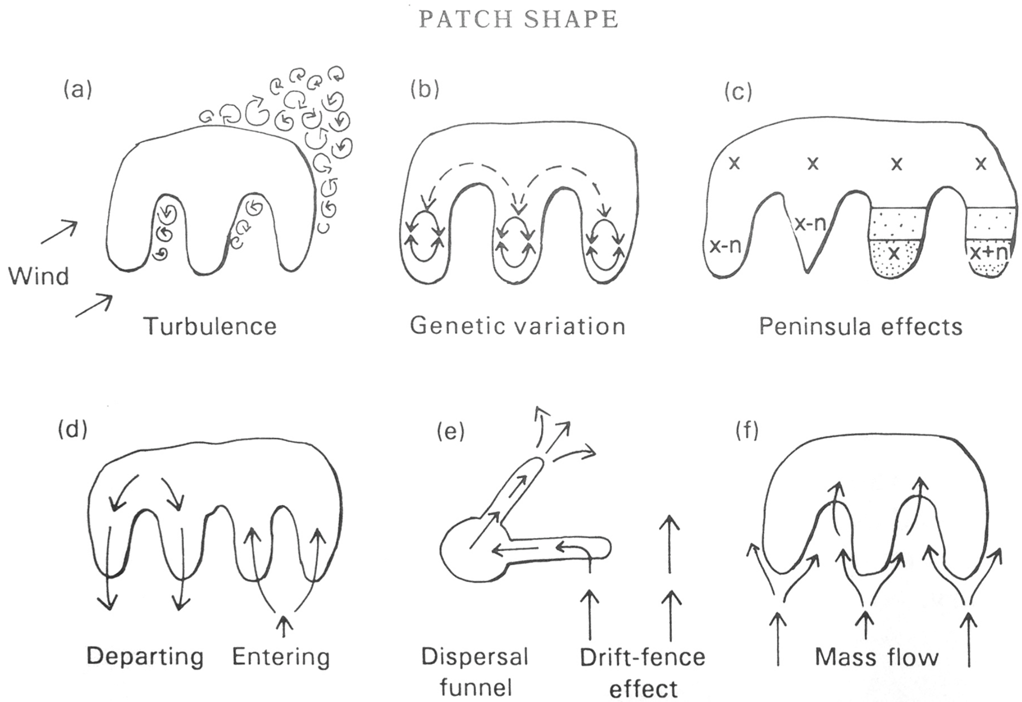


Figure 6.6: Patch shapes and associated properties, from Richard Forman, *Land Mosaics*, 1995.

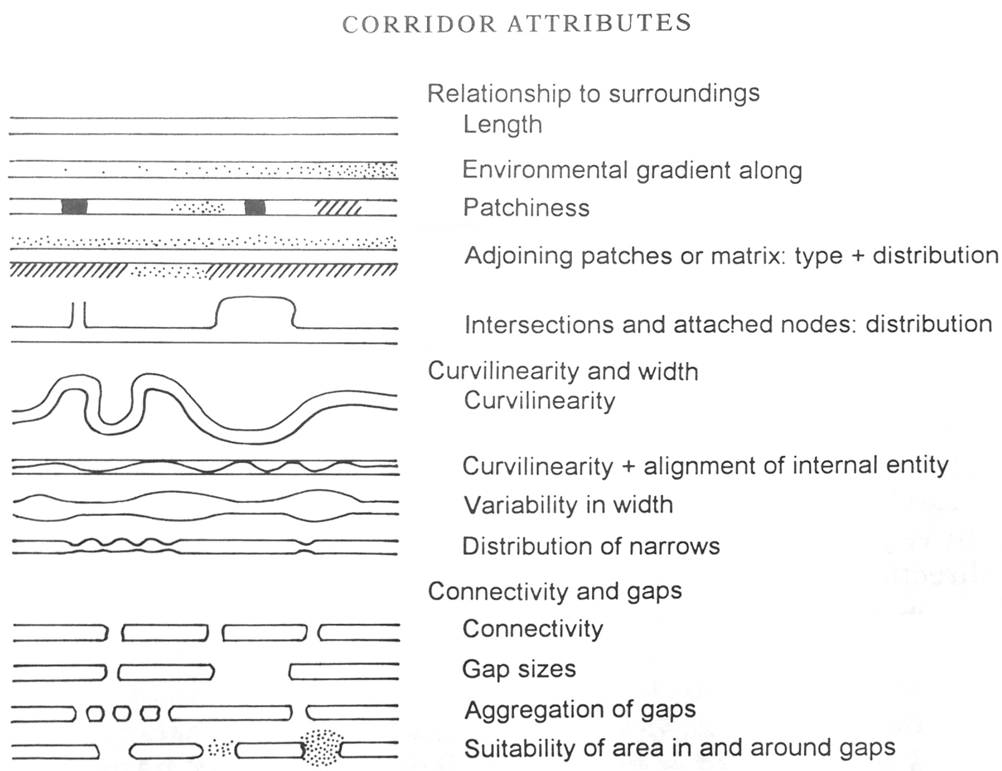


Figure 6.7: Attributes of the external structure of corridors, from Richard Forman, *Land Mosaics*, 1995.

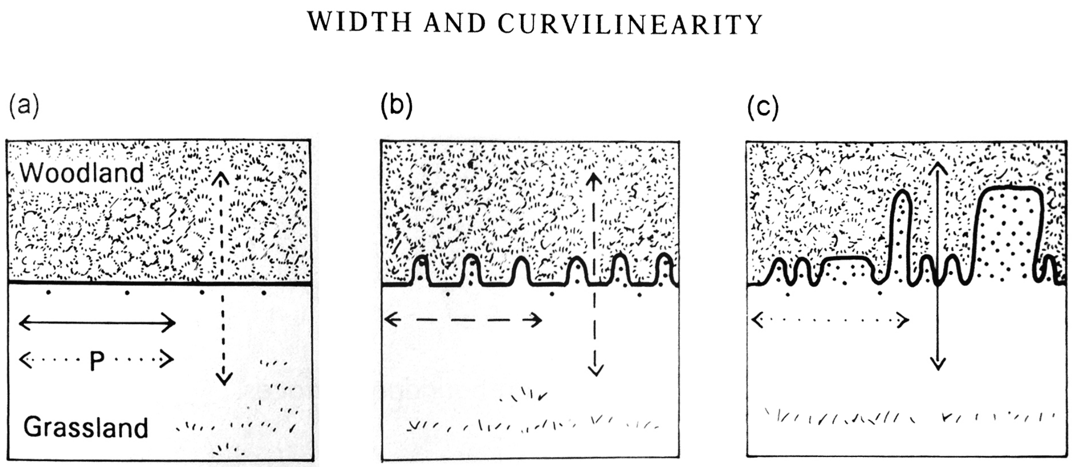


Figure 6.8: Width and curvilinearity in a boundary condition between a woodland patch and a grassland patch, from Richard Forman, *Land Mosaics*, 1995.

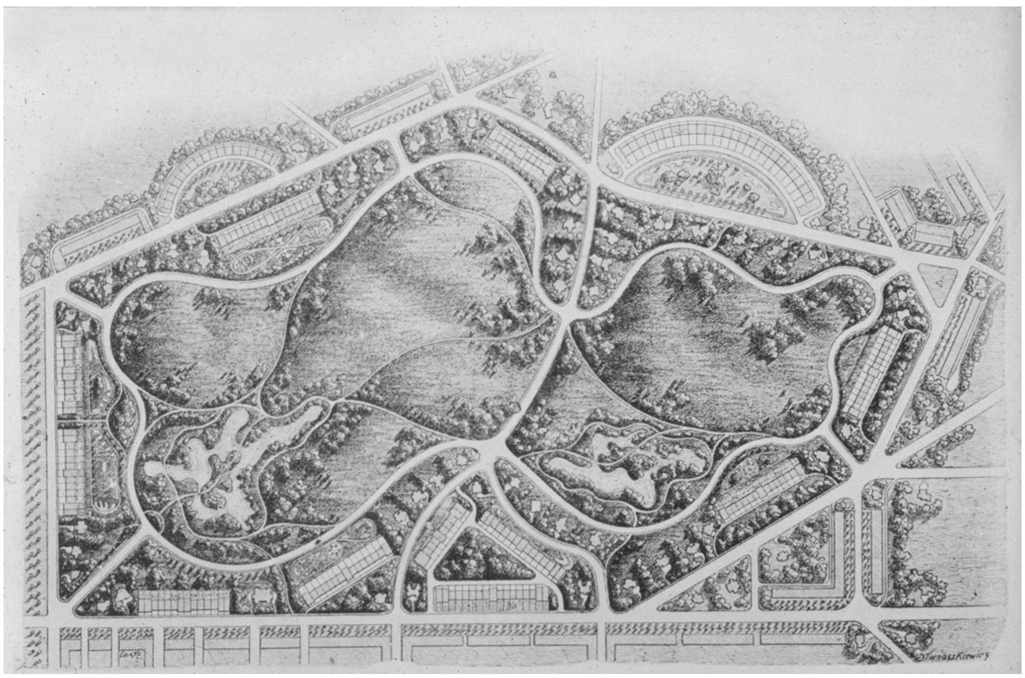


Figure 6.9: Plan of Birkenhead Park. Joseph Paxton, *Birkenhead Park*, Liverpool, United Kingdom, 1843.

Figure 6.10: 1870 plan of Prospect Park, Frederick Law Olmsted and Calvert Vaux, *Propect Park*, Brooklyn, New York, USA, 1866-1867.

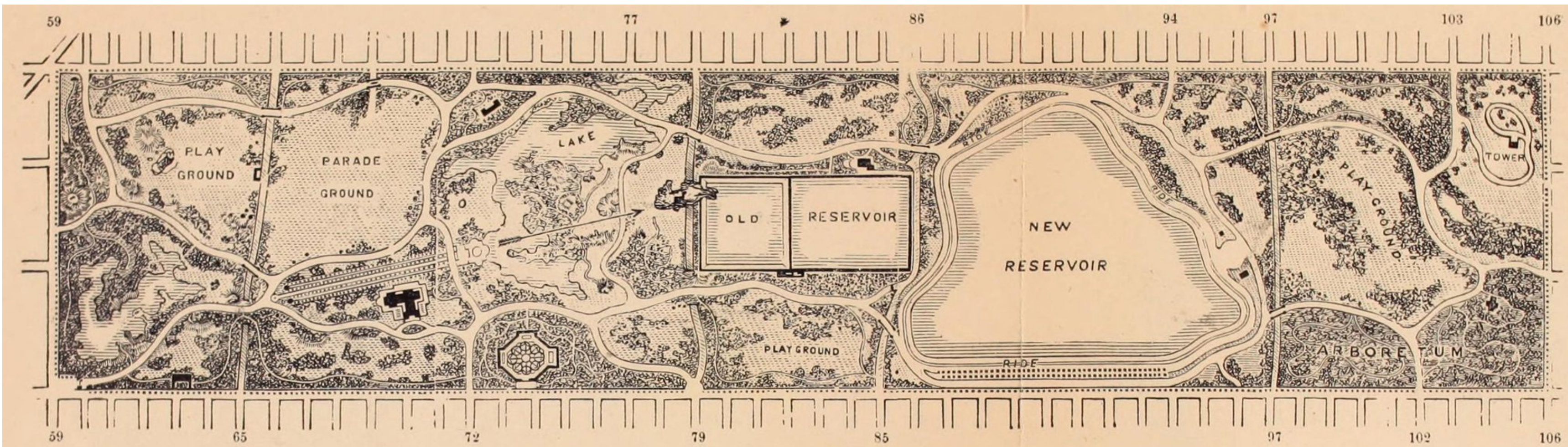
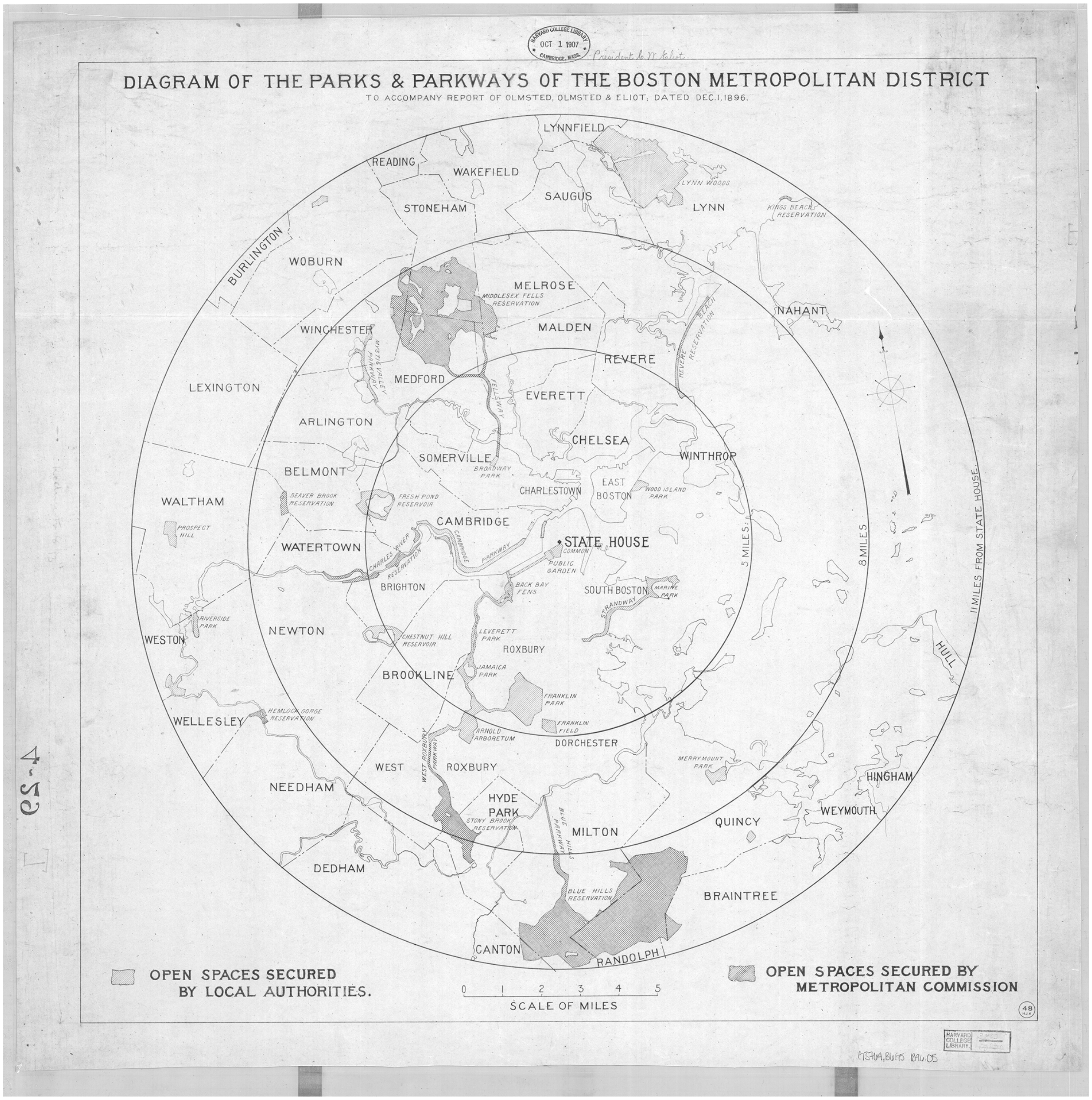


Figure 6.11: "Greensward" plan, winner of the 1858 competition for a design of Central Park. Frederick Law Olmsted and Calvert Vaux, *Central Park*, New York, USA, 1858-1873.

Figure 6.12: Central Parl as paradoxical garden, a garden that soon became also a clearing, by conforming a gap within the continuous mass of the city that circumscribed it, as the Manhattan grid got overfilled during following century. Frederick Law Olmsted and Calvert Vaux, *Central Park*, New York, USA, 1858-1873. Photograph by Lee Friedlander.



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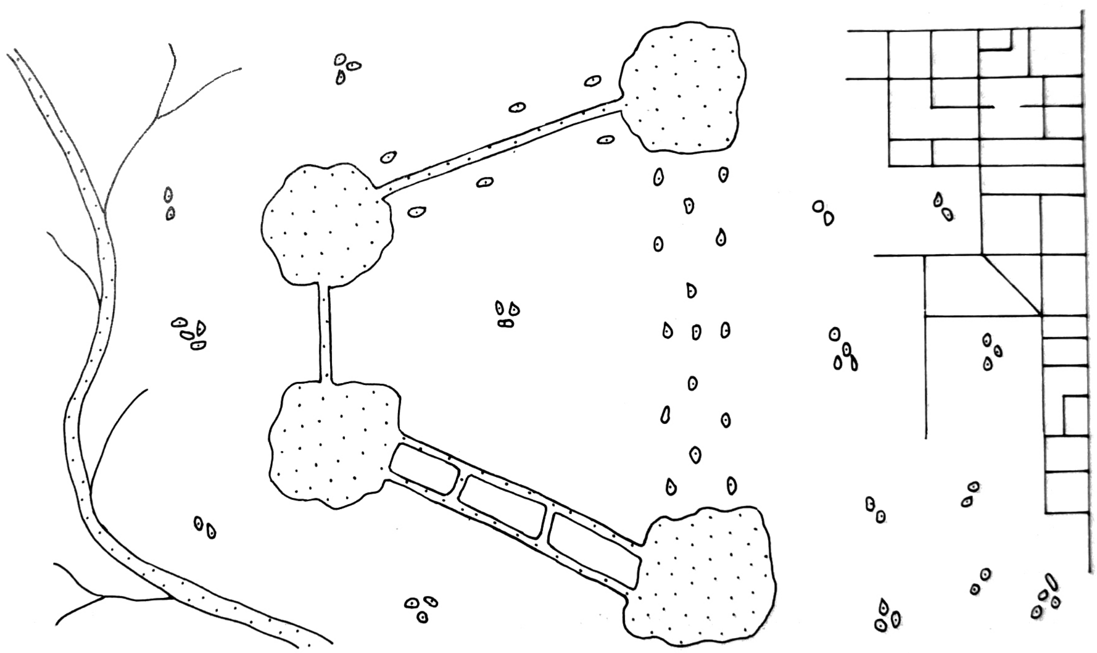

Figure 6.14: Top-priority ecological "indispensables" in planning a landscape: A few large patches of vegetation, major stream or river corridor, connectivity with corridors and steppting stones between large patches, and hetergoeneous bits of nature accross the matrix, in Richard T. T. Forman, *Land Mosaics*, 1995.

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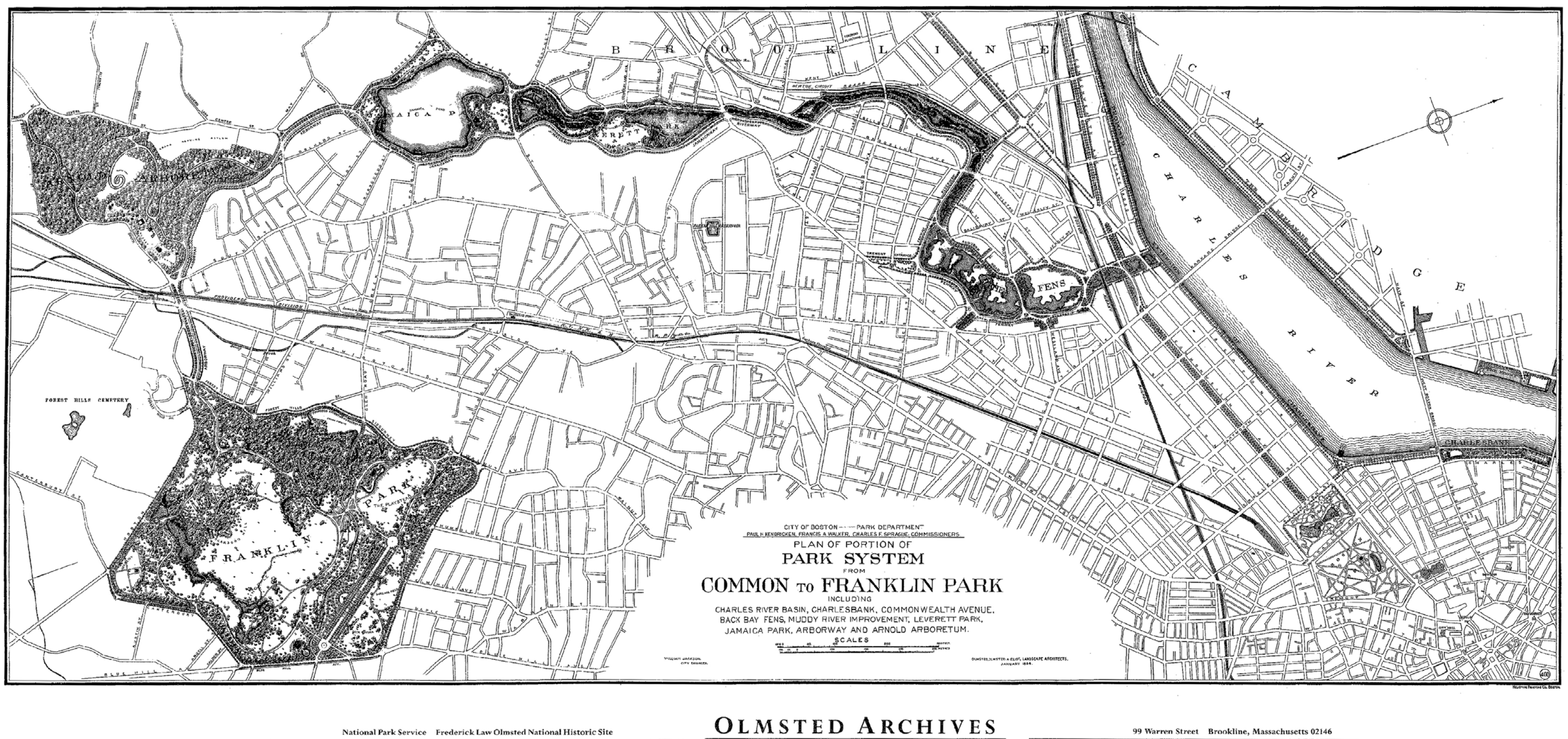
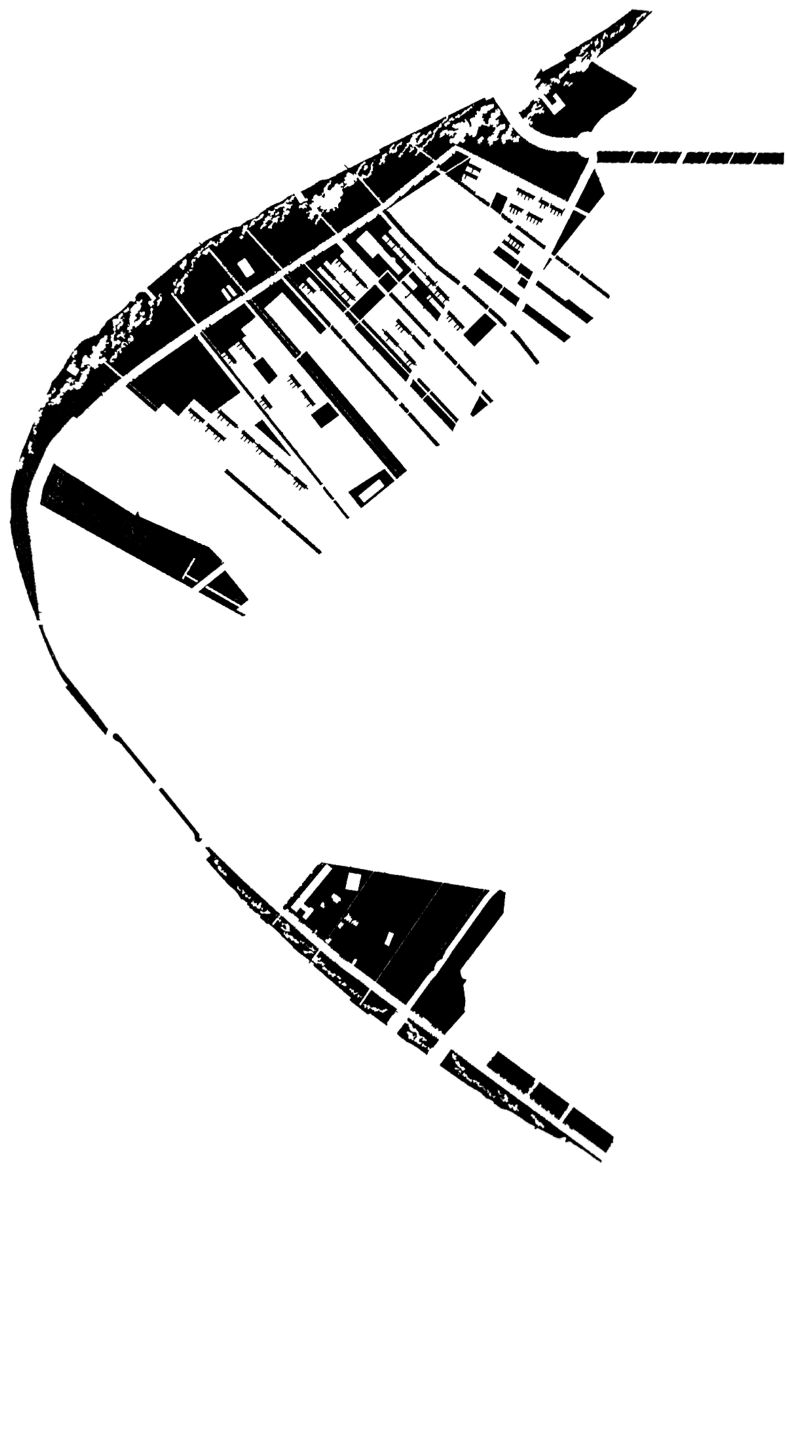


Figure 6.16: Frederick Law Olmsted, Frederick Law Olmsted Jr., and Charles Eliot, *Plan of Portion of Park System from Common to Franklin Park*, Boston Metropolitan District, Massachusetts, USA, 1894.



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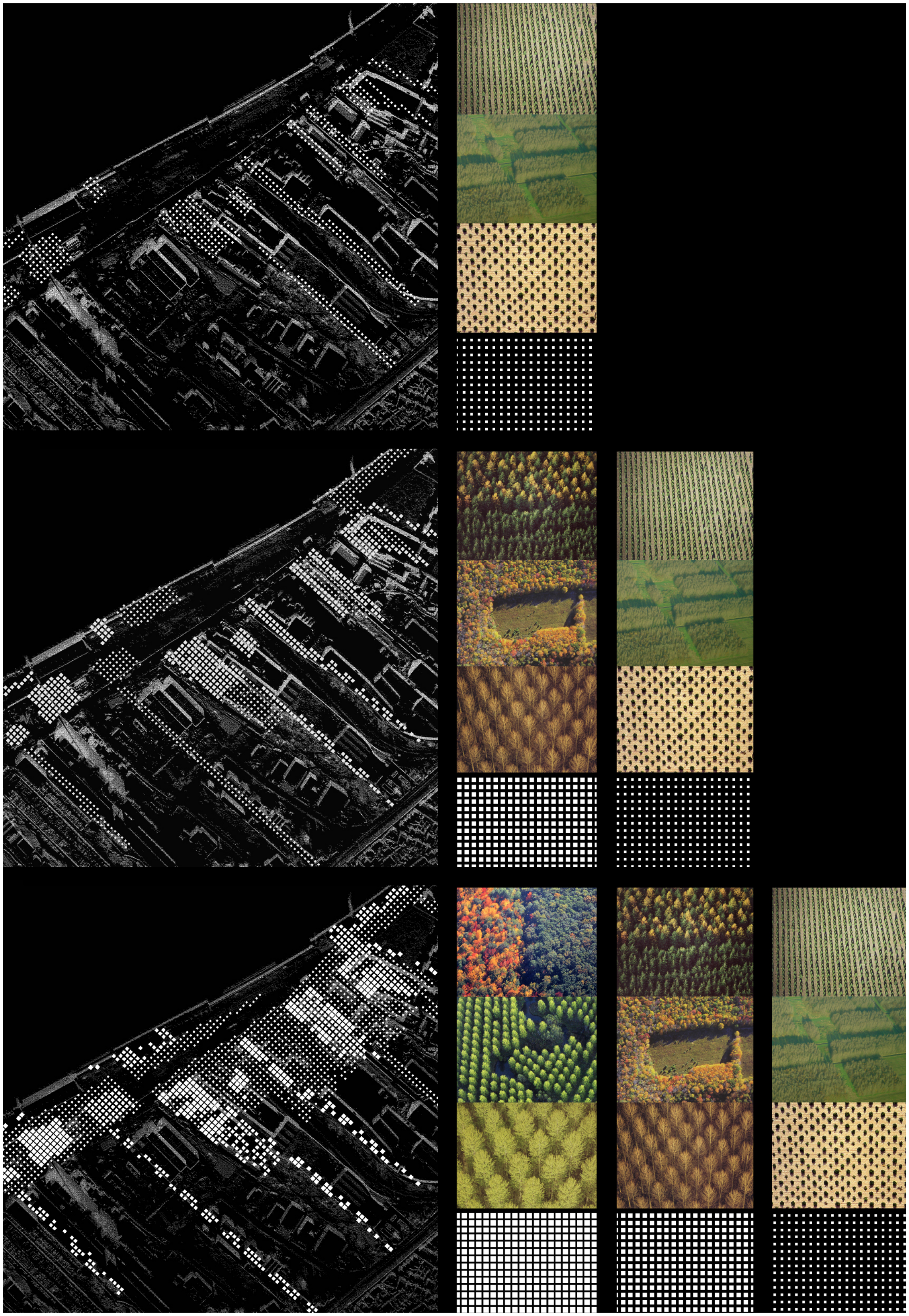


Figure 6.19: Michel Desvigne, successional diagram for the study of the Right River Bank of Bordeaux, France, 2000-2004.

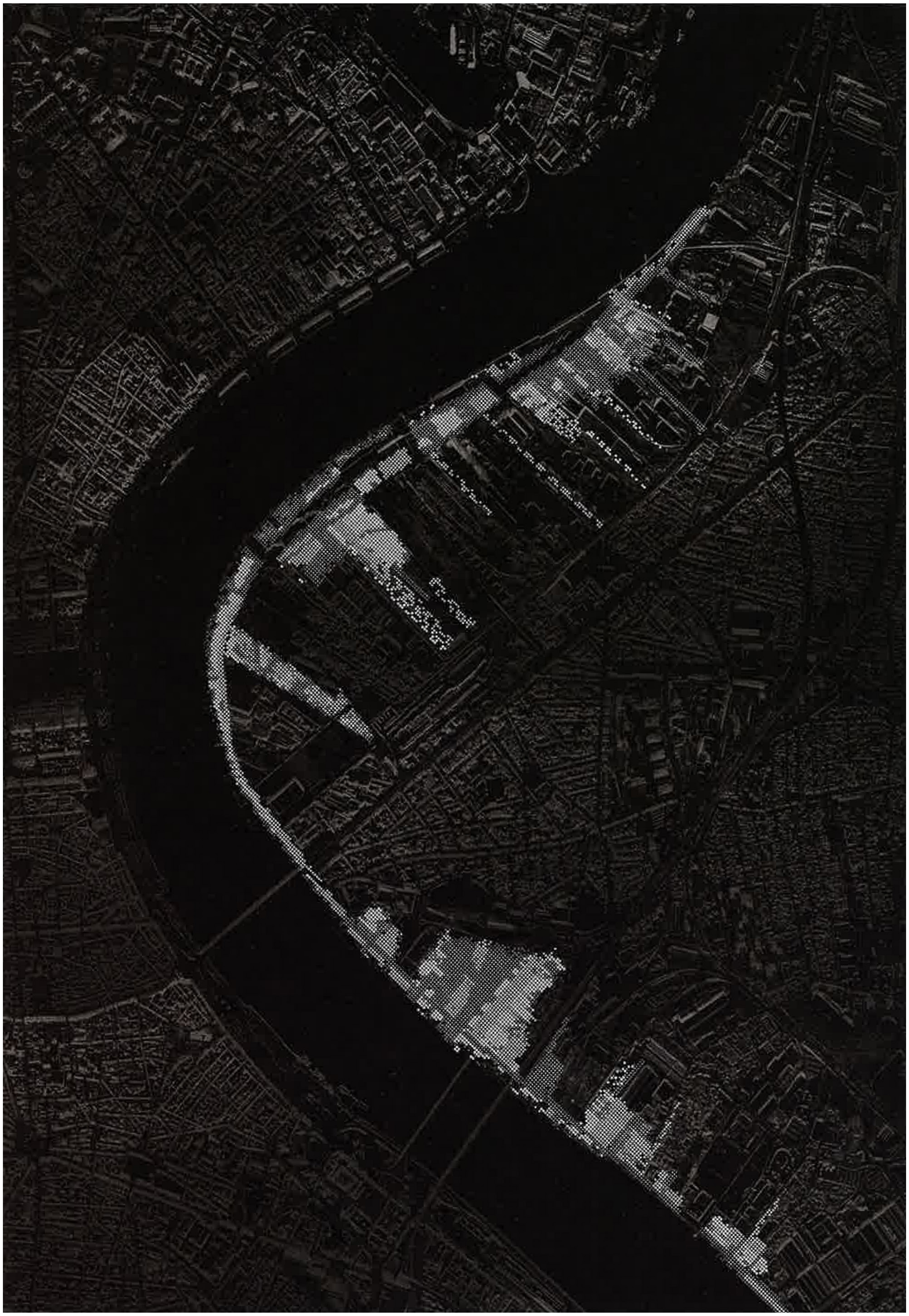


Figure 6.20: Michel Desvigne, comprehensive diagram for the study of the Right River Bank of Bordeaux, France, 2000-2004.

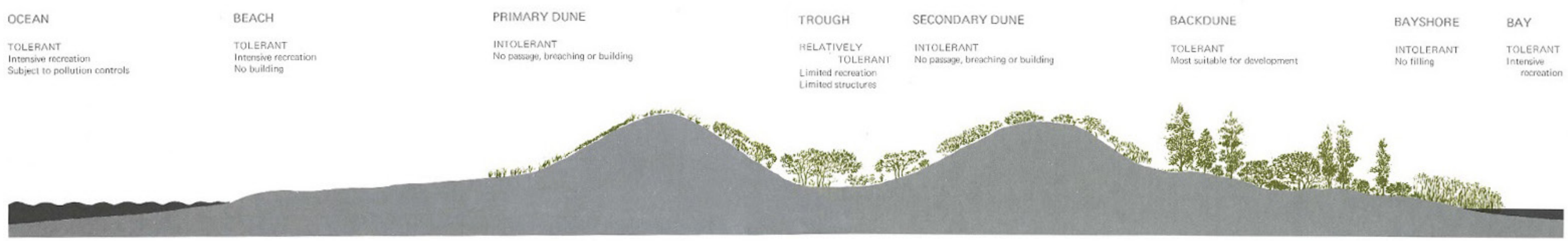


Figure 7.1: Ian McHarg, community types in the formation of a dune, as clear example of creative processes towards environmental fitness, in McHarg, *Design with Nature*, 1969.

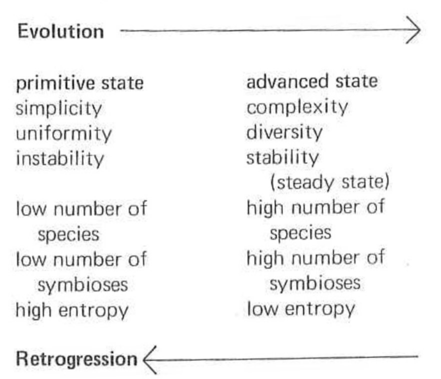


Figure 7.2: Ian McHarg, evolution versus retrogression and associated concepts, in McHarg, *Design with Nature*, 1969.

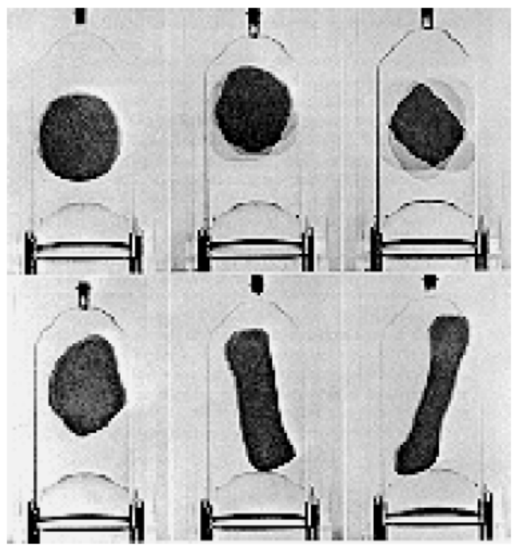


Figure 7.3: Rudolf Arnheim, "Fuel tank filled with clear oil and colored water of equal density," in Rudolf Arnheim, *Entropy and Art: An Essay on Order and Disorder*, 1971.

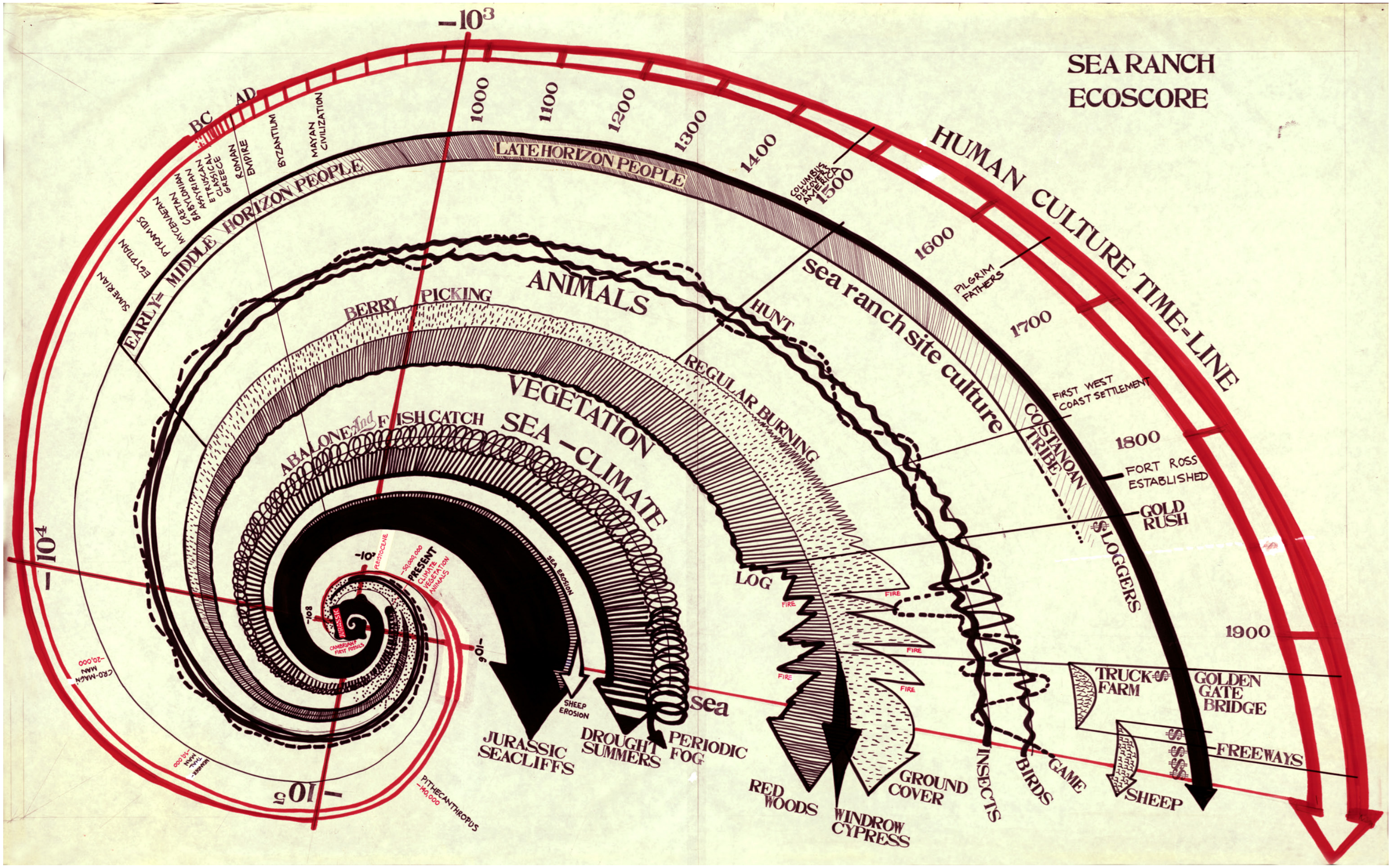


Figure 7.4: Lawrence Halprin, "Sea Ranch Ecoscore," illustrating the impact of man on the land at Sea Ranch in a geological perspective, in Lawrence Halprin, *The RSVP Cycles: Creative Processes in the Human Environment*, 1969.

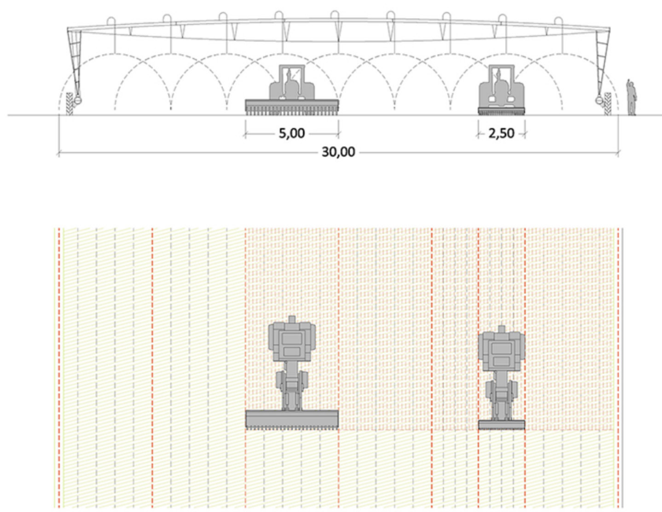
Figure 7.5: Lawrence Halprin, *Sea Ranch*, California, USA, 1962. Photograph by Peter Dodge.

Figure 7.6: Lawrence Halprin, *Sea Ranch*, California, USA, 1962. Photograph by Danielle Choi.

Figure 7.7: Agricultural landscape pattersn fading into coastal grasslands near Wildlife Reserve Torreblanca, Castellón, Spain. Source: Google Earth.

Figure 7.8: Dryland farming valleys in Monegros, Zaragoza, Spain. Source: Google Earth.

Figure 7.9: Teresa Galí-Izard, Arquitectura Agronomía, et al., infrastructure drawing for the *Valencia Central Park Competition*, Valencia, Spain, 2013.



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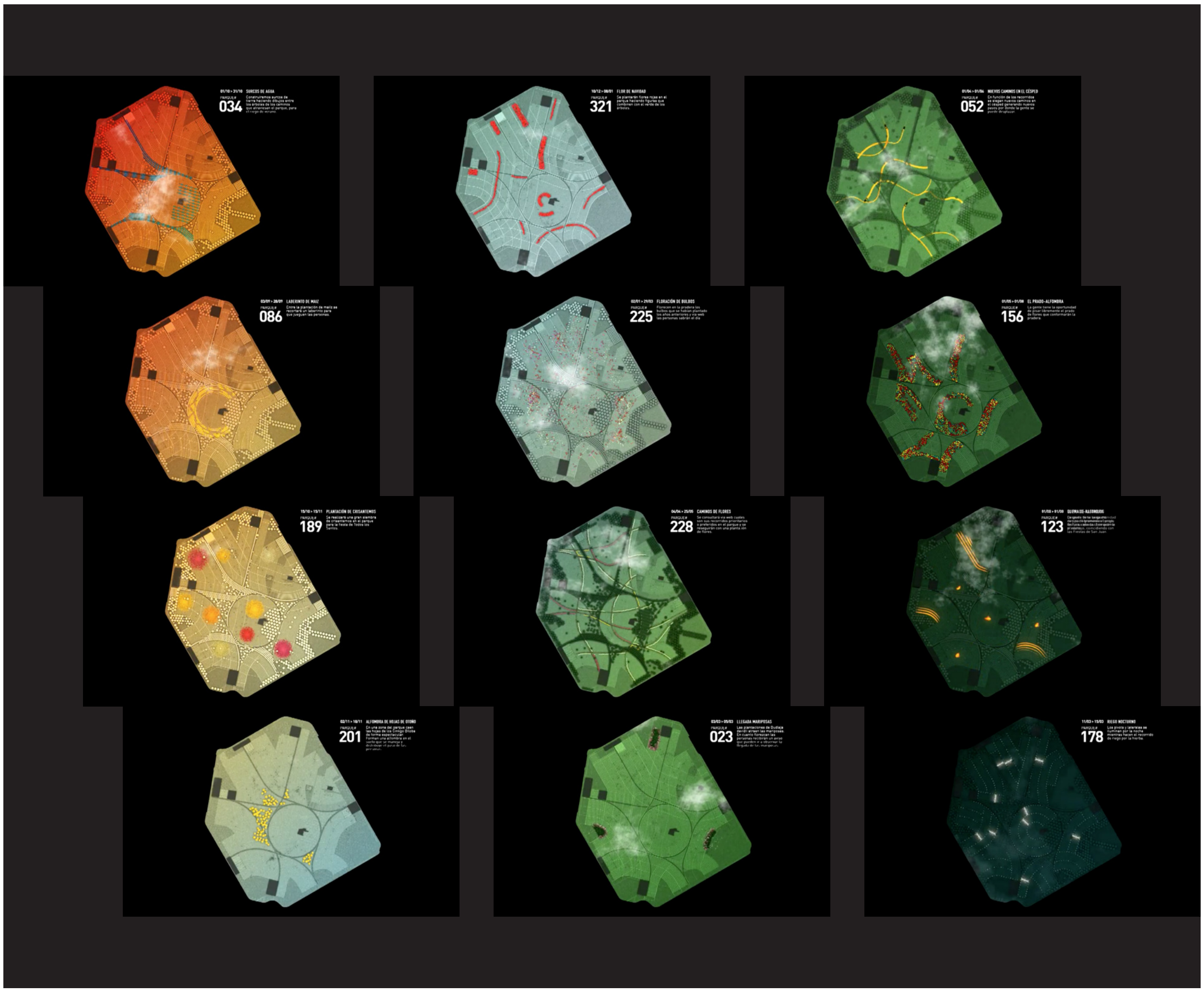
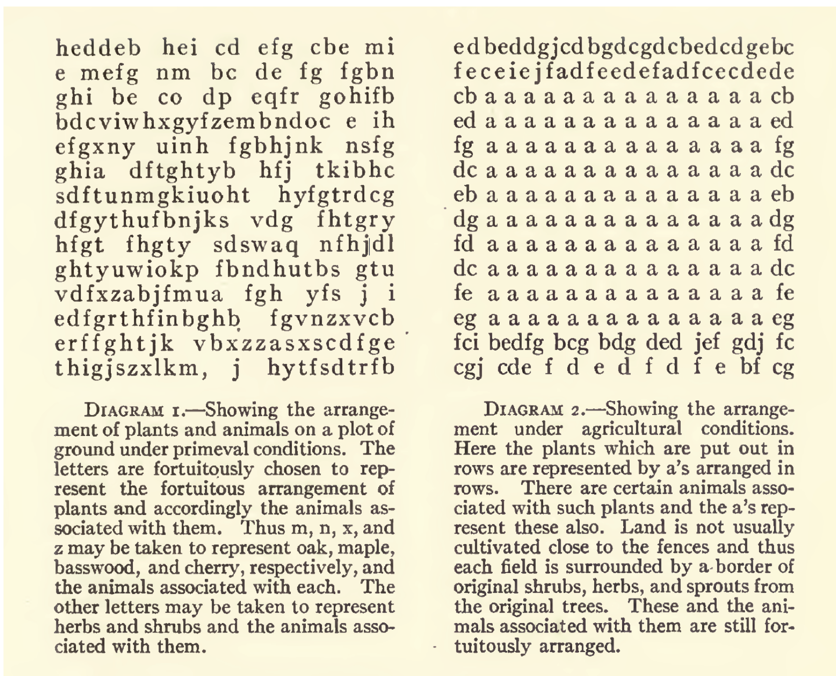


Figure 7.13: Teresa Galí-Izard, Arquitectura Agronomía, et al., sequence of some of the events for the *Valencia Central Park Competition*, Valencia, Spain, 2013.



heddeb hei cd efg cbe mi
e mefg nm bc de fg fgbn
ghi be co dp eqfr gohifb
bdcviwhxgyfzembndoc e ih
efgxny uinh fgbhjnk nsfg
ghia dftghtyb hfj tkibhc
sdftunmgkiuoht hyfgtrdcg
dfgythufbnjks vdg fhtgry
hfgt fhgty sdswaq nfhjdl
ghtyuwiokp fbndhutbs gtu
vdfxzabjfmua fgh yfs j i
edfgrthfinbghb fgvnzxvcb
erffghtjk vbxzzasxscdfge
thigjszxlkm, j hytfsdtrfb

Diagram 1.—Showing the arrangement of plants and animals on a plot of ground under primeval conditions. The letters are fortuitously chosen to represent the fortuitous arrangement of plants and accordingly the animals associated with them. Thus m, n, x, and z may be taken to represent oak, maple, basswood, and cherry, respectively, and the animals associated with each. The other letters may be taken to represent herbs and shrubs and the animals associated with them.

edbeddgjcdbgdcgdcbedcdgebc
feceiejfadfeedefadfcecdede
cb a a a a a a a a a a a a a a cb
ed a a a a a a a a a a a a a a ed
fg a a a a a a a a a a a a a a fg
dc a a a a a a a a a a a a a a dc
eb a a a a a a a a a a a a a a eb
dg a a a a a a a a a a a a a a dg
fd a a a a a a a a a a a a a a fd
dc a a a a a a a a a a a a a a dc
fe a a a a a a a a a a a a a a fe
eg a a a a a a a a a a a a a a eg
fci bedfg bcg bdg ded jef gdj fc
cgj cde f d e d f d f e bf cg

Diagram 2.—Showing the arrangement under agricultural conditions. Here the plants which are put out in rows are represented by a's arranged in rows. There are certain animals associated with such plants and the a's represent these also. Land is not usually cultivated close to the fences and thus each field is surrounded by a border of original shrubs, herbs, and sprouts from the original trees. These and the animals associated with them are still fortuitously arranged.

Figure 7.14: Equilibrium and tension before and after the introduction of agricultural practices on the land. Under preagricultural conditions, plants are arranged irregularly, as roughly indicated by the letters in Diagram 1; after the introduction of agricultural purposes, they are arranged as in Diagram 2. In Victor Shelford, *Animal Communities in Temperate America*, 1913.

Figure 7.15: Tension in coastal conditions, Afsluitdijk, Netherlands. Source: Google Earth.

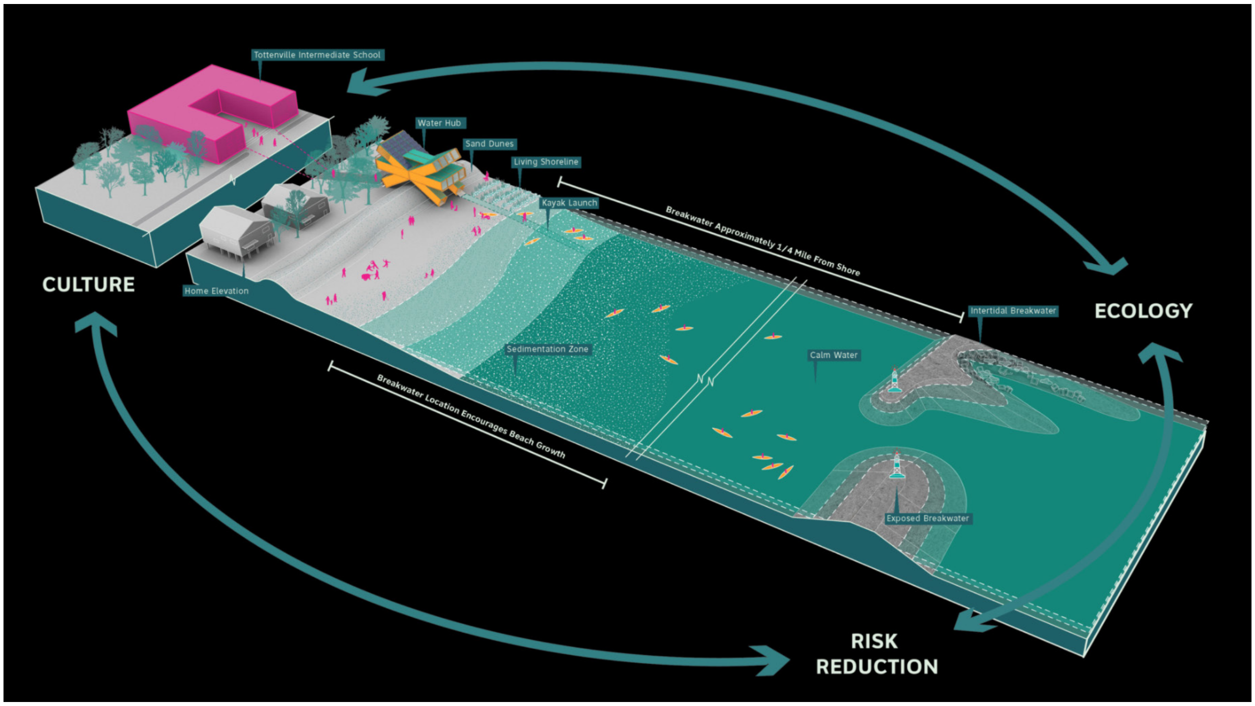


Figure 7.16: Gradual and distributed system of different elements and agents for coastal protection. Scape, *Living Breakwaters Rebuild By Design Competition*, Staten Island, New York, USA, 2014.

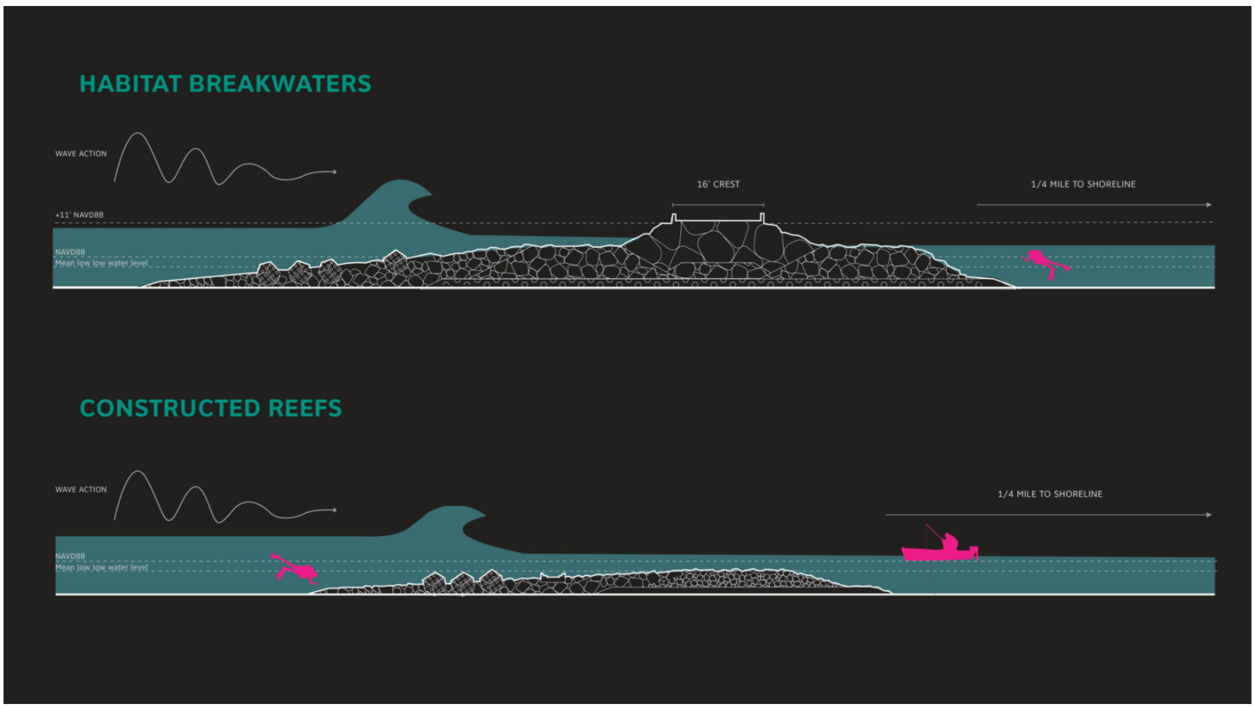


Figure 7.17: Layered submerged landscape designed to absorb and dissipate oceanic forces. Scape, *Living Breakwaters Rebuild By Design Competition*, Staten Island, New York, USA, 2014.

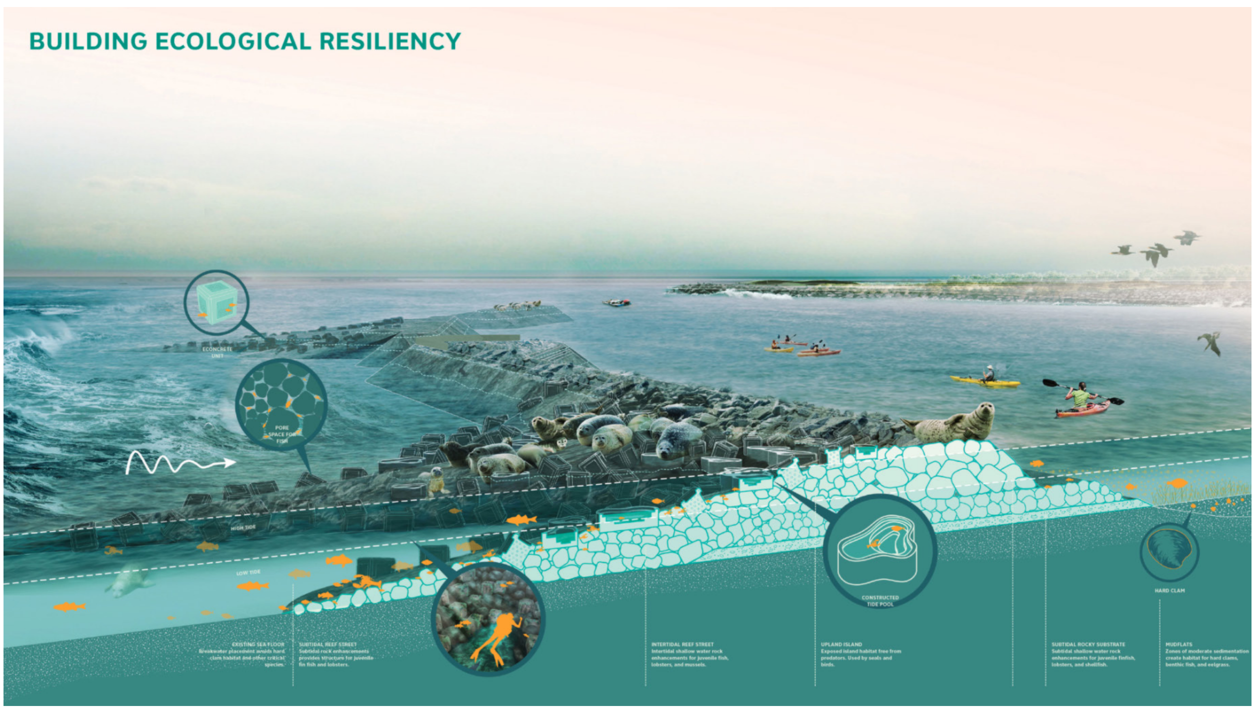


Figure 7.18: Scape, Building Ecological Resilience, *Living Breakwaters Rebuild By Design Competition*, Staten Island, New York, USA, 2014.

Figure 7.19: Restored canal and new river course, Georges Descombes, *River Aire Renaturalization*, Geneve, Switzerland, 2001-2013.

Figure 7.20: Network of channels excavated in the area where the new “naturalized” river is to flow, a highly erodible landscape, Georges Descombes, *River Aire Renaturalization*, Geneve, Switzerland, 2001-2013.

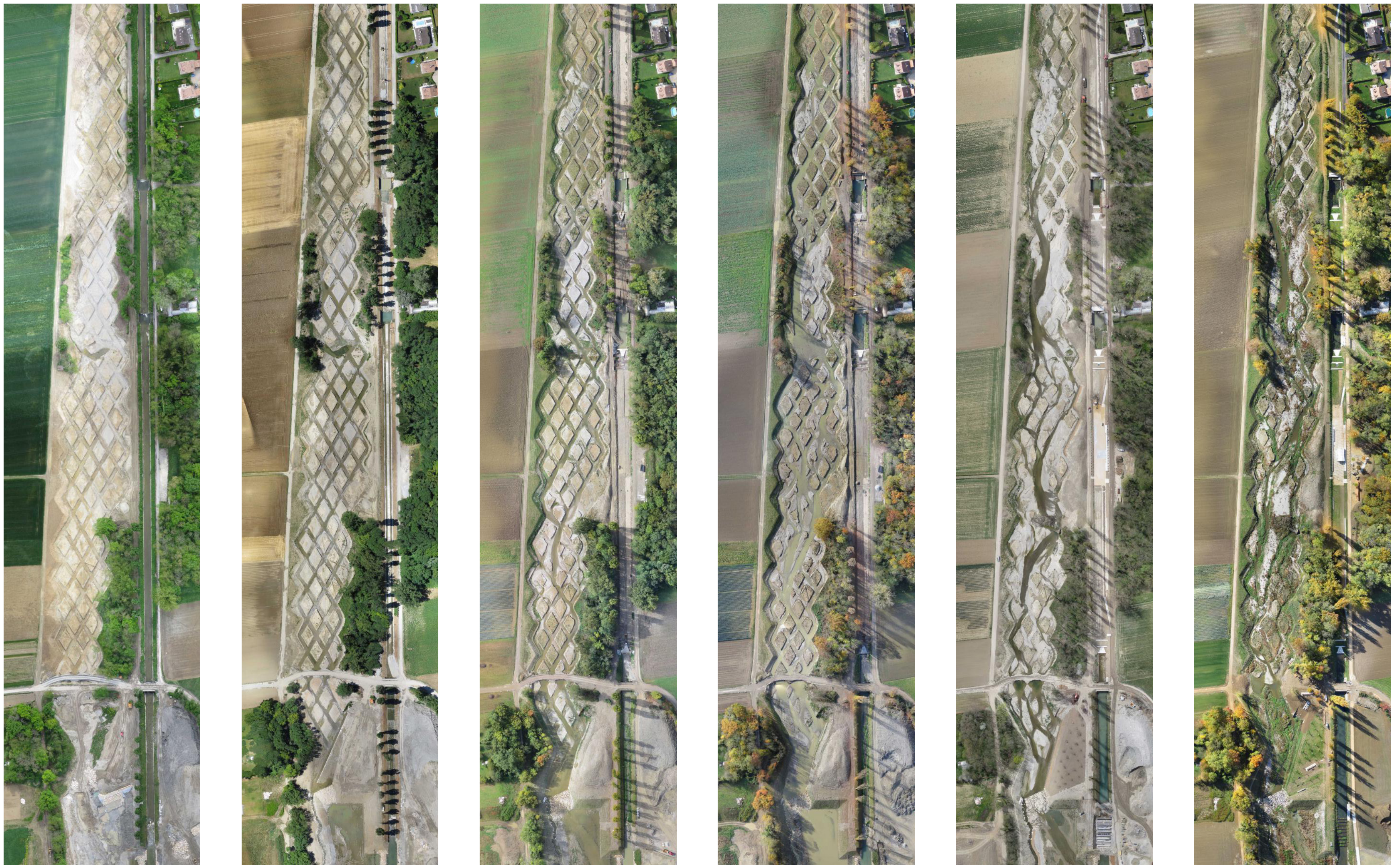


Figure 7.21: Series of photographs documenting the river bed erosion between October of 2013 and August of 2015, Georges Descombes, *River Aire Renaturalization*, Geneve, Switzerland, 2001-2013.

Figure 7.22: Eroded river bed as of September of 2015, Georges Descombes, *River Aire Renaturalization*, Geneve, Switzerland, 2001-2013.

Figure c.1: Gardens of Versailles, France. Source: Google Earth.

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