The
Ecological Design
and Planning Reader

Edited by Forster O. Ndubisi

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ISLANDPRESS

For my parents,
the late Dr. Bennett E. Ndubisi and Lady Mary Ndubisi
My in-laws,
the late Mr. William and Mrs. Mary Martin
and
My wife *June* and daughter *Danielle.*

Contents

Part Seven: Emerging Frameworks

Note from the Publisher

This volume is a collection of previously published writings on ecological design and planning chosen by Forster Ndubisi and his advisors with input from professors in the field. Professor Ndubisi has written a new introduction to frame the collection, new introductions to each section that explain the importance of the writings, as well as a conclusion that lays a foundation for future thinking and practices.

We have chosen to set the papers, which range from journal articles to book chapters, in a consistent format and typeface but have otherwise retained the style and idiosyncrasies of the originals. The figures have been reproduced for quality purposes and renumbered for ease of use.

The author has chosen to excerpt some of the selections rather than reprint them in their entirety, and the footnotes and endnotes have been removed to allow more space for the essays. Publishing information for each paper can be found in the Copyright Information section in the back matter.

Preface

In one volume, *The Ecological Design and Planning Reader* assembles and synthesizes selected seminal published scholarly works in ecological design and planning from the past 150 years. Existing information on the growing field of ecological design and planning is unfocused, fragmented, and scattered across numerous articles, books, and other publications. This collection of readings provides students, scholars, researchers, and practitioners with a condensed history, key theoretical and methodological innovations, and exemplary practices in ecological design and planning during this period, as well as a critical synthesis on its continuing evolution.

This book has two complementary objectives: educational and scholarly. The educational objective is to provide a teaching resource for upper-division undergraduates and graduate students in design, planning, and allied disciplines such as architecture, environmental sciences, geography, and forestry. The volume offers insights into key themes that shape the theory and practice of ecological design and planning—the evolution, theory, methods, and exemplary past and contemporary practice. By offering a critical analysis and synthesis of the continued advancement of these theories, methods, and practices, the volume examines future issues to be addressed by scholars and researchers.

Public awareness of the undesirable effects of human actions on the landscape has grown rapidly since the mid-twentieth century. There has been increased legislation worldwide in the areas of environmental protection and resource management, as well as accelerated advances in scientific knowledge and technology for balancing human use with ecological concerns. The roots of ecological problems have been widely debated and solutions have been offered. Yet ecological problems continue to intensify at all spatial scales—global, national, regional, local, and site. We are constantly reminded of climate change and urban sprawl as we see the effects in the fragmentation of landscapes, soil erosion, disruption of hydrologic processes, degradation of water quality,

destruction of unique animal and plant habitats, the reduction of biological diversity, and the loss of prime agricultural lands.

Ecological planning is one promising direction for balancing human use with environmental concerns. It is the application of the knowledge of ecological relationships in decision making about the sustained use of the landscape, while also accommodating human needs. A related term, *ecological design,* relies on this knowledge to create objects and spaces with skill and artistry across the landscape mosaic. The two concepts are closely intertwined. Ecological planning is not a new idea, but the level of ecological awareness required in balancing human actions with ecological concerns has increased over the past five decades, at least in North America and Europe, and arguably in many parts of the world, including Asia and South America. The prominent landscape architect and planner Ian McHarg provided an inspiring synthesis of ecological planning in his seminal book, *Design With Nature* (1969). Yet ecological planning still remains an unfinished, evolving field and an uncharted territory for rigorous scholarly work.

Over the past twenty-four years, I have taught courses in ecological design and planning at the undergraduate and graduate levels. I have engaged my students on its various facets. There is considerable information on different dimensions of this topic, but it is scattered across numerous journals and reports. The key books on ecological planning focus on a specific aspect—for example, theories of applied human ecology or landscape ecology, or on methods, or on specific themes, such as the resiliency of ecological systems in urban design and landscape planning. The breadth of the subject matter in ecological planning is very diverse.

This book provides a road map to guide the reader through the diverse terrain, illuminating important contributions in the field of ecological design and planning. The readings focus on published scholarly articles from peer-reviewed journals, books, book chapters, and monographs, as well as published professional reports. As a result, the substantive information in a significant majority of the readings has already been validated by peers and leaders in the field of ecological design and planning. The time span of selected readings begins in the mid-1800s, especially those dealing with the historical context. Some important writings by visionary thinkers such as Ralph Waldo Emerson, George Perkins Marsh, and Frederick Law Olmsted occurred during this period. The 1930s through the early 1960s laid the foundation for contemporary developments in ecological design and planning. Parallel developments in ecological science occurred during the same period, notably in 1935 when English botanist Sir Arthur Tansley coined the term "ecosystem" to describe the biological and physical features of the environment considered in its entirety.

The specific articles in each part of the book were chosen largely through a survey of thirty prominent leaders in the field of ecological planning and design. Each was asked to nominate key readings/articles on the history, theory, method, and practice of ecological design. I ultimately selected those included here with guidance from the book's advisory committee of leaders in the field. To the best of my knowledge, no other book exists that compiles classic, authoritative, and contemporary writings in one volume on the history, evolution, theory, methods, and exemplary practice of ecological design and planning.

The information presented in this book will be useful for students, teachers, planners, designers, researchers, and the general public who are interested in balancing ecological concerns with human use of the landscape. Students and teachers in landscape architecture, and by extension, allied disciplines such as urban and regional planning, geography, rangeland science, forestry, and soil science, will find it an important text in landscape and environmental land use assessment, design, and planning courses. Practitioners in the private and public sectors will use this book as a reference tool for understanding the theory, methods, and exemplary practice in analyzing landscapes, as well as for making informed decisions on how and when to use them.

Land developers, interested citizens, and conservation groups will find the book a useful source of information for understanding how landscape architects and planners prescribe options for the design, planning, and management of landscape change. Because ecological design and planning is still an unfinished, evolving field, researchers will have the opportunity to address the issues raised in the book, and as a result, contribute in advancing the much needed theory and methods of ecological design and planning.

Acknowledgments

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I owe particular thanks to Trisha Gottschalk, and especially Thena Morris, for their invaluable contribution in getting this manuscript into form. Thena ensured that I got all the permissions we needed for the essays and artwork. Debby Bernal also deserves credit for her support and assistance. Many of my friends and current colleagues—far more that I can name here—provided help and advice at various stages in the preparation of this manuscript: Jon Rodiek, George Rogers, and Chanam Lee.

I thank Dr. Jorge Vanegas, Dean of the College of Architecture as well as Chris Novosad and his team in the College of Architecture business office, for providing monetary support and processing the financial transactions that enabled me to obtain the necessary permissions for the essays in this document in a timely manner. I also express my gratitude to Heather Boyer, my editor, for

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Lastly, I thank my family, especially my brothers and sisters Chinedu, Bennett, Uju, Ngozi, and Chioma for their encouragement and support; my daughter Danielle for her patience and thoughtful insights, and my wife June for her inspiration and review of earlier drafts of this manuscript.

Introduction

Concerted efforts to balance human use with ecological concerns sustainably in the twenty-first century continue to be necessary. In the eighteenth and nineteenth centuries, visionary giants like George Catlin, Ralph Waldo Emerson, George Perkins Marsh, Frederick Law Olmsted, and Ebenezer Howard alerted us to the negative impacts of human actions on the landscape. Today, almost two hundred years later, human impacts are greater and more complex, making solutions increasingly difficult to achieve. Landscapes serve as life support systems for people and other organisms but continue to gradually degrade, even as promising solutions are offered. An urgent need, thus, exists to continue to search for ways to effectively balance human use with ecological concerns.

The landscape is the geographical template in which human activities take place. It lies at the interface between natural and cultural processes. It implies the totality of the natural and cultural features on, over, and in the land.[1] Put simply, the landscape "is that portion of land that the eye can comprehend in a single view, including all its natural and cultural characteristics."[2] As such, "landscapes are dynamic entities defined by their interactive parts and integrative whole."[3] Landscapes change over time as humans mold natural processes, sometimes in harmony with the processes, and at other times, altering them. When altered in adverse ways, ecological problems arise and are expressed in different ways at varied spatial and temporal scales—global, national, regional, local, and site.

In the last few decades, the type, scope, magnitude, and complexity of ecological issues and problems have expanded and intensified in response to changing demographic, social, economic, and technological forces. These forces are the key drivers of change in the landscape.[4] We are currently witnessing rapid population growth worldwide. For instance, the world population grew more than tenfold, from 22 million in 1900, to about 2.9 billion in 1999.[5] In 2012, 7.2 billion people inhabited the earth. The United Nations (UN) estimates that this population will reach 8.2 billion in 2030, and 9.2 billion in 2050, of which more than 70 percent will reside in metropolitan areas.[6]

Increased population growth in metropolitan areas has intensified pressures on landscapes to accommodate our daily needs for food, work, shelter, and recreation. Variability in the nature and intensity of these needs across communities and regions is directly related to consumption patterns and practices, resulting in varying levels of demand on the natural, social, and economic resources required to satisfy these needs. These demands are translated directly onto the landscape, altering it either positively or, more often, negatively (figure 0-1).

The term *nature* is used widely throughout this book, thus clarification is essential. Nature is a very complex social construct. The concept of nature has a long history with diverse interpretations.[7] Nature is sometimes used synonymously with the term *environment* or *landscape*. Nature is commonly thought of as a part of the physical world other than humanity and its constructions. The *natural* usually implies phenomena occurring without human involvement. Yet, it is difficult to find an environment that is not impacted by humans, either directly or indirectly. As a result, discussions about nature must embrace humanity. Neil Everton asserted: "Once we accept, through the study of Nature, that all life is organically related, organically the same through the linkage of evolution, then humanity is literally a part of Nature. Not figuratively, not poetically, but literally an object like other natural objects."[8]

I concur with Everton and many others that nature is a social construct that reveals how people interpret their interactions with the natural world. As such, it should embrace humanity. But nature embraces humanity at different levels of intensity. These intensities span from nature as the natural, wild, and undisturbed environment with little human influence, to nature as the fully humanized world. I use the term nature to imply the "natural" as well as those aspects of people's interactions with the environment that are "harmonious" rather than "destructive."[9]

Figure 0-1 Flooding in Calgary, Canada (Photograph from Wikimedia Commons, accessed March 10, 2014).

Effects of Landscape Change

One type of land use conversion—sprawl—results from the haphazard distribution of land uses and infrastructure, often on greenfields beyond the urban center. It has been linked to dramatic consumption of resources, expensive infrastructure expansion, declining quality of life, and intense financial burdens to communities. Sprawl degrades the environment, accelerates the conversion of large amounts of agriculturally productive soils into urban uses, and may cause visual pollution.[10] Between 2005 and 2007, about 4.1 million acres (1.7 million ha.) of agricultural lands were converted into urban uses in the United States.[11] This trend continues.

The need to accommodate metropolitan growth has led to the fragmentation or division of land into smaller parcels, which in turn, leads to land conversions and changes in land use type and intensity. The development of metropolitan areas influences ecological conditions through alterations in the physical condition of the landscape mosaic.[12] The term *mosaic* emphasizes that landscapes are spatially heterogeneous geographical units characterized by diverse interacting ecosystems in which human actions occur. Landscape fragmentation isolates, degrades, and homogenizes habitats;[13] which in turn, affects

biogeochemical cycling and leads to the erosion of biodiversity.[14] Alterations to the landscape may also modify the operation of hydrological systems, and tend to create soils with high concentrations of heavy and inorganic materials. The modifications may also decrease soil permeability and overflow, increasing pollution runoff. In short, the development of metropolitan landscapes disrupts ecological function—the flow of energy, minerals, and species across the landscape. Sprawl exacerbates the negative ecological effects of urban development. Land use alterations are further linked to rapidly changing climate regimes and urban heat island effects, intensified by the growing concentrations of energy consumption for transportation, industry, and domestic use.

Population and economic growth in metropolitan areas in the United States have had positive effects such as increased wealth, economic prosperity, and job creation for many people.[15] The economic prosperity, however, has not been distributed equitably. For instance, central cities lost population from the 1950s to the 1980s as a result of the suburbanization of jobs and income, rapid mechanization of agriculture, and the search for a better quality of life by the city's prosperous residents.[16] Consequently, the population of central cities became poorer. Neighborhoods that were once socially and economically viable have witnessed substantial social dislocation. Fortunately, inner cities have grown modestly since the 1980s.[17] This trend has become a catalyst for reinvestment in inner-city areas, creating a demand for the rehabilitation and restoration of derelict urban landscapes.[18] Contemporary social, demographic, and economic changes have further shaped the character of urban and rural landscapes. Accelerated advances in communications, transportation, and information technology coupled with globalization have intensified decentralization by increasing the capacity for social interaction at a distance, especially when social and economic forces favor it.[19] The interactions among these demographic, social, and technological forces are dynamic, and some of the effects are not yet understood.

Interventions

Ecological planning and design provides a promising way to balance human actions and ecological concerns. Put simply, it is a way of managing change in the landscape so that human actions are more in tune with natural processes.[20] It is a form of intervention that enables us to anticipate the nature and dynamics of landscape change and to plan effectively how to manage both desirable and undesirable effects. *Ecology* deals with the "reciprocal relationship of all living things to each other (including humans) and to their biological and physical environments."[21] Of all the natural and social sciences, ecology arguably provides the best understanding of the relationships between our physical and

social worlds. The essence of ecology is, therefore, to know and understand reality in terms of relationships. This in turn is the rationale, among many, for its use in design and planning.

Ecological planning is the application of the knowledge of the relationships in decision making about how to achieve the sustained use of the landscape, while also accommodating human needs. A related term, e*cological design,* relies on this knowledge to create objects and spaces with skill and artistry across the landscape mosaic.[22] Ecological design and ecological planning are closely intertwined. The objects and spaces created through design, in turn, are employed in facilitating decision making at multiple spatial and temporal scales to create and sustain places. It is difficult to find any decision related to the organization of the physical environments that does not contain an ecological aspect at some level. The development of modern ecology as both a theoretical and an applied science, however, has dramatically heightened interest in employing ecological ideas in a systemic way in design and planning. Although the level of ecological awareness in balancing human actions with ecological concerns has increased over the past five decades, ecological design and planning is not new.

When visionary thinkers such as Thoreau, Marsh, Olmsted, Howard, and Geddes alerted us to human abuses of the landscape, many of them offered solutions as well (see part 1, essay 1). George Perkins Marsh (1801–1882) put forth a persuasive argument that efforts by people to transform the landscape should be accompanied by a sense of social responsibility and he proposed an approach for restoring degraded landscapes (see part 1, essay 2). David Lowenthal, the noted scholar on George Perkins Marsh, provided additional authoritative perspectives on the significance of Marsh's contributions (part 1, essay 3). Although Frederick Law Olmsted Sr.'s (1822–1903) work is not included in the essays in part 1, it is noteworthy that he made significant contributions to the evolution of ecological design and planning by advocating an understanding of the landscape from ecological and aesthetic perspectives. He was successful in translating his ideas into practice, as evidenced by in the numerous landscapes he designed, such as Central Park and Prospect Park in New York, and the plan for the Yosemite Valley Park in California.

Ebenezer Howard (1850–1928), the English proponent of the garden city concept, advocated new communities that fused the beneficial quality-of-life attributes of cities with the naturalness of the countryside (see part 1, essay 4). Like Olmsted, he implemented his ideas in the development of the new towns of Letchworth (1904) and Welwyne (1917) in England. Patrick Geddes (1854–1932), the Scottish botanist and planner, proposed a regional survey method grounded on "folk-work-place" attributes (see part 1, essay 5). Benton Mac-Kaye (1879–1975) articulated the conceptual linkages between regional planning and ecology in an authoritative fashion (see part 1, essay 6). The solutions

proposed by these visionaries have been modified, refined, and expanded by others to adapt to the twentieth- and twenty-first-century social, economic, political, and technological realities. Notable contributions include the works of Lorien Eisley, Jens Jenson, Benton MacKaye, Lewis Mumford, Rachael Carson, Ian McHarg, Philip Lewis, Eugene Odum, Carl Steinitz, Richard Forman, and Frederick Steiner (see part 1, essays 6 and 7).

Since the 1960s, legislation in the areas of environmental protection and resource management has increased dramatically worldwide, and at varied spatial scales. These legislations and policies address a wide spectrum of ecological concerns, from natural resource and habitat conservation, to the protection of clean air and water quality, to the reduction of landscape fragmentation, and collectively, to the prevention and correction of the degradation of landscape resources. Examples of federal legislation include the National Environmental Policy Act (1970), as amended in 1975 and 1982; Clean Water Act (1972), as amended in 1977 and 1987; and the National Endangered Species Act (1973), as amended in 1978, 1979, and 1982). Many states and communities have ordinances in place to balance human use with ecological concerns as well.

Increased interest in ecological design and planning has resulted in a proliferation of theoretical concepts and methodological innovations for understanding and evaluating landscapes to ensure a better "fit" between human actions and ecological systems. This has manifested in movements or sub disciplines such as eco-design, green design and architecture, green infrastructure, low-impact development, sustainable development, smart growth, sustainable regionalism, ecological urbanism, and landscape urbanism. Although we now have an impressive array of approaches for balancing ecological concerns with human actions, it is important to understand the foundational ideas and approaches to understanding and solving the ecological degradation of the landscape. The historical and contemporary approaches are brought together in this book.

Map of the Book

In this book, I bring together classic and important contemporary published works on the history, theory, methods, and practice of ecological design and planning. In the new material, I provide a critical analysis and synthesis of the key issues and discuss the similarities and differences of complementary approaches, with the intent to find a common base of understanding. The readings include seminal contributions from landscape architecture, planning, geography, ecology, environmental science, and green architecture.

This book contains an introduction, seven parts, and a conclusion looking at

future thinking and practice. The parts are historical precedents, ethical foundations, substantive theory, procedural theory, methods and processes, dimensions of practice, and emerging frameworks. In part 1, "Historical Precedents," I introduce key writings on the history of ecological planning with the acknowledgment that ecological problems remain evident at all spatial scales, despite promising interventions. Planners and designers are beginning to acknowledge the significance of ecology as a guiding principle in decision making about the optimal uses of the landscape.

In part 2, "Ethical Foundations," I examine the ethical foundations for ecological design and planning, emphasizing contributions from Ian McHarg, Aldo Leopold, Rachel Carson, Timothy Beatley, and Baird Callicot. A consistent theme in the readings is that people are intricately interdependent with their biological and physical environments. A disturbance in one part of the system affects the behavior of other parts, suggesting specific ethical positions on how we ought to behave toward the land. I conclude that various ethical positions co-exist today and that establishing priorities in reconciling them will become increasingly important.

In part 3, "Substantive Theory," I point out that a feature of the continued development of ecological design and planning is the emergence of methodological directives for translating ecological ideas into practice. I draw a distinction between substantive and procedural theories—the former deals with content theory while the latter emphasizes the processes for balancing human uses with ecological concerns.

Part 4, "Procedural Theory," highlights the contributions of many designers, planners, and ecologists, including Ian McHarg, John Tillman Lyle, and Richard Forman. A consistent theme found in the readings is a search for optimal uses of the landscape, with each author offering ideas about how this may best be achieved, thereby contributing to the richness and diversity of approaches. I conclude that each of the readings has something to offer for the continued advancement of the theoretical-methodological base in ecological design and planning.

In part 5, "Methods and Processes," I review selected ecological design and planning methods to illustrate the diversity of approaches. Each method strives to ascertain the fitness of a tract of land for a particular use, but does so in varied and complementary ways. The suitability method associated with Ian McHarg, for instance, was widely cited by the other authors, especially for its novelty in pulling together an ethical framework, working theories, and ideas for putting theory into practice. I conclude that no single approach can address every ecological problem. Rather, designers and planners should draw upon the strengths of each approach and ignore their less desirable aspects.

I examine case studies of exemplary practice in part 6, "Dimensions of Practice." Each of these represents a wide spectrum of global ecological design and planning practices. They span from those that originate from the research environment, such as professor Carl Steiner's San Pedro River Basin study in the United States; to others that stem from private practice, for instance, the Design Workshop's Aguas Claras mining reclamation and satellite community scheme in Brazil. The type of ecological problems addressed range from new community and restoration schemes, to biodiversity and resource conservation proposals at spatial scales from national to local, from many parts of the world, including Africa, China, South America, and the United States. The studies reveal, to varying degrees, a skillful blending of aesthetic form, functional utility, and ecological health and process in the proposed design and planning solutions. I conclude that each case study makes a unique contribution to the continued development of ecological design and planning practice.

In part 7, "Emerging Frameworks," the essays reflect that the world is becoming increasingly urban and that the problems associated with this are becoming progressively complex. Because urban landscapes are complex, heterogeneous, and interacting ecological systems, comprehending them and proposing sustainable solutions to their problems necessitate an interdisciplinary and holistic perspective. Each author offered solutions or provided insights for ways to understand or even resolve these concerns. Ethical framework, resilience, adaptation, regeneration, sustainability, ecosystem services, regional thinking, evidence-based solutions, aesthetic appreciation of landscapes, and collaboration, are the major themes embedded in the solutions. These will continue to be important as we seek to effectively balance human use with ecological concerns (figure 0-2).

In the conclusion, I provide a critical analysis and synthesis of the themes covered in the essays to illuminate issues that scholars and researchers need to address in the continued advancement of the theory, methods, and future practice of ecological design and planning. I argue that new ideas on how to effectively balance human use with ecological concerns are necessary due to the increasing diversity, magnitude, timing, and complexity of ecological problems arising from changing societal forces.

I offer principles built upon the rich foundations laid by others. At the core of the principles is the quest for *creating and maintaining adaptive regenerative places that are beautiful*. I explore supportive principles for creating such places.

Future solutions will embrace the creation of places that move beyond the promise of sustainability, to those that are beautiful, adaptable to change, and yet conserve, repair, restore, and regenerate the flow of energy, materials, and

Figure 0-2 Conserved natural corridors through the city serve as ecological networks in Cape Town, South Africa (Photograph by author).

species across the landscape mosaic. I conclude that new research and knowledge that has been drawn from reflective practice will be needed, and will enrich our understanding and make us more effective in creating and maintaining viable adaptive and regenerative places.

Notes

1. Aldo Leopold, "The Land Ethic," in *A Sand County Almanac, and Sketches Here and There* (New York: Oxford University Press, 1949); Forster Ndubisi, *Ecological Planning: A Historical and Comparative Synthesis* (Baltimore: Johns Hopkins University Press, 2002), 4.
2. Frederick Steiner, "Landscape," in *Human Ecology: Following Nature's Lead* (Washington, DC: Island Press, 2002), 77.
3. Ibid., 86.
4. Frederick Steiner, *Design for A Vulnerable Planet* (Austin, Texas: University of Texas Press, 2011): Landscape Architecture Foundation [LAF], 2000.
5. Mariana Alberti, "The Effects of Urban Patterns on Ecosystem Function," *International Regional Science Review* 28, no. 2 (2005): 168.
6. The United Nations, accessed September 10, 2013, and January 25, 2014. http://www.un.org. Demographic change and dynamics in the United States follows a similar trend. Between 1960 and 2010, the population of the United States grew from 179.3 million to 308.7 million,

representing a 72.2 percent increase. It is estimated that by the year 2050, the population of the United States will be approximately 410 million, and 86 percent of this growth will be located in metropolitan areas.

7. Neil Everton, "The Fragile Division," in *The Social Creation of Nature* (Baltimore: Johns Hopkins University Press, 1992), 93. Two distinct viewpoints about people's relations to nature emerged that are still evident today. The first is that nature has an order, a pattern that humans have to understand, conserve, and manage with wisdom. The other is that nature is a resource to be used by people for their exclusive use (Worster 1979). Different people, in different ways, and for different reasons have aligned themselves on either side of the duality. Those who subscribe to the first viewpoint believe that nature has an order that has an intrinsic value, that is, a value that exists independent of humans, that needs to be nurtured and preserved. On the contrary, adherents of the second viewpoint look to nature as a storehouse of resources to be organized and used by people. The scientific historian Donald Worster commented on the ramifications of this duality for understanding the history of ecology. "In any case, one might cast the history of ecology as a struggle between rival views of the relationship between humans and nature: one view devoted to the discovery of intrinsic value and its preservation, the other to the creation of an instrumentalized world and it exploration." In David Worster, *Nature's Economy: The Roots of Ecology* (San Francisco, CA: Sierra Club Books, 1979), xi.
8. Everton, "The Fragile Division," 93.
9. Anne W. Spirn, "The Authority of Nature: Conflict, Confusion, and Renewal in Design, Planning, and Ecology," in *Ecology and Design: A Framework for Learning*, Kristina Hill and Bart Johnson (eds.), (Washington, DC: Island Press, 2001), 32. Landscape architect Anne Whiston Spirn's views on this topic are equally instructive. She pointed out that "Nature is mirror of and for culture. Ideas about nature reveal as much or more about human society as they do about non-human processes and features." Yet, people's interactions with the environment may be harmonious or destructive.
10. Forster Ndubisi, "Sustainable Regionalism Evolutionary Framework and Prospects for Managing Metropolitan Landscapes," *Landscape Journal* 27, no. 1 (2008): 51–68.
11. American Farmland Trust, accessed February 16, 2011. http:/www.farmland.org/resources; Steiner, *Design for A Vulnerable Planet.*
12. Alberti, "The Effects of Urban Patterns on Ecosystem Function."
13. Ndubisi, "Sustainable Regionalism Evolutionary Framework and Prospects"; Alberti, "The Effects of Urban Patterns on Ecosystem Function"; Mark McDonnell et al., "Ecosystem Processes Along an Urban-to-Rural Gradient," *Urban Ecosystems* 1, no. 1 (1997): 21–36.
14.   Bruce Wilcox and Dennis D. Murphy, "Conservation Strategy: The Effects of Fragmentation on Extinction," *The American Naturalist* 125, no. 6 (1985): 879.
15. Ndubisi, "Sustainable Regionalism Evolutionary Framework and Prospects," 51.
16. John M. Levy, *Contemporary Urban Planning* (Englewood Cliffs, NJ: Prentice Hall, 1988).
17. U.S Bureau of the Census, 2010.
18. The resurgence of population into the inner city has some costs. For instance, it is creating inequality in urban areas. Those who have more access to resources and power benefit substantially from inner-city investments, while the underprivileged and economically challenged miss out on the emerging opportunities; for instance, see http://www.theatlantic cities.com/jobs-and-economy/2014/02/why-income-inquality-so-much-worse-atlanta -omaha/8451/.
19. Levy, *Contemporary Urban Planning.*
20. Ndubisi, *Ecological Planning: A Historical and Comparative Synthesis.*
21. Frederick Steiner. *The Living Landscape: An Ecological Approach to Landscape Planning* (Washington, DC: Island Press, 2008), 4.
22. Frederick Steiner, *Human Ecology: Following Nature's Lead*; Ndubisi, *Ecological Planning: A Historical and Comparative Synthesis.*

Introduction to Part Five

When Frederick Law Olmsted and his protégée Charles Eliot (1855–97) developed plans for the Fens and River Way in Boston (completed in 1891, resulting in the development of the first metropolitan park system planned around hydrological features and ecological ideas), the processes or methods they employed enabled them to effectively translate ecological ideas into design, although their directives were not as obvious as those that have been utilized over the past fifty years. Scottish biologist and planner Patrick Geddes proposed a regional survey method in 1915, which was refined subsequently by urban historian Lewis Mumford. Geddes's method was based on understanding the nature of the complexities between human action and the environment. *Survey before plan*—a maxim well known to planners even today—is a phrase attributed to Patrick Geddes. He contended that planning should be viewed as a problem-solving activity.

In the 1950s, landscape architects and planners espoused "staged models of design."[1] These models emphasized the design and planning processes as problem-solving activities, building on Geddes's earlier proposition. One of the most eloquent voices of this perspective was that of landscape architect Hideo Sasaki, as articulated in his paper "Design Process."[2] Sasaki viewed design as "relating all the operational factors into a comprehensive whole, including the factors of costs and effects."[3] Critical thinking when applied to design involves *research* to understand the factors involved; *analysis* to highlight the ideal

functional relationships among the factors under consideration; and *synthesis* to articulate the complex relationships among the pertinent factors into some form of spatial organization (figure 5-1). This synoptic-rational view of design and planning, as it was later coined by planner Barclay M. Hudson, was prevalent when Ian McHarg proposed his method for landscape architecture in the mid-1960s.[4]

The seven readings presented in this part begin with the classic essay by Ian McHarg "An Ecological Method for Landscape Architecture," first published in *Landscape Architecture* in 1967.[5] He offered a method for landscape architecture grounded on ecology and interpreted nature as an interacting process that exhibits opportunities and limitations for human use. This work signifies an important phase in the evolution of ecological planning, characterized by methods that were increasingly defensible in public debates. Prior methods employed information and techniques that were covert and often ambiguous.

In the next reading, "Methods for Generating Land Suitability Maps: A Comparative Evaluation" (1977),[6] Lewis Hopkins systematically examined land suitability methods for their validity and reliability and offered guidance on when to use one method over another.

In the classic piece by Kevin Lynch and his colleague Gary Hack "The Art of Site Planning" (1962, 1984),[7] the authors described site planning both as a problem-solving activity and an art in which goals are based upon morals and aesthetics. The first edition of this reading, in 1962, filled a gap in planning education and practice by providing credible methods for transforming landscapes for human use and habitation at varied spatial scales.

The reading by Danilo Palazzo and Frederick Steiner follows. "Processes" (2012)[8] reviewed several methods and processes to determine their relevance to urban design. Palazzo and Steiner proposed an interdisciplinary approach for investigating the transformation of urban spaces, supported by theories, techniques, visual information, and case studies.

In the next reading, "On Teaching Ecological Principles to Designers,"[9] Carl Steinitz proposed a strategy that organizes six different questions framed within the context of problem solving, each of them emphasizing a "theory-driven answer or model." This reading contributed to the foundation of Steinitz's book *A Framework for Geodesign: Changing Geography by Design* (2012), in which he proposed a collaborative design process for transforming large landscapes.[10]

Next, in "Framing the Land Use Plan: A Systems Approach" (2012),[11] William M. Marsh proposed a conceptual model that employs a systems approach for framing land use. His basic idea was to identify and examine the types of landscape systems that shape the site or locale under consideration, and to use

GENERAL TO SPECIFICS

Knowledge of the Client

Knowledge of the Site

Knowledge of the Context

Knowledge of Project Economics

Knowledge of the Program and Users

Knowledge of Design Precedents

Synthesis

· Base Map
· Analysis Drawings
· Program Diagram
· Images
· Budgets
· Ideas and Details
· Goals and Metrics

Explore

Conceptual

Evaluate

· Start with An Idea
· The Dumb Plan

· Model

Explore

Schematic

Evaluate

Explore

Design Development

Evaluate

Explore

Construction Document

Evaluate

Explore

Construction Administration

Document

SPECIFICS TO GENERAL

Figure 5-1 Design processes (Kurt Culbertson, 2002, Reproduced with permission of Design Workshop, Redrawn by Yuan Ren, 2014).

the resultant information to frame thinking and developing plans for the optimal uses of the landscape.

In the last reading, "A Synthesis of Approaches to Ecological Planning" (2002),[12] I offer a synthesis of the major approaches to ecological planning, illuminate their differences and similarities, and propose when one approach may be favored over another.

The ecological design and planning methods reviewed here strive to ascertain the fitness of a tract of land for a particular use but do so in diverse yet complementary ways. Each of them relies on employing ecological principles to inform decisions pertaining to the optimal uses of the landscape. Methods proposed by McHarg and Marsh focus exclusively on processes that lead to the development of a plan. On the other hand, those offered by Lynch and Hack, Palazzo and Steiner, and Steinitz clearly acknowledge to varying degrees that the planning and design process extends beyond the development of a master or site plan, to include plan implementation and administration. The method espoused by Steiner, which I referred to elsewhere as *strategic-suitability methods* in the book *Ecological Planning,* focuses simultaneously on how decisions regarding the optimal uses of the landscape are made and how the resultant decisions are implemented.[13] The innovative framework proposed by William Marsh relies heavily on delineating the formative systems of a site. However, he provided little guidance on how to resolve situations when the formative system is not easily delineated on a project site, or when the site is too small. Almost all the methods reviewed acknowledge implicitly or explicitly the need to incorporate public interest and values in the search for the optimal uses of the landscape.

Each approach makes a contribution in the continued evolution of ecological design and planning. For instance, McHarg's method is widely cited by the other authors, especially for his originality in bringing together an ethical framework, working theories, and ideas for putting theory into practice. His propositions for interpreting nature as an interacting system that offers opportunities and constraints for human uses, as well as his layer-cake model that is based on chronology, are groundbreaking contributions. Hopkins's insightful comparative evaluation of land suitability methods was extremely timely. For instance, he revealed that the method used by McHarg in his Richmond Park Study (McHarg, 1969), which involved overlaying resource factor maps for resources such as soils and vegetation, assumed mathematical operations that were invalid. This method, which Hopkins referred to as the *ordinal combination* method, uses an additive mathematical function analogous to adding apples and oranges. Yet the map overlay technique, similar to the one McHarg

used, was an important and widely used technique employed in landscape architecture, land-use planning, and ecological design and planning practice during that era (1960s and 1970s).

Lynch and Hack revealed in ways few people before them had done that site planning involved the search for ways to most effectively accommodate human behavior and activities. Throughout their article, the authors emphasized the behavioral dimension of site planning. They were emphatic that site planning establishes a behavioral setting where "physical form and human activity are repeatedly associated."[14] Palazzo and Steiner's article, on the other hand, exposes the reader to a wide variety of methods that may be adapted to urban design, and also proposes an interdisciplinary framework for urban design that embraces the considerations of urban ecology and sustainability issues.

The framework proposed by Carl Steinitz has some noteworthy features. Take, for instance, the question that leads to implementing his *evaluation model*: Is the landscape functioning well? This question focuses on ascertaining the current state or well-being of an ecosystem as a point of departure in examining the landscape—an issue that is rarely addressed in ecological design and planning methods. My reading enables planners to be more informed of the theoretical and methodological assumptions made by these approaches in balancing human use with ecological concerns.

In conclusion, these methods illustrate some of the diversity in approaches. Advances will continue to be made to effectively respond to landscape change, especially by improving the technical validity and predictive capabilities of the analytical operations; incorporating advances in ecological sciences flawlessly in design; and skillfully integrating innovations in information, communication, visualization, remote sensing, and computing technologies. Other advances include increasing the involvement of affected interests to ensure that their values are reflected in design decisions, as well as seamlessly embracing culture and aesthetics and sustaining effective collaboration in balancing human use with ecological concerns.

Notes

1. Simon R. Swaffield (ed.), *Theory in Landscape Architecture: A Reader* (Philadelphia, PA: University of Pennsylvania Press, 2002).
2. Max Nicholson cites Hideo Sasaki's work in *The Environmental Revolution: A Guide for the Masters of the World* (New York: McGraw-Hill, 1970).
3. Swaffield (ed.), *Theory in Landscape Architecture: A Reader*, 35.
4. Barclay Hudson and Jerome Kaufman, "Comparison of Current Planning Theories: Counterparts and Contradictions," *Journal of the American Planning Association* 45 (1979), 387–406.

5. Ian McHarg, "An Ecological Method for Landscape Architecture," *Landscape Architecture* 57, no. 2 (1967), 105–07.

6. Lewis D. Hopkins, "Methods for Generating Land Suitability Maps: A Comparative Evaluation," *Journal of the American Planning Association* 43, no. 4 (1977), 386–400.

7. Kevin Lynch and Gary Hack, "The Art of Site Planning," in *Site Planning* (Cambridge, MA: MIT Press, 1984).

8. Danilo Palazzo and Frederick Steiner, "Processes," in *Urban Ecological Design: A Process for Regenerative Places* (Washington, DC: Island Press, 2011), 25–36.

9. Carl Steinitz, "On Teaching Ecological Principles to Designers," in *Ecology and Design: Frameworks for Learning,* B. Johnson and K. Hill (eds.) (Washington, DC: Island Press, 2002), 231–244.

10. Carl Steinitz, *A Framework for Geodesign: Changing Geography by Design* (New York: ESRI, 2012).

11. William M. Marsh, "Framing Land Use: A Systems Approach," in *Landscape Planning: Environmental Applications* (Hoboken, NJ: Wiley, 2010).

12. Forster Ndubisi, "A Synthesis of Approaches to Ecological Planning," in *Ecological Planning: A Historical and Comparative Synthesis* (Baltimore: Johns Hopkins University Press, 2002).

13. Ndubisi, "A Synthesis of Approaches to Ecological Planning," 95.

14. Lynch and Hack, "The Art of Site Planning," 8.

Processes

Urban Ecological Design: A Process for Regenerative Places (2011)

Danilo Palazzo and Frederick Steiner

Urban design connects knowledge to action through a systematic process that adapts to the specific circumstances of the project. The urban designer brings knowledge from previous experience, generates new intelligence about the project, and guides the process through to its realization.

We apply a model to urban design to help designers be more effective project managers. In this capacity, the designer glans, controls, and coordinates "a project from conception to completion . . . on behalf of a client [and] is concerned with the identification of the client's objectives in terms of utility, function, quality, time, and cost and in the establishment of relationships between [available] resources" (Blyth and Worthington, 2001).

Sticking to a process does not necessarily guarantee a successful project. However, an organized process can aid in collaboration and can clarify expectations of all involved parties. It can also help to make the best use of available resources, including time and money.

In the design and planning literature, several examples of processes and models are useful in considering a specific process for urban design. Michael Brawne (2003) investigates the architectural design process or, to say it in a different way, how architects and designers "proceed from the past and present to a forecast of the future." Brawne assumes that the way architects proceed can be assimilated to sequence in the same way Karl Popper explained how scientific theories come into being. Popper's explanation appeared mainly in *The Logic of Scientific Discovery*, first published in German in 1935 and then in English in

1959. Brawne described the Popper sequence as a process that starts with "the recognition of a problem, then put[s] forward a hypothesis, a kind of tentative theory which need[s] to be tested in order to eliminate errors and end[s] with a corroborated theory which is, however, the start of a new sequence in which it becomes the initial problem" (Brawne, 2003). Brawne then concludes that "although clearly architecture is not a scientific pursuit . . . I nevertheless believe that the problem, tentative solution, error elimination, problem sequence is the most accurate description of the design process."

In the field of planning, a well-known and heavily discussed dictum is *survey before plan*, coined by Scottish biologist and planner Patrick Geddes and then further elaborated on by English planner Patrick Abercrombie (Hall, 1995). This succinct dictum establishes the framework for linking knowledge to action in the process. Theoretical reflections on planning and design, particularly after the Second World War, have resulted in many examples of processes applied to planning and design. Some examples, in order of appearance in the literature, follow.

In 1980, the Royal Institute of British Architects, in the *Handbook of Architectural Practice and Management*, proposed in the field of urban design a process model divided into four phases (RIBA, 1980, quoted in Moughtin et al., 2004):

1. *Assimilation*—the accumulation of general information and information specifically related to the problem
2. *General Study*—the investigation of the nature of the problem; the investigation of a possible solution
3. *Development*—the development of one or more solutions
4. *Communication*—the communication of the chosen solution/s to the client

Hamid Shirvani (1985) distinguishes six groups of design methods: internalized, synoptic, incremental, fragmental, pluralistic, and radical. The *internalized* method is the intuitive one: "The designer who uses the intuitive method first develops a design for the project in his or her mind, with the benefit and assistance of memory, training, and experience."

The *synoptic* method, which is also commonly described as "rational" or "comprehensive," is usually composed of seven steps (Shirvani 1985):

1. Data collection, survey of existing conditions (natural, built, and socioeconomic);
2. Data analysis, identification of all opportunities and limitations;
3. Formulation of goals and objectives;
4. Generation of alternative concepts;

5. Elaboration of each concept into workable solutions;

6. Evaluation of alternative solutions; and

7. Translation of solutions into policies, plans, guidelines, and programs.

The *incremental* method is described by Shirvani as another version of the synoptic method in which "the designer establishes a goal and then develops incremental steps to achieve it." The fragmental process is similar to the synoptic, except that it is incomplete. The designer can "go through four out of the total *seven* steps suggested for the synoptic process." The *pluralistic* process is an approach that incorporates into the design process the inhabitants' value system and the functional/social structure of the urban area involved in the design. Shirvani's final approach, the *radical* process, has as an underlying concept that "in order to understand and design for a complex urban setting, social processes must be understood first."

A process of ecological planning, consisting of eleven steps, was proposed by Frederick Steiner in *The Living Landscape* (2008) (figure 5-10). These eleven interacting steps are as follows:

Step 1. Problem and/or opportunity identification
Step 2. Goal establishment
Step 3. Regional-level inventory and analysis
Step 4. Local-level inventory and analysis
Step 5. Detailed studies
Step 6. Planning concept
Step 7. Landscape plan
Step 8. Education and citizen involvement
Step 9. Detailed designs
Step 10. Plan and design implementation
Step 11. Administration

This ecological planning model synthesizes other processes of regional and landscape planning. Its main references are the ecological methods for design and planning formulated since the 1960s by Ian McHarg (1966, 1969, 1981). . . . The principal idea links environmental information through ecological knowledge to design and planning decisions by what McHarg called the "layer-cake model."

In the field of urban planning, Larz Anderson, on behalf of the American Planning Association (1995), defines an urban planning process as composed of nine strongly interconnected phases. The process of plan making was viewed as a continuous cycle that recognizes the iterative and interactive nature of planning (figure 5-11; Steiner and Butler, 2007):
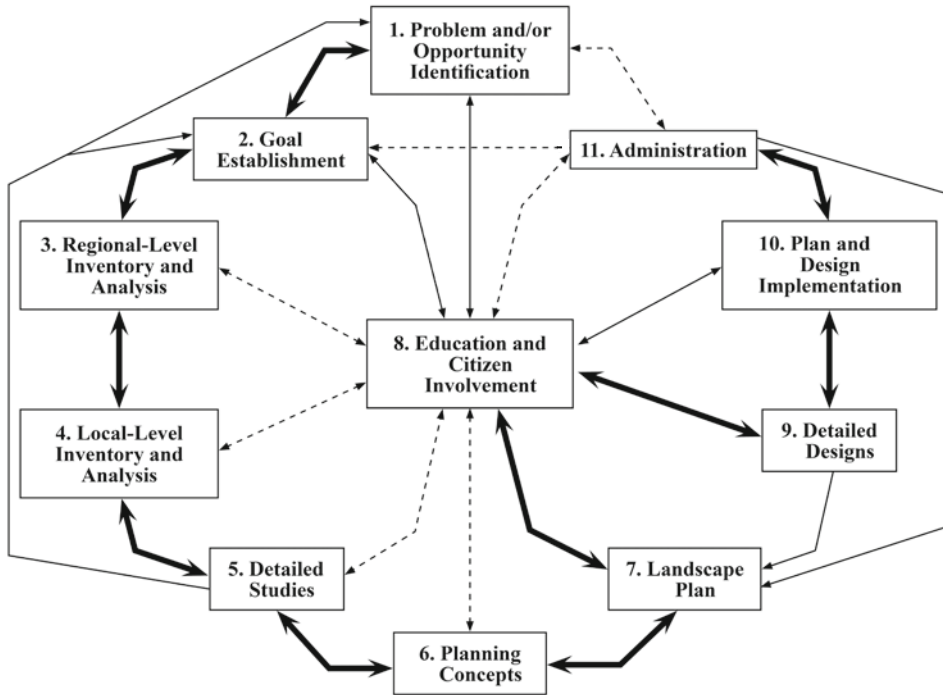
Figure 5-10 Ecological planning model (Palazzo and Steiner, 2011, Reproduced with permission of Island Press, Redrawn by Yuan Ren, 2014).

1. Identify issues.
2. State goals, objectives, and priorities.
3. Collect and interpret data.
4. Prepare plans.
5. Draft programs for plan implementation.
6. Evaluate impacts of plans and implementation programs.
7. Review and adopt plans.
8. Review and adopt implementation programs.
9. Administer implementation programs.

Planning involves managing land uses in cities, agricultural areas, and forests. Planning is studied and practiced in terms of process. The planning and management of natural resources can be accomplished using the principles of *stewardship*, which can be defined as "the call to care for the Earth," counting on human and individual responsibility to "guide individuals toward the common goal [of the preservation of] Earth's beauty and productivity for future generations" (President's Council on Sustainable Development, 1996) and can
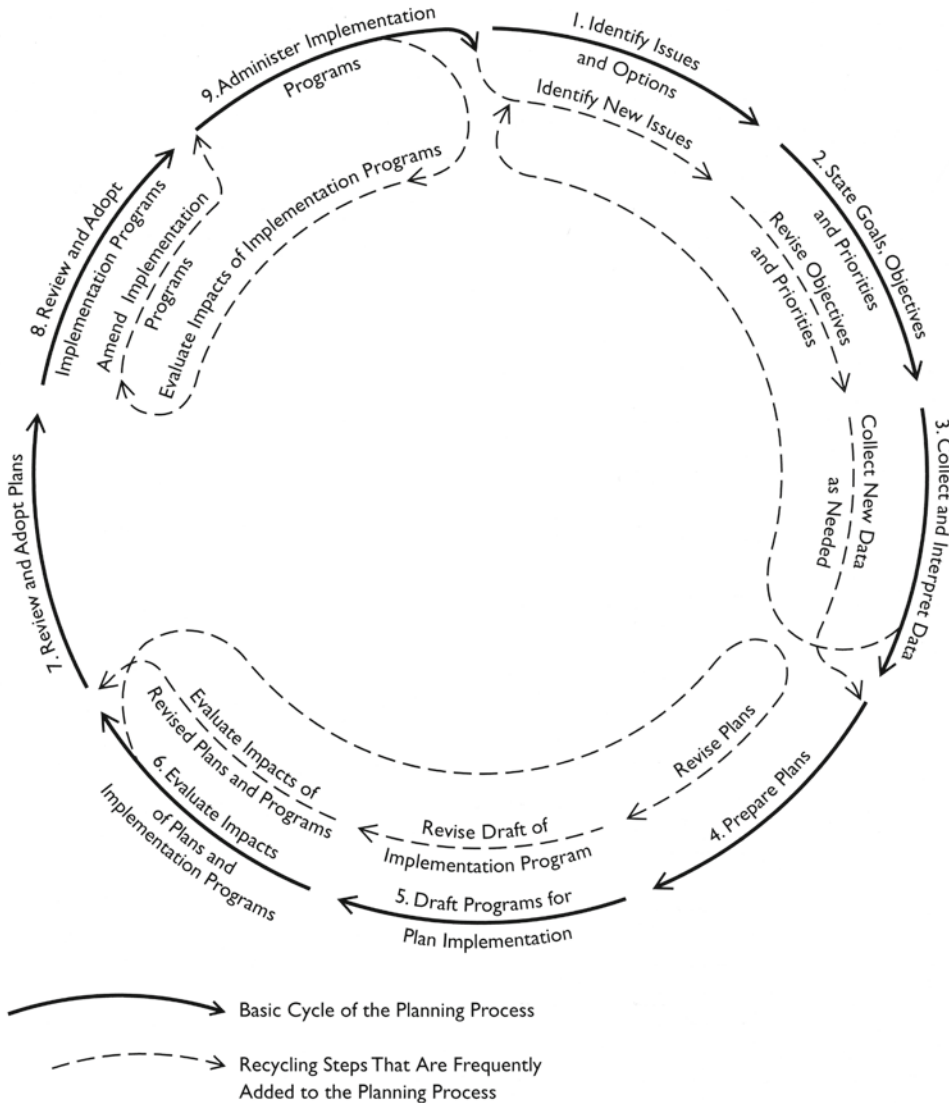
Figure 5-11 The process of plan making as a continuous cycle (Palazzo and Steiner, 2011, Reproduced with permission of Island Press).

be undertaken, according to Sexton et al. (1999), using the seven-step process summarized below:

1. Identify the problem, decision makers, their authorities, the stakeholders, and the decision-making process.
2. Define the problem and refine the objectives.
3. Develop alternative actions to achieve the objectives.
4. Compare each alternative with the objective.

5. Choose a preferred alternative.
6. Implement the chosen alternative.
7. Monitor and evaluate. (Reynolds et al., 1999, 690–92)

Tony Lloyd Jones (2001), discussing the urban design process, distinguishes between artistic inspiration and Geddesian analysis. The first approach (which barely can be considered a process) is driven by the view of "many designers who see themselves as . . . gifted artists." Therefore, according to Lloyd Jones, "the stress is on beautifying the city through grand and often formal street layouts and landscaping interventions." This very clearly relegates the landscape to decoration ("landscaping") in the grand plan, rather than the deeper meaning of landscape as a synthesis of nature and cultural processes with clear ecological implications. On the opposite side of the "artistic inspiration," there is the Geddesian approach that views the design action as a problem-solving activity

> concerned with the issue of spatial organisation to meet functional need. . . . [This] approach [also labeled "functionalist" because of its engineering origin] suggests that if we analyze the problems that the design sets out to address in sufficient detail and in a scientific manner, a spatial solution will emerge from this analysis or "programme." It suggests that design is a linear process, which, if carried out with sufficient rigor, will lead to a single, optimum solution.

Lloyd Jones suggests that there is a third option that overcomes the inspirational and the deterministic approaches. This approach takes the form of a cyclic process of analysis-composition-evaluation: "an attempt to reconcile factors that relate to client or user needs, factors that relate to the site or area under study and its context, and factors that relate to the constraints of planning policy and local planning regulation. It involves understanding the problems that are to be addressed and refining, abstracting and prioritizing the essential issues." Lloyd Jones's third option lends itself to an ecological interpretation that emphasizes cyclic process and interaction.

Following are the four steps of the urban design process:

1. *Defining the problem*—starting from a study area appraisal and the project brief
2. *Developing a rationale*—taking into account summary analysis on planning/socioeconomic context; built form/townscape; land use/activity; movement and access; physical and natural environment; public realm and social space; and perceptual and cultural factors
3. *Summarizing development opportunities and constraints*—balancing the potentials of the site for its projected uses

4. *Conceptualizing and evaluating design options*—envisioning the possibilities for the study area with relative merits and shortcomings

Urban design can be considered "a continuous process of trial-test-change, involving imaging (thinking in terms of solutions), presenting, evaluating, and reimagining (reconsidering or developing alternative solutions)" (Carmona et al., 2003, 55), a process characterized by cycles and iterations "by which solutions are gradually refined through a series of creative leaps or conceptual shifts."
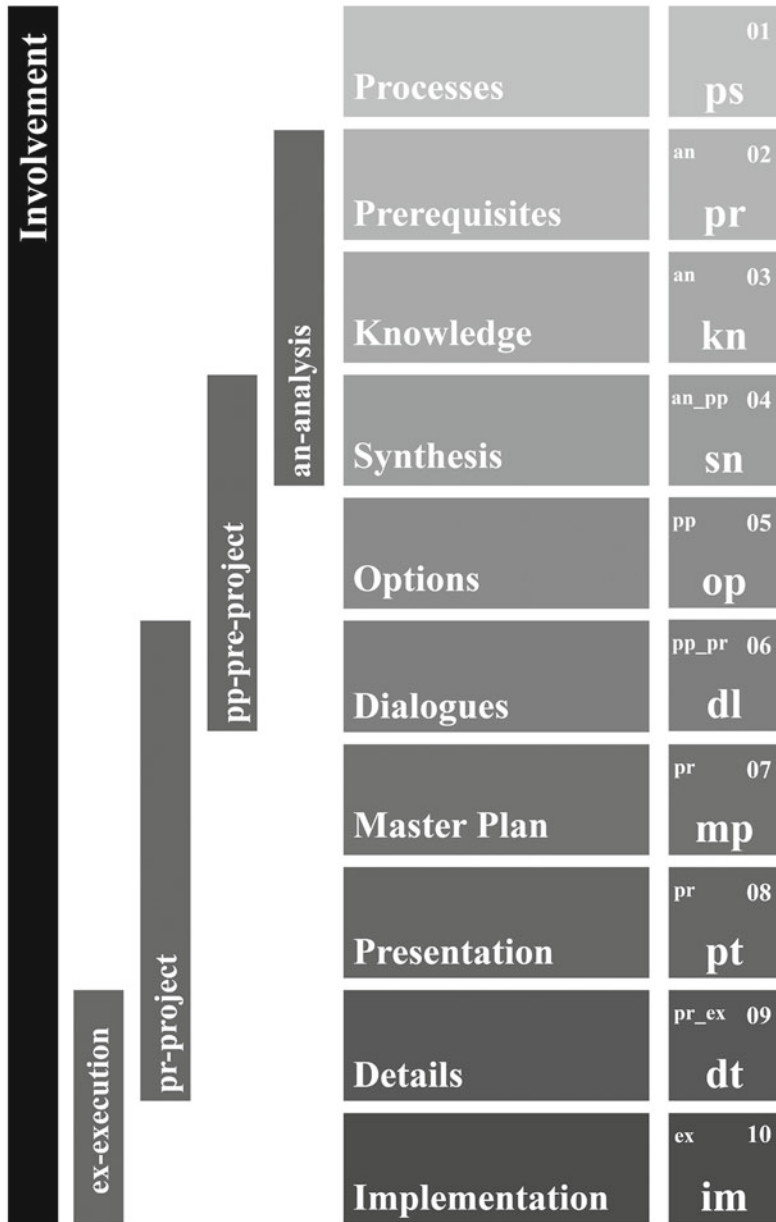
Process Strategies

As the process begins, it helps to provide an outline of future steps that should be considered during the project development. Available time, project character, and necessary materials to achieve the briefs requirements are important criteria for defining the process scope. In environmental impact assessments, scoping is used to define the proposed action, identify significant issues, eliminate peripheral issues, identify project requirements, indicate the decision-making schedule, and identify cooperating agencies. These activities are generally relevant to many urban design projects as well (especially if an environmental assessment is required by law).

The urban design process described in this book can be used as a reference basis, but every design project will possess its own particular characteristics (see figure 5-12). Defining the times, responsibilities, meeting schedules, and interim deadlines is useful. However, as the project progresses, the outline will need to be amended as a result of factors that are often unpredictable in the idealized planned process.

Any urban design process should have a strategy, as Kevin Lynch and Gary Hack explain (1984, 369):

> Plans imply agreements. Without the agreement of those with the power to make changes, and at least the passive assent of those who could stop them, plans remain on paper. To have an effect beyond that of an influential intellectual model, the process of site planning must follow a strategy: it must organize the analysis, programming, design, and implementation so that ideas and decisions are meshed. A strategy includes many choices: how to define the problem, the particular design approach, the use of intuition or rationality, the response to uncertainty, the technique of learning, the degree of participation, the linking of form and management, the use of professionals, and the relation to the client and other decision makers. A good many of these decisions are in the usual case simply customary. But . . . such choices should be made explicitly.

Figure 5-12 The not-only-one solution process and its ten phases (Palazzo and Steiner, 2011, Reproduced with permission of Island Press, Redrawn by Yuan Ren, 2014).

The Process Strategy in the Workshop on Chisinau, Moldova

Organizing the design process takes into consideration the time available, the competencies, the prerequisites, and the nature of the assignment. When time is particularly short, as is usually the case in a workshop, the process organization has a significant value. In 2007, an urban design workshop was conducted in Lecco, Italy, for a strategic area of Chisinau, the capital of Moldova, the Eastern European state that borders Romania to the west and the Ukraine to the east. . . .

Chisinau is the political, industrial, and commercial center of Moldova. Located on the Bîc River in the center of the country, it is the largest city of Moldova, with 650,000 inhabitants. During the Soviet domination (1944–1991), the heavy industry of the country was located along the Bîc River. Today, the industrial areas have been largely abandoned. Some buildings were demolished and replaced by retail centers; others are only partially used. The Bîc River and its adjacent soils are heavily polluted.

The municipality of Chisinau and Milan Polytechnic promoted a design initiative to define some ideas for the area along the river. A two-week workshop was organized to produce a proposal for the City of Chisinau. The workshop was held with practitioners from the London office of Skidmore, Owings & Merrill (SOM), with academics from the Universidat Autònoma de Barcelona (Autonomous University of Barcelona) and Milan Polytechnic, and with students from various European and Asian countries. In addition, four design and planning professionals from Chisinau communicated daily via computer with this group of twenty-one people. To redefine the function of the whole area (7,400 acres, or 3,000 hectares), the team decided to work on different issues:

- *Transportation* at national, regional, and urban levels
- *Mobility* of people and goods
- *Environment and landscape,* including the pollution of the river and soils and the need to redesign the areas along the river in terms of hydraulics and for recreational uses
- *Agriculture,* one of the most important resources of the nation and the major land use outside Chisinau
- *Energy,* the need to understand how to reduce natural gas use by introducing biomass plants
- *Finance,* finding the financial sources to implement the workshop proposals
- *Administration and management* of the whole project

To perform these tasks, the twenty-five-member team was split into different groups focusing on specific issues. A phasing table was proposed to organize the process and to give the team pace and rhythm. The process was determined at the very beginning of the two-week workshop on the basis of the time available, the strengths of the team, the request of the "client," and a rational organization of the steps from initial research and analysis (which correspond to the "knowledge" and "synthesis" steps described in this book) to preliminary concepts ("options") to final plan ("master plan") and then the final presentation. The "prerequisites" were contained in a briefing book prepared in advance and distributed to workshop participants and in "dialogue" between the Milan team and the local participants in Chisinau.

Summary

Usually, the designer provides an early version of the project plan, perhaps only roughly sketched. The idea is to begin imagining the final outcome but to avoid getting locked into a fixed solution. This "open-endedness" permeates the entire process and is indeed important, even if it is difficult to manage. The project is the process target, its goal. It is therefore natural and expected that designers direct individual thought, their own actions, toward that final outcome during all the steps of the process.

In the design process, as in planning, improvisation can occur so that information is synthesized before the data survey is completed as part of the knowledge phase.

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