Greenways as Strategic Landscape Planning: theory and application

Jack Ahern

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Promotor: Prof. ir. K. Kerkstra
hoogleraar Landschapsarchitectuur
Wageningen Universiteit

Samenstelling promotiecommissie:
Dr. R.H.G. Jongman (Wageningen Universiteit)
Dr. F. Steiner (University of Texas, USA)
Prof.dr. A. van der Valk (Wageningen Universiteit)
Prof. ir. M.J. Vroom (Wageningen Universiteit)

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John F. Ahern

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Abstract

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This thesis investigates greenways as an emerging strategy for landscape planning. In the thesis, greenways are researched through case studies in the Netherlands and the USA and through published literature. Application of the greenway concept is made to several landscape planning projects in the USA. An original greenway typology is proposed based on: scale, goals, spatial context, and planning strategy. Using the typology, greenway planning is compared with other contemporary landscape planning concepts and activities including: ecological networks, wildlife corridors, and habitat networks. The thesis discusses three fundamental benefits of greenways: the hypothesis of co-occurrence of resources; the inherent benefits of landscape connectivity; and the concept of compatible, or synergistic multiple use in greenways. A "framework method" for landscape/greenway planning is proposed based on an alternative future scenario approach. The method provides a framework for applying landscape ecological principles to landscape planning (i.e. landscape ecological planning). The integration of cultural resources and issues is identified as a challenge in greenway planning and is integral with the framework method. Landscape aesthetics is considered as fundamental in greenway and is incorporated in the case applications and reviewed in the literature. A survey of greenway planning in the USA was conducted which found that: greenways are increasingly integrated with comprehensive landscape planning in the USA, and greenways are often initiated to provide trail and recreational use, but evolve to support multipurpose/multi-functional planning goals and objectives. Finally, the thesis addresses the issue of uncertainty in data and knowledge for planning and proposes an interactive and adaptive approach through which greenway planning may be conducted with imperfect knowledge.

Key Words: greenways, spatial concepts, landscape planning, landscape ecology

for Linda

my love and best friend

Contents

1 Introduction

Introduction

Greenways are systems and/or networks of protected lands that are managed for multiple uses including: nature protection, biodiversity management, water resources, recreation, and cultural/historic resource protection. Greenway planning is defined here as a strategic action that integrates theories from landscape ecology with theories and methods of landscape planning to focus on the goal of realizing a sustainable "greenway" network of protected lands, managed for compatible multiple purposes. A greenway system or network includes linear corridors and larger areas of protected land that are physically and functionally connected. Decision-makers and stakeholders are able to imagine and understand greenways. As a result, greenways often arise at a grassroots level and are subsequently integrated into a broader-scaled system. Greenways are strategic and spatially efficient for protecting and managing land because greenway resources are not randomly distributed but rather are concentrated in corridors.

This dissertation argues that greenways originated in the United States of America (USA) but are spreading internationally because the greenway concept is: (1) based in part on scientific knowledge, (2) understandable and "imageable" to the public, and (3) strategic in realizing multiple goals. Greenways are supported by theories from landscape ecology, particularly those concerning spatial configuration and connectivity. Because Greenways are a relatively new concept in landscape planning, new theory, planning strategies, and planning methods are needed. The application of greenways as a component of sustainable landscape planning requires new approaches which integrate abiotic, biotic, and cultural resources and issues. This dissertation includes reviews of international greenway literature and makes original contributions to this emerging theory, planning strategies, and planning methods. Case studies and case applications are used to explain and test the theory, strategies, and methods.

Key concepts in the emerging greenway theory and methods include: alternative future scenarios and adaptive management/planning. Scenarios are useful in conceiving alternative future landscapes and greenways feature prominently in many scenario studies. Both scientific knowledge and creative concepts are needed to formulate effective greenway scenarios. Greenway planning is often conducted with uncertain or incomplete knowledge. Adaptive planning/ management offers a framework for planning and implementing greenways in an experimental manner that yields new knowledge through application, plan implementation and monitoring. Scenarios and adaptive planning/management are addressed from multiple perspectives in this dissertation.

Greenway case studies and case applications are reviewed and presented to derive and test the propositions advanced in this dissertation. A framework method for greenways and landscape ecological planning is proposed which integrates these key theories from landscape ecology, spatial concepts and scenarios, and adaptive management. The framwork method is applied in several test applications in the USA and discussed in the Dutch context.

Dissertation Propositions

The individual chapters contained in this dissertation are unified by five general propositions. These propositions have been articulated to guide the research and writing, to inform the selection of case studies, and test applications. Figure 1.1 presents a summary of the five propositions as they specifically relate with the chapters.

Figure 1.1 tracks the relationship between the dissertation chapters and the five main research propositions that are explored, tested and applied. The individual chapters have been written to assure that the propositions are addressed from multiple perspectives, in various physical and cultural contexts, and evaluated through case studies, or applied through case/test, applications. Figure 1.1 illustrates how this relationship is specifically expressed in the chapters, with each proposition being addressed in at least three chapters, and with each chapter addressing at least two of the propositions. The concluding chapter summarizes, reviews, and discusses the five propositions. In Chapter 7, conclusions are offered, as are subjects and directions for future research and applications.

Proposition 1: Greenways offer strategic advantages for sustainable landscape planning

Greenways represent a strategic approach to landscape planning, because they are proactive and multi-objective. Three arguments support this proposition: (1) the hypothesis of co-occurrence of resources in greenways, (2) the inherent benefits of landscape connectivity, and (3) the concept of compatible or synergistic multiple use in greenways.

The hypothesis of co-occurrence posits that abiotic, biotic and cultural greenway resources are spatially concentrated in distinct corridors, usually following riparian valleys or corridors, ridgelines, and coastlines. Therefore, protection of these corridors will result in a strategic advantage to protect the greatest amount of resources with the least amount of land. Greenways promote connectivity which supports a multitude of ecological and cultural processes. Therefore, maintaining and supporting these processes (e.g. species habitat and movement, hydrology, soil stabilization, recreation) through greenways, promotes a sustainable landscape condition. Greenways exploit the compatibility of multiple use, to gain spatial and economic efficiency, and to promote long-term cultural and political support.

In Chapter 2 “Greenways as Planning Strategy”, a typology for greenways classification is offered. The typology includes four fundamental planning strategies: protective, defensive, offensive, and opportunistic. These strategies, or combinations thereof, can guide and represent the application of greenways in any context. In Chapter 5 “Time, Space, Ecology and Design: Landscape Aesthetics in an Ecological Framework in the Netherlands” greenways as networks of protected land are described as an essential component of a strategic approach for a sustainable landscape condition, and argues that the new

	Propositions				
Chapters	Greenways offer strategic advantages for sustainable landscape planning	Landscape ecological theory and principles are fundamental for greenway planning	Alternative future scenarios are particularly effective for greenway planning	Cultural resources are integral to landscape ecological planning	Implementation of landscape ecological planning requires an adaptive approach
2. Spatial concepts, planning strategies and future scenarios:	------------	Planning theory reviewed, landscape ecology featured	Scenarios featured in framework method and case study	Cultural resources are integral to framework method	Adaptive approach integrated in framework method
3. Greenways as a planning strategy	Greenway typology includes four fundamental planning strategies	Landscape ecology principles reviewed in case studies	---------------	Cultural resources integral to case studies	Adaptive management discussed
4. Greenways as ecological networks	-------------	Landscape ecology principles applied in test application	Alternative scenarios presented in case study	-----------	------------
5. Time, space, ecology, and design:	Networks argued as necessary for Sustainable landscapes	-----------	-----------	Greenways provide context for cultural expression	--------------
6. Greenways in the USA	Three theoretical principles supporting greenways	Inherent benefits of connectivity support greenways	-------------	Including cultural res. Is key to multiple use And public support	------------
7. Conclusion:	Strategic advantages of greenways from all chapters summarized	New perspectives are reviewed and discussed	The role of scenarios in greenway planning is reviewed	Cultural resources included in adaptive planning method	Outlines an adaptive approach for landscape and greenway planning

Figure 1.1 Dissertation Chapters and Propositions Matrix

paradigm of sustainability needs an aesthetic component/dimension. Chapter 6 "Greenways in the USA: theory, trends and prospects" offers three theoretical principles which support greenways as a form of strategic planning.

Proposition 2: Landscape ecological theories and principles are fundamental to greenway planning

Landscape ecology has advanced scientific theory and principles that are increasingly applied in landscape planning. Foremost among these are theories with direct and explicit spatial implications for planning. These theories are based largely on island biogeography and metapopulation theories which address the interactions between species in a dynamic sense: species populations and landscapes constantly change. Principles from landscape ecology relating to spatial and temporal scales are also important and are understood in an hierarchical framework. The landscape scale is appropriate for sustainability planning because it is large enough to accommodate heterogeneity and disturbance regimes, yet small enough to survey, assess, plan, design, and manage for specific landscape structure. Operating at the landscape scale planners can hope to understand and manage fundamental pattern and process relationships and dynamics. Applied landscape ecology integrates topological and chorological perspectives on landscapes. Conventional, topologically based, landscape planning methods are valuable and established methods to understand "vertical" heterogeneity, the interactions of landscape elements and processes, in one place. The chorological perspective, as advanced by applied landscape ecology, complements the topological perspective by engaging abiotic, biotic, and cultural resources and processes that occur "horizontally" across heterogeneous landscapes, the interactions between landscape elements and the suite of processes that they support.

Chapter 2 "Spatial concepts, planning strategies and future scenarios: a framework method for integrating landscape ecology and landscape planning" reviews the recent evolution of planing theory with an emphasis on the increasing integration of landscape ecology theory. In Chapter 3 "Greenways as a Planning Strategy" landscape ecology theory is reviewed through greenway case studies in the USA and The Netherlands. In Chapter 4, "Greenways as Ecological networks in Rural Areas" landscape ecology theory is applied in a test application for the Quabbin-to-Wachussett Greenway corridor. Chapter 6 "Greenways in the USA: theory, trends and prospects" focuses particularly on the issue of connectivity in greenway planning, referenced to the contemporary landscape ecology literature.

Proposition 3: Alternative scenarios are particularly effective in greenway planning

Alternative scenarios which address landscape configuration and function are a useful method for applying landscape ecology to greenway planning. Because greenways are strategic and proactive, the greenway concept can be effectively communicated through alternative scenarios. Scenarios may integrate rational and intuitive thinking. Scenarios can link actions or policies with outcomes in the landscape. When used in the proposed framework planning method scenarios can support participatory decision making and represent a promising method for trans-disciplinary research and applications.

In Chapter 2 "Spatial concepts, planning strategies and future scenarios: a framework method for integrating landscape ecology and landscape planning," the theory and literature of scenarios are reviewed and scenarios are featured in a proposed framework method for landscape ecological planning. A case application in Orange, Massachusetts, USA illustrates how scenarios can be applied in greenway planning. Chapter 4 "Greenways as ecological networks in rural areas compares two alternative scenarios in the Quabbin-to-Wachussett case application.

Proposition 4: Cultural resource values need to be integrated into landscape ecological planning

Challenges remain to integrate the emerging physical and biological theories and principles of landscape ecology, with a more comprehensive view of landscape planning which integrates cultural and aesthetic resources and issues. Given that the existing cultural landscapes of the world manifest historical values and knowledge, if these values and knowledge are to change to reflect the emerging paradigm of sustainability, a fundamental change in landscape values (including aesthetics) is warranted. This change will have consequence for landscape-scale planning decisions as well as site-scale design decisions.

In Chapter 2, "Spatial concepts, planning strategies and future scenarios" a proposed framework method for landscape planning is proposed. This method integrates the cultural perspective, as a fundamental resource, in parallel with the abiotic and biotic. Chapter 3 "Greenways as a Planning Strategy" includes cultural resources in the proposed greenway typology, and demonstrates how cultural resources can be featured in greenways through the Minute Man Greenway Case study. Chapter 5 "Time, space, ecology and design" argues that cultural and aesthetic resources and issues are essential to include if greenways are to be considered sustainable. Chapter 5 also poses that greenways provide an ideal context for cultural expression in landscapes, reflecting evolving cultural values and traditions. Chapter 6 "Greenways in the USA" argues that including cultural resources in greenways is essential to gain public support and to realize the presumed benefits of compatible multiple use.

Proposition 5: An adaptive approach is necessary for landscape ecological planning

Adaptive management/planning is an essential concept to reconcile the inherent uncertainty of site-specific scientific knowledge for planning as an opportunity to generate new knowledge (or to validate certain hypotheses). To accomplish effective adaptive management/planning, new protocols for monitoring and analysis need to be developed, implemented and communication needs to improve between scientists and planners. Scientists can help planners to conceive designs as experiments, and planners can help scientists to introduce intuitive thinking into experiments.

Chapter 2 : Spatial concepts, planning strategies and future scenarios" Features a proposed "framework method for sustainable landscape planning. The framework features an adaptive approach in which monitoring results, and new knowledge are part of an iterative, and continuous planning process. Chapter 3 "Greenways as a planning strategy" discusses the need for an adaptive approach to ecologically based planning and management.

Organization of the Dissertation

This dissertation is comprised primarily of a series of five, refereed, previously published journal articles and book chapters (Chapters 2-6). Prior to publication each of these works have each been blind, peer- reviewed by experts in landscape planning and/or landscape ecology. These individual works have been conceived, prepared, and published to be included as chapters of this dissertation. Chapter 7 is a summary and conclusion of the dissertation, including an analysis of the extent to which the dissertation propositions have been addressed. This dissertation is the first time that these published works have been aggregated in a comprehensive form. The references from each of the published chapters have been merged into a master reference section.

Chapter 2: Spatial Concepts, planning strategies and future scenarios: a framework method for integrating landscape ecology and landscape planning

This paper reviews contemporary landscape planning theory to compare emerging theory from landscape ecology with established planning theories and methods. Based on this comparison, an original framework landscape planning method is proposed. Key elements of this theory/method include:

1) the theories of island biogeography and metapopulations
2) the role of planning strategies and spatial concepts
3) the use of scenarios to generate, visualize, and evaluate the consequences of various landscape planning decisions
4) inclusion of adaptive management within an iterative and continuous planning process

A case application from the town of Orange, Massachusetts demonstrates the framework method, featuring alternative scenarios.

Publication citation: Jack Ahern. 1999. Spatial concepts, planning strategies and future scenarios: a framework method for integrating landscape ecology and landscape planning. Chapter 10 in Landscape Ecological Analysis: Issues and Applications, Jeffrey Klopatek and Robert Gardner, Editors, Springer-Verlag Inc. New York, pp. 175-201.

Chapter 3: Greenways as a Planning Strategy

Greenways is a generic term that has been applied to a wide range of landscape planning strategies, concepts, and plans. While there is some consensus emerging on the benefits of protecting networks of land, there is little agreement on terminology. As a result, communication and knowledge exchange are limited. This paper offers an inclusive definition of greenways; discusses greenway characteristics, benefits, and liabilities; and presents a typology for greenway classification based on: scale, goals, landscape context, and planning strategy. This typology is applied in three case studies from the Netherlands and the USA, selected to represent a range of greenway types, to articulate similarities, differences, and to explore the transferability of knowledge and concepts. Through this discussion, greenways are argued as a useful strategy for planning, design, and management of sustainable landscapes.

Publication citation: 1995. Jack Ahern. "Greenways as a Planning Strategy" Landscape and Urban Planning, Special Greenways Issue. 33:1-3, 131-155. Also published in the book: Greenways: The Beginning of an International Movement J.G. Fabos and J. Ahern, Editors, 1996, pp. 131-155 Elsevier, Amsterdam.

Chapter 4: Greenways as ecological networks in rural areas

It is the thesis of this paper that greenway planning should be integral to a comprehensive landscape planning effort, including consideration of the development suitability, open space resources, wildlife habitat protection, and scenic resource management. In this larger context, greenways may be seen as the connecting elements in a network which links protected lands. This chapter reviews the relevant literature from landscape ecology and landscape planning, and applies a method for multifunctional greenway planning to a case study "The Quabbin-to-Wachussett Wildlife Corridor" in Central Massachusetts, USA. Greenway implementation strategies and techniques are described in terms of their effectiveness and efficiency.

Publication citation: 1994. Jack Ahern. "Greenways as Ecological Networks in Rural Areas" in E.A. Cook and H.N van Lier, Editors: Landscape Planning for Ecological Networks. Elsevier, Amsterdam, pp. 159-178.

Chapter 5: Time Space, Ecology and Design: Landscape Aesthetics in an Ecological Framework in the Netherlands

This paper starts from the premise that landscape aesthetics should support and provide visible expression of the concept of sustainability. Recent international agreements on sustainability are perhaps the closest the world has ever come to a consensus on environmental policy, and provide a sound conceptual foundation for developing a new landscape aesthetic. The paper asserts that landscape architecture is uniquely poised to address the challenge of sustainability in the realms of both planning and design, at multiple scales, by advancing a landscape aesthetic and spatial strategy structured by a greenway network, or framework of protected lands. The paper uses concepts, theories, and case studies from The Netherlands, known internationally for innovative and progressive landscape planning.

Publication citation: 1994. Jack Ahern and Klaas Kerkstra. "Time Space, Ecology and Design: Landscape Aesthetics in an Ecological Framework in the Netherlands" In proceedings : Ecology Aesthetics and Design, American Society of Landscape Architects (ASLA), Washington, DC, pp. 49-60.

Chapter 6: Greenways in the USA: theory, trends and prospects

Greenways is a popular, contemporary planning concept and strategy that originated in the USA. It has historical precedents in 19th Century landscape architecture and city planning practice in the United States. Greenways continue to expand across the USA and are increasingly becoming of international interest, particularly in Western Europe. The late 19th and early 20th Century greenway planners in the USA intuitively recognized the same three fundamental theoretical greenway principles that are proposed in this paper: 1) The hypothesis of co-occurrence of resources in greenways, 2) The inherent benefits of landscape connectivity. 3) The concept of compatible, or synergistic multiple use in greenways. This paper asserts that these three fundamental greenway principles derive from landscape planning theory, are supported and strengthened by emerging landscape ecology theory, and that their application as greenways supports the contemporary international policy goal of sustainability. The paper briefly reviews the history of greenways in the USA, and identifies contemporary trends based on a recent original survey which found that: (1) greenways are increasingly integrated with comprehensive landscape planning at the state level in the USA, (2) greenways are often initiated to provide trail and recreational use, but evolve to support multipurpose/multi-functional planning goals and objectives.

A future prognosis for greenways in the USA is offered including an expected shift from locally-initiated to regional and interstate greenway planning and implementation, and more explicit integration of multiple uses in greenways.

Publication citation: Jack Ahern. (accepted for publication, June 2001). Greenways in the USA: theory, trends and prospects. In R.H.G. Jongman and G. Pungetti, Editors: New Paradigms in Landscape Planning: Ecological Networks and Greenways. Oxford Press.

Chapter 7: Conclusion: An Adaptive Approach to Landscape Planning

This chapter reviews the research presented in the dissertation, evaluates the research propositions, identifies the original contributions of the research and identifies future research questions.

2 Spatial Concepts, planning strategies and future scenarios: a framework method for integrating landscape ecology and landscape planning

Publication citation: Ahern, Jack. 1999. Spatial concepts, planning strategies and future scenarios: a framework method for integrating landscape ecology and landscape planning. Chapter 10 in Landscape Ecological Analysis: Issues and Applications, Jeffrey Klopatek and Robert Gardner, Editors, Springer-Verlag Inc. New York, pp. 175-201.

Spatial Concepts, Planning Strategies, and Future Scenarios: A Framework Method for Integrating Landscape Ecology and Landscape Planning

Landscape planning can be defined as the practice of planning for the sustainable use of physical, biological, and cultural resources. It seeks the protection of unique, scarce, and rare resources, avoidance of hazards, protection of limited resources for controlled use, and accommodating development in appropriate locations (Fabos 1985). Sustainable landscape planning has been strongly supported through major international policy agreements, and can be generally defined as "a condition of stability in physical and social systems achieved by accommodating the needs of the present without compromising the ability of future generations to meet their needs" (IUCN 1980; WCED 1987). Increased international interest in sustainable landscape planning has stimulated much discussion at professional conferences and svmposia and in recent publications (Lyle 1994; Forman 1995). More significantly, and in the context of this chapter, this challenge for sustainable landscape planning has also inspired a dialogue between ecologists and landscape planners within the discipline of landscape ecology (Forman 1990a, Golley and Bellot 1991, Vos and Opdam 1993, Hersperger 1994, Langevelde van 1994).

There are multiple dimensions to sustainability including, economic, social, ethical, and spatial. Landscape planning is most fundamentally linked with the latter, the spatial dimension, and predominantly at the scale of the landscape. Landscape plans are actually hypotheses of how a proposed plan (i.e., landscape structure) will influence landscape processes. The landscape plan offers specific recommendations regarding, land-use allocation, designation of levels of protection and management, and setting a strategy to 'undo' negative changes in the landscape from the past. If the planning recommendations are implemented, the plan. as a landscape ecological hypothesis, becomes a field experiment from which landscape ecologists may gain new knowledge (Golley and Bellot 1991). This model of landscape planning and landscape ecological cooperative interaction follows the concept of adaptive management (Holling 1978). All of these applied landscape ecological activities engage the pattern:process dynamic that is at the core of landscape ecology (Turner 1989). Thus the activity of landscape planning can be seen as a primary basis for collaboration and knowledge exchange between landscape planners and landscape ecologists.

The landscape scale is appropriate for sustainable planning because it is sufficiently large to contain a heterogeneous matrix of landscape elements that provide a context for mosaic stability (Forman 1990a, 1995). The definition of landscape by Forman and Godron (1986, p. 594) is referenced in this context. "A heterogeneous area composed of a cluster of interacting ecosystems that are repeated in similar form throughout. Landscapes vary in size, down to a few kilometers in diameter." A landscape has at least a theoretical potential to support disturbance regimes, landscape succession, and changes in land use while maintaining some level of "mosaic stability." The ecosystem scale is by definition vulnerable to irrecoverable disturbance or "permanent" chance because of building projects and, therefore, is not an appropriate scale for sustainable landscape planning. The ecosystem is a useful spatial unit to understand vertical or topological relationships, but is spatially too limited to understand the "horizontal" or chorological patterns and processes (Zonneveld 1995). At the other end of the scale continuum, the biosphere is perhaps the ultimate ecological scale, the scale in which all ecological processes are involved. Humans are only beginning to understand the global dimensions of ecology, let alone attempting to conceive and implement plans at the biosphere scale. The landscape scale is consistent with the scale of human perception, decision making, and physical management; the biosphere scale is not. At least in conceptual terms, the landscape is probably the optimal scale for sustainable landscape planning.

Landscape ecology has provided a terminology and taxonomy for describing, landscapes and their associated patterns and processes. Hierarchy theory has established a conceptual means for understanding the inter-dependence of patterns and processes within a system of nested scales. First principles are emerging to inform and guide planning,. Landscape ecology has thus established a theoretical foundation for clear communication of research results and for application to decision making.

Landscape ecologists and planners are united by a common interest in the pursuit of sustainable landscapes. Beyond this rather obvious and intuitive common pursuit, and the common interest in the fundamental interaction of landscape pattern:process, just how can the scientific and the applications "sides" communicate, or even better collaborate?

This chapter attempts to answer this recurring question. It will do this first by reviewing some basic theory and methods from landscape planning, and proposing essential attributes of a landscape ecological-based planning framework method. It will then introduce the idea of spatial concepts, which acknowledges the centrality of the spatial dimension of sustainable landscape planning (Forman 1990a, Zonneveld 1991). The idea of spatial concepts moves the sustainability discussion away from abstract theory toward specific solutions by integrating, landscape ecological principles and knowledge with creative solutions appropriate to a specific spatial context. A thesis of this paper is that landscape ecology can assist in the conception and evaluation of spatial concepts, and that the implementation of spatial concepts in landscape plans represents a basis for field experiments which can, in turn, generate new knowledge.

A well-conceived spatial concept for landscape planning requires a strategic approach to develop and implement the actual plan. Scenarios can be employed in strategic planning to achieve surprising, yet plausible plans and unexpected results (Hirschorn 1980). The use of scenario studies has proven effective, especially in the Netherlands, to communicate the spatial consequences to the landscape of specific policy decisions (Steinitz et al. 1994, Schooenboom 1995; Veenenklaas 1995).

This paper contains numerous references to Dutch landscape planning and landscape ecology. This is, in part, the result of the author's continued involvement with the Wageningen Agricultural University, but more so because the Netherlands is a landscape under severe ecological stress. By a number of measures of ecological integrity, the Netherlands is in a non-sustainable condition. In the face of this dire situation, and following a tradition of ambitious and innovative responses to profound challenges the Dutch have embarked on a national plan for a sustainable environment that is globally unprecedented. For this reason the Netherlands has been labeled an "experimental garden" and was the subject of a major edited book on landscape ecology (Vos and Opdam 1993). There is a great deal to be learned from the Dutch landscape experience, particularly with respect to the manner in which landscape planning and landscape ecology are integrated in theory and application.

The chapter presents an application of the proposed framework method to a landscape plan for the town of Orange in Massachusetts. The plan emphasizes open space planning, which was broadly interpreted to include the abiotic, biotic, and cultural resources and issues. The planning process employed spatial concepts, defined strategies, and offered scenarios as a basis for community decision making. The application illustrates the proposed framework method for landscape ecological planning.

Landscape Planning Theories and Methods

Landscape planning is an activity that promotes the wise and sustainable use of resources, hazard avoidance, and management of the process(es) of landscape change. It determines the capacity and limits of natural resources and the effects of chances. Landscape planning, has been described as "the process of choice based on knowledge about people and land" (Steiner 1991, p. 520). McHarg defines ecological planning as "that process whereby a region is understood as a biophysical and social process comprehensible through the operation of laws and time. This can be reinterpreted as having explicit opportunities and constraints for any particular human use. A survey will reveal the most fit locations and processes" (McHarg 1997, p.321). Landscape planning, "cuts across" numerous planning sectors, and is performed at multiple scales and governmental levels (Kiemstedt 1994). As a professional activity, it has roots in landscape architecture and physical planning (Fabos 1985). As these definitions and statements suggest, landscape planning is an inherently interdisciplinary field with biological, physical, and social science components, as well as strong connections with the creative traditions of landscape architecture.

In the latter part of the twentieth century, as humankind gained an unprecedented perspective on the global environment through remote sensing, landscape planning gained visibility and a sense of urgency. Many have called for, or offered, perspectives on the theory which could guide the development, teaching and practice of landscape planning (Lynch 1985, Berger 1987, Steiner Young and Zube 1988, Steinitz 1990, Ndubisi 1997). Many have also acknowledged the significance of the landscape ecological perspective on landscape planning, and a resulting need for reconsideration of planning, theory and methods (Berger 1987, Steiner and Osterman 1988, Golley and Berlot 1991, Hersperger 1994, van Langevelde 1994, Ahern 1995, Forman 1995). Through landscape ecology, the limitations of some previous landscape planning theories and methods were revealed, and new methods have been proposed to apply the knowledge generated from landscape ecology to landscape planning.

Ndubisi (1997) defines two fundamental theories in landscape planning: substantive and procedural. Substantive theories originate in the natural and social sciences and provide descriptive and predictive information. Procedural theories concern the methodology of planning. The interaction of the two theoretical types produces a tension that both challenges and rewards interdisciplinary research. Hersperger (1994) suggests that in true landscape ecological planning, the distinction between substantive and procedural theories might blur.

Steinitz (1990) argues the need for a more robust theory among all those professions involved with altering landscapes. His six-step framework is based on discrete models for representation, process, evaluation, chance, impact, and decision. This framework can be divided into two major parts the, descriptive/evaluative and the prescriptive/planning components. The descriptive/evaluative part has strong parallels with landscape ecology in that it deals with articulating the fundamental landscape pattern:process dynamic. In Steinitz' framework, this is included in the framework's representation, process, and evaluation models. Turner (1989) describes how spatial pattern influences many ecological processes, and how landscape planning and management, in turn, influence landscape pattern. Turner argues that as landscape pattern and process are dynamically interrelated, the landscape pattern:process dynamic forms a basic tenet of landscape ecology. In the prescriptive/planning part of Steinitz' framework, change, impact, and decision models are included with a landscape ecological perspective. These models largely cover the domains of landscape planning and design, where alternative actions are conceived, evaluated, and implemented. Steinitz' framework provides a basis for continued advancement of theories and methods, and identifies the major questions and knowledge gaps to which interdisciplinary collaboration between landscape ecologists and planners may be directed.

Recently, several landscape planning methods have been advanced that explicitly include a landscape ecological perspective (Berger 1987, Steiner 1991, Buuren van and Kerkstra 1993). A number of methodological changes can be identified in these methods, as contrasted with earlier methods. They are characterized by an interdisciplinary approach, they address landscape pattern:process at multiple scales, and they include a human ecological component.

One distinction between landscape ecology and earlier approaches to landscape planning is the integration of topological and chorological perspectives. Topological analysis is a parametric approach which describes and analyzes the "vertical" relationships between many factors that occur at a given location, be it a patch of wetland, a forest edge, or a residential neighborhood. The topological approach popularized by McHarg (1969) builds a "layer cake" of factors which collectively describe a place or places. Factors considered often start at the "bottom" with bedrock ecology and are followed by surficial geology, soils, subsurface and surficial hydrology, vegetation, wildlife, and climate. In many methods, these factors are overlaid with aggregate values derived from the combinations of spatially concurrent factors.

In landscape ecological planning, the topological approach is complemented, not replaced by, a chorological approach which describes and analyzes horizontal relationships and flows (Zonneveld 1995). It can describe dynamic spatial processes and particularly horizontal relationships such as hydrological dynamics between land uses, nutrient flows, metapopulation dynamics in fragmented landscapes, and human transportation. The chorological perspective is still in the process of integration with landscape planning.

Berger (1987) proposes a landscape planning framework that links the traditional physical, biological, legal, and economic tools of planning with a humanistic view of how people use, perceive, and shape a landscape. He suggests that a "land use ecology" could link the earth and life sciences with resource management. The framework is inherently interdisciplinary and presumes complementarity of the knowledge bases of the collectively disciplines that are involved with landscape planning. Berger's framework includes contributions from environmental history to analyze changes in the regional social and natural context; cultural ecology to derive a view of patterns of use and traditions as a basis for siting new uses; and cultural history to evaluate the ability of the environment to provide basic human needs. He argues for a humanistic view, to understand how ordinary landscapes fit into everyday life, as well as a knowledge of local attitudes towards the planning process.

In the "landscape planning working method," Steiner and Osterman (1988) and Steiner (1991) argue for an interdisciplinary and integrated approach, coordinated across scales, with significant public participation and a human ecological perspective. Their method explicitly links landscape pattern and process with planning goals and continues through to implementation and monitoring of the plan. This method advances the established practice of ecologically based planning, although its explicit consideration of three nested scales simultaneously and through its focus on the human ecological component of planning.

Lyle (1994) argues for a systemic planning process based on an ecosystem model. He attributes the failure of much past planning to its fundamental starting premise. Since the passage of the U.S. National Environmental Policy Act of 1969, much planning has been focused on attempting, to reduce adversity, rather than in seeking systemic solutions. 'We must learn to deal with environmental problems at the systemic level; if we heal the trunk and branches, the benefits to the leaves will follow naturally' (Karl Henrik Robert, in Lyle 1994, p. 10).

Lyle's planning approach is based on three modes of ecosystem order: structure, function, and location. Integral with his plans are models of energy and nutrient flows and transformations. In this sense Lyle, like Steinitz, engages the fundamental landscape pattern:process dynamic. He also presents a somewhat radical yet optimistic perspective in which the creative intellectual capability of humans is understood to be a powerful ecological force itself, capable of reconceiving human environments according to an ecosystem model. Human intervention is not viewed as an activity whose impacts need to be controlled, but rather for its potential to create human ecosystems that are physically and biologically sustainable, which may add cultural meaning and may express the concept of sustainability in physical form in the landscape. This idea is closely related to spatial concepts discussed later in this chapter.

From this brief review of recent landscape planning theory and methods, the essential attributes of a landscape ecological planning method can be identified. The theory reviewed indicates an increasing awareness of landscape ecology as an essential basis for landscape planning, but also calls for more attention to the cultural aspects of landscape planning, and emphasizes its creative dimension.

Essential Attributes of a Landscape Ecological Planning Method

Landscape planning methods vary widely as a function of physical scale, planning objectives, time frame, coals, political support, availability of data and knowledge, level of participation in the planning process, and driving issues. The preceding review of planning theory identifies a clear interest in integrating landscape ecology with landscape planning. The following attributes are proposed as essential to a landscape ecological planning method, independent of the variables mentioned above. These attributes are integral to the framework method proposed in this chapter (Figure 2.1).

1. The planning process is inherently interdisciplinary and integrates public expert participation and advice.

The challenge of sustainable development depends on a constant infusion of knowledge from scientific research and monitoring. This expert knowledge is central to understanding the fundamental landscape pattern:process dynamic and must be integral to a landscape ecological planning process. Scientists representing the abiotic, biotic, and cultural disciplines should be fully integrated with the planning method.

A landscape plan is different from a research project. It will promote recommendations that may be implemented and will influence residents and stakeholders. Therefore, a participatory process involving non-expert public officials, local inhabitants, and special interest representatives is essential. This type of planning process promotes "mutual learning" (Friedmann 1973) through which experts and participants are jointly involved in process leading to goal determination, integration of local landscape knowledge, perceptions, and values; evaluation of alternatives; and ultimately, implementation, monitoring, and management.

2. The dynamic relationship between landscape pattern and process is fundamental to the planning process.

If the ecosystem is understood as the basic unit of landscapes, then ecosystem structure and function are essential to understand in landscape planning (Turner 1989). The dynamic relationship of landscape pattern to process is therefore fundamental to both landscape ecology and to landscape planning. In current landscape ecological knowledge, the landscape pattern:process dynamic is perhaps best understood in its abiotic and biotic dimensions (Quinby 1988, Turner 1989, Forman 1990b, Schreiber 1990). Often landscape ecological plans focus only on goals articulated in terms of biodiversity, water quality, or soil protection. Although these goals are undeniably essential components of a sustainable landscape, the cultural component is also important, but has been given less attention in research and publications (Berger 1987, Schreiber 1990, Golley and Bellot 1991). Ndubisi et al. (1995) call for an integration of abiotic, biotic, and cultural understanding of landscapes as a basis for landscape planning at multiple scales. The cultural component should also consider the appearance of the landscape because people express understanding and preferences about ecological quality from the look of the land, and this, in turn is vital in landscape planning (Nassauer 1992).

When a landscape plan is based on an understanding of pattern:process dynamics, the plan can be explicitly linked with the consequences, and the plan itself, when implemented, may be considered a field experiment.

3. The planning, process is explicit and replicable.

For the process to be equitable, rigorous, and defensible, the methods and processes must be explicit and replicable. This is particularly relevant in the era of GIS-based spatial analysis, through which methods and procedures can be subjected to rigorous tests of accuracy and replication. When the planning process is explicit and transparent, and the assumptions, variables, and goals clearly presented, several benefits can be realized. Interdisciplinary collaboration is facilitated, non-expert participation is enabled, and alternatives can be generated that demonstrate the spatial and ecological consequences of modification of planning assumptions. This often leads to the generation of alternative planning scenarios, which will be discussed later.

4. The process should integrate knowledge, goals, and spatial concepts in a strategic manner.

Landscape planning is inherently a strategic process in that it attempts to understand and manage the elements and forces that are the causes of landscape changes rather than employing tactics to respond to the changes themselves (Sijmons 1990, Ahern 1995). Planning is, by definition, proactive, but not all planning is strategic. Effective strategic planning requires integration of interdisciplinary knowledge to define strategic goals consistent with political expectations, economic factors, and the reality of the existing landscape condition. Strategic landscape planning requires a balance of knowledge, vision, and political skills.

Spatial concepts and strategies are also ways to build systemic solutions to complex problems, to achieve symbiotic synthesis of rational and intuitive thought that collectively can identify spatial concepts that may Get ahead of problems that landscape plans address.

5. Landscape planning is an iterative process integrating adaptive management.

As ecological knowledge has become more routinely integrated in planning, a common dilemma regarding the accuracy and certainty of the knowledge recurs. The planners ask legitimate questions, such as “How wide does the corridor need to be?” and the ecologist replies, “It is impossible to generalize this type of information-detailed, site-specific research is the only path to the answer.” The concept of adaptive management (Holling 1978, Gunderson et al. 1995). addresses this dilemma by re-conceptualizing the ‘problem’ of making planning decisions with imperfect knowledge as an opportunity. In addition to contributing the best current knowledge available to a planning decision, the ecologist provides guidelines for implementation and monitoring, through which the planning decision may become a field experiment from which new knowledge may be generated.

Proposed Framework Method

The following process is presented as a working method to integrate landscape ecology and landscape planning. It is a framework in that it identifies the major components (steps) in the process. In actual use the framework will be complemented with additional steps to complete the planning process, including goal definition, resource assessments, alternative plan generation, and implementation.

The framework method is graphically presented as a linear process (Figure 2.1). In use, however, the process is intended to be nonlinear, cyclical, and iterative, and it may be initiated at any stage. For example, the planning process may start with an evaluation of a preexisting plan, followed by a revision of earlier goals, and resource assessments.

In Figure 2.1 the process begins with a determination of sustainable landscape planning goals, defined strategically to match the public will, economic climate, and existing landscape condition. In a participatory process including interdisciplinary experts and stakeholders, specific goals are proposed for abiotic, biotic, and cultural resources. A synthesis of these assessments defines areas of potential spatial conflict and compatibility and is used to design spatial concepts. Next, appropriate planning strategies are selected from protective, defensive, offensive, or opportunistic approaches (Ahern 1995). The spatial concepts are used to design a number of scenarios to illustrate possible futures, including the means to their realization. With expert and stakeholder participation, the scenarios are evaluated and ultimately revised or modified into a dynamic landscape plan. When the plan is implemented, a policy of adaptive management is followed, based on monitoring to yield new knowledge for continuing the planning process.

The framework method includes several key ideas/steps that will be discussed in greater detail: planning strategies, spatial concepts, and future landscape scenarios. An Open Space Plan for Orange Massachusetts illustrates the application of the framework method.

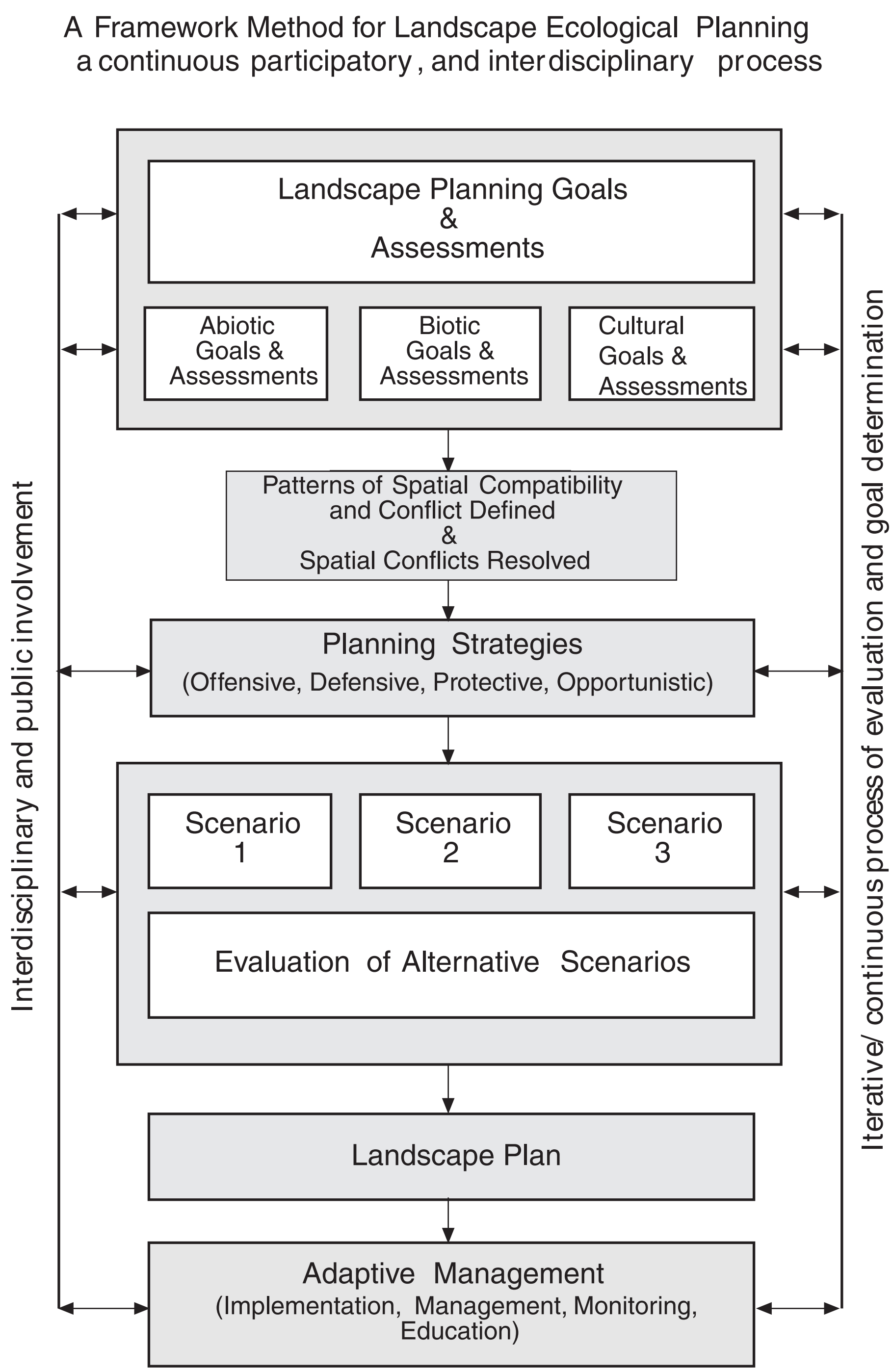


Figure 2.1 The framework method for landscape ecological planning: an iterative, continuous, participatory and interdisciplinary process

Spatial Concepts

"Make no little plans for they have no magic to stir men's blood, and probably themselves will not be realized. Make big plans: aim high in hope and work, remembering that a noble, logical diagram once recorded will never die"

Daniel Burnham

A spatial concept expresses through words and images an understanding of a planning issue and the actions considered necessary to address the issue. Spatial concepts are related to the proactive, or anticipatory, nature of landscape planning, in that they express solutions to bridge the gap between the present and the desired future situation. Spatial concepts are often carefully selected metaphors, for example "Green Heart" or "Stepping Stones" which communicate the essence of the concept clearly, to build consensus, and as a basis for more concrete planning decisions (Steiner 1991, Zonneveld 1991, Langevelde van 1994).

Spatial concepts structure the planning process. Five functions of spatial concepts can be defined:(1) the cognitive in which interdisciplinary knowledge is synthesized; (2) the intentional to manifest the creative insights of planners and designers; (3) the institutional to influence landscape regulation; (4) to improve communication between experts, stakeholders, and special interests; and (5) action to influence the achievement of planning objectives (Zonneveld 1991). Translation of knowledge of landscape pattern and process is a key value of landscape ecology to spatial concept development. Spatial concepts often manifest basic assumptions upon which more specific decisions can be based (Alexander et al. 1977).

Although scientific input from landscape ecology is essential to conceive spatial concepts, its potential is limited. Many scientists are reluctant to make the "leaps of faith" that are essential to conceive spatial concepts. There is an essential element of creativity in the design of spatial concepts. They represent an interface of empirical and intuitive knowledge. If human intellectual and spiritual activities are accepted as valid ecological elements, then, clearly spatial concepts are a legitimate part of the planning process (Lyle 1994, Zonneveld 1995). Through spatial concepts, rational knowledge is complemented with creative insights. Spatial concepts in landscape planning can be thought of as design concepts-essential ideas that transcend basic knowledge and result in successful solutions. In site-scale landscape architecture, decision concepts are the basis for giving physical form in response to; goals, resource assessments, and the designer's creative insight. In landscape planning, spatial concepts are the basis for giving form to landscapes in like manner, in either a generic or a spatially specific manner. Figure 2.2 presents a series of spatial concepts that have been used in landscape planning. Some are intentional, others result from the long-term interaction of physical, biological, and cultural forces. All can be linked with metaphors and synonyms that aid in their imageability by scientists, planners, and those involved with, or affected by, a plan.

The Netherlands has a rich tradition of landscape planning and has long employed spatial concepts in the planning process. The "Green Heart" is a good example of a spatial concept in Dutch landscape planning. It is a spatial strategy to maintain a "green core" of agriculture, forests, and recreation within the densely populated western Netherlands. The core is surrounded by the Randstad (Ring City), which is a reciprocal strategic spatial concept. The "green heart" concept has significantly guided Dutch planning and development strategies since the 1950s, during a major period of population growth and land-use change.

The framework concept is a more contemporary spatial concept for landscape planning in the Netherlands. It is based on the paradox of time and uncertainty. Change and uncertainty are both fundamental in natural and cultural systems. The landscape is no different-change is fundamental-and uncertainty is a "given". This is the paradox of time in landscape planning. Some key ecological processes, like groundwater recharge require a certain level of stability to function within acceptable limits. These are the "low dynamic" functions. In the case of groundwater recharge, a degree of stability is necessary in terms of vegetative cover, soil stability, and nutrient inputs to maintain a renewable supply of clean groundwater. Other processes in the landscape, driven by social and economic forces, are more uncertain and "high dynamic." (such as land-use change) and require flexibility. The framework provides nature a long-term stability and allows more flexibility for land use change in the other areas. This is the framework's quid pro quo (Ahern and Kerkstra 1994). In the Netherlands the framework concept is known as 'casco' in reference to an architectural practice in which buildings are designed with only a main structural framework, allowing occupant modification. In the context of this discussion, casco is both a spatial and conceptual framework for landscape planning (Hamhuis et al. 1992). The framework concept promotes a spatially integrated network of lands, managed for "low dynamic" functions and uses, based primarily on abiotic factors. It is spatially defined by the hydrologic landscape structure, in which discrete geohydrological units can be identified (Kerkstra and Vrijlandt 1990, Buuren van and Kerkstra 1993). Within this network structure, which is reserved for "low dynamic" functions, are opportunities for "high dynamic" functions and uses (Figure 2.2).

Forman's spatial solution (1995) is a generic spatial concept based on the assertion that certain indispensable landscape patterns exist in all landscapes and that a spatial solution can be defined to support these patterns and their associated ecological functions. The indispensable patterns are large patches, riparian corridors, bits of nature, and connecting corridors. Forman adds a dynamic dimension to his spatial solution, the "jaws" model, through which the presence of the indispensable patterns is maintained for the maximum

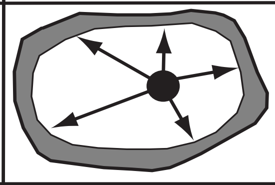
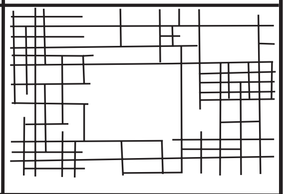
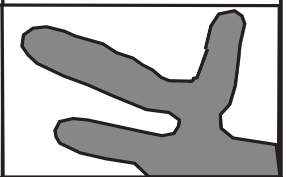
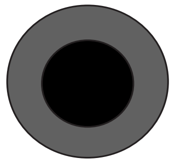
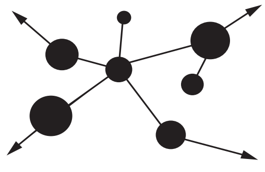
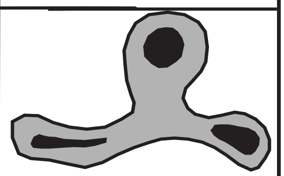
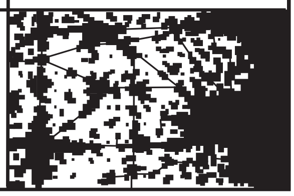
Spatial Concept	Examples & References	Metaphors & Synonyms	Diagram
Containment	• Cloister • Fortification • Greenbelt • Refuge	• Border • Barrier • Wall • Harness • Levee	
Grid	• U.S. 1785 Land Ordinance Survey • International School	• Network • Rational • Authority • Eglatarian • Anthropocentric	
Interdigitation	• The New Exploration (MacKaye, 1962) • Pattern Language (Alexander et al 1977) • Forman 1990a	• Symbiosis • Harmony • Biocentric • Interdependent • Complementary	
Segregation	• Compartment Model (Odum, 1969) • Euclidian Zoning (USA) • MAB Biosphere Reserves	• Controlled • Strategic • Compromise • quid pro quo	
Network	• National Ecological Network (Netherlands) • U.S. Interstate Highway System	• Integrated • Linked • Nodes & Corridors • Stepping Stones	
Framework	• CASCO, Plan Stork (de Bruin et al, 1987) • Hydrological Framework (van Buuren & Kerkstra, 1993)	• Integrated Network • Topological & Chorological • Low Dynamic	
Laissez faire *(defacto no strategy)*	• Suburban sprawl • Megalopolis (Gottman, 1961) • Edge City (Garreau, 1991)	• Mosaic • Individualistic • Dynamic • Free-Market • Competitive	

Figure 2.2 Spatial concepts for landscape planning

time through a process of landscape transformation. The jaw's model succeeds in translating fundamental landscape ecological knowledge into the spatial language of planning.

Greenways have become a popular spatial concept in North America in the last decade. It is a spatial concept based on the particular advantages of linked linear systems. It has captured popular attention in a manner unprecedented for a landscape planning issue (Little 1990). The President's Commission on Americans Outdoors (1987) provided the metaphor of a "the giant circulating system" capturing the public attention and presenting just the type of powerful, clear logical diagram that Burnham describes. Greenways are multipurpose and often favor recreation over ecological goals. The ecological potential of greenways has been increasingly recognized and has been the subject of significant recent research (Smith and Hellmund 1993, Fabos and Ahern 1995).

Landscape ecology can assist in the conception and evaluation of spatial concepts. It can identify indispensable patterns that support an ecological functions, it can demonstrate the strategic benefits of connectivity, particularly the movement of organisms (Soulé 1991, Vos and Opdam 1993). It also provides a basis for understanding the frequency and distribution of disturbances, defining a minimum dynamic area, and linking other forms of pattern:process knowledge with the landscape planning process.

Planning Strategies

Landscape planning is an inherently strategic activity. It strives to craft policies and actions that systematically address the trends and forces that shape and change landscapes. Strategic planning is driven by goals that are focused, linked with implementation, and presumed to be achievable. When strategic planning is informed by a landscape ecologically informed understanding of pattern:process dynamics, and is guided by appropriate spatial concepts, it may form a sound basis for plan development and implementation. There are a number of fundamental strategies that can be employed, including protective, defensive, offensive, and opportunistic (Ahern 1995).

When the existing landscape supports the abiotic, biotic, and cultural resource goals, a protective planning strategy may be employed. Essentially this strategy articulates the spatial pattern that is desirable and protects it from change. Conversely, it defines the areas in the landscape where change can be accommodated. The protective strategy is useful in relatively undisturbed landscapes and can often be applied at low cost. Ironically, it is difficult to promote politically because, by definition, it is used when the landscape is already functioning well. While landscape planners attempt to be forward thinking and anticipatory, human nature is often reactive. In this case, education and public awareness are useful to promote understanding of the issues and strategic options available.

When the existing landscape is already in a spatial configuration that is negatively impacting abiotic, biotic, or cultural resources, a defensive strategy is needed. This strategy seeks to control and arrest the negative processes of landscape change (i.e., fragmentation, dissection, perforation, or attrition) (Forman 1995). As a last resort, the defensive strategy is often appropriate, but it can also be described as reactionary and ineffective. By definition, a defensive strategy attempts to "catch up with" or "put on the brakes" against the inevitable process of landscape change. When the root causes of negative landscape change remain active, the defensive strategy will never be completely effective and best delays the inevitable change in defense of an ever-decreasing nature (Sijmons 1990).

In marked contrast with the defensive, the offensive strategy is inherently proactive in nature. It is appropriate when the landscape is already deficient with respect to supporting biotic, abiotic, or cultural resources. It promotes a "possible" future landscape that can be realized only through restoration. Since, by definition, it cannot be guided by an assessment of existing, resources, it must be based on a spatial concept crafted by a combination of rational and creative processes. The offensive strategy relies on knowledge from; landscape ecology, planning, and ecological restoration. It is costly and uncertain. This strategy is often practiced in Europe, where centuries of use have produced a cultural landscape with limited opportunities for protection or defense of desirable landscape patterns and associated processes.

Often landscapes contain unique elements or configurations of elements that allow for opportunistic landscape planning. These unique elements may or may not be optimally located, but represent positive opportunities, nonetheless. This strategy is dependent on the presence of certain unique landscape elements, which are often in the configuration of a corridor (e.g., abandoned railroad lines, transmission line corridors) or as a remnant environmental resource patch (Forman and Godron 1986). This strategy involves recognition of such special opportunities and integrating them with other planning strategies, often with the opportunistic strategy.

These four strategies collectively constitute a typology (Ahern 1995). The typology can promote more accurate communication between landscape ecologists, planners, and stakeholders in the planning process. The strategies are not mutually exclusive-they are more often used in an integrated manner. The strategies are a key link between abiotic, biotic, and cultural resource assessments, spatial concepts and scenarios with a resulting landscape plan.

Future Landscape Scenarios

Scenarios are important tools for landscape planning and are integral with the framework landscape ecological planning method. They provide a perspective that is not constrained by the present situation. Scenarios have been used in corporate and governmental decision making since the 1970s because of their inherent advantages over expert judgments and other planning approaches. In landscape planning, scenarios are well suited to linking goals and assumptions with the potential future spatial changes. A complete scenario should include a description of the current situation, a potential future state, and a means of implementation. Without all three of these elements, scenarios can be faulted as utopian. Scenarios are different from forecasts that attempt to predict the expected future. In contrast, scenarios pose, and answer a series of "if then" questions. Scenarios may be based on mathematical models. Other models can be used in scenarios or they may be more normative. The scenario approach is more appropriate when there is a great deal of uncertainty concerning the future or when there is a general dissatisfaction with the present. Trend breaks are one reason that scenarios may be more useful than forecasts. Changes in technology or global economics can cause a paradigm shift that can alter the most fundamental assumptions in a planning activity (Schooenboom 1995, Veeknenklaas 1995).

Two fundamental types of scenarios can be defined-state and process. A state scenario simply describes a future situation without articulating the steps or events needed to get there. A process scenario provides a "road map" of assumptions, events and steps linking the present with the future (Hirschorn 1980). Process scenarios are the most appropriate for landscape planning. Two fundamental types of process scenarios can be identified. A "forecasted," or "beginning state driven," scenario projects current trends and control practices to produce a trajectory on which a possible future may be conceived. A common forecasted scenario in landscape planning is the "build-out", in which current land use controls are used to determine a theoretical or maximum level of development as base line for comparison of other alternatives. A "backcasted", or "end state driven," scenario, in contrast, is based on an idealized spatial concept, or vision, of what the future could be. Backcasted scenarios are often designed to articulate and visualize the spatial consequences of (Schoonenboom 1995). Hirschorn (1980) proposes that "developmental scenarios" are most useful for planning. They are process based, beginning state scenarios containing "chains of cause and effect," with explicit decision rules to link the present with a possible future that is both plausible and surprising.

In many instances, alternative scenarios are intentionally generated with the explicit purpose of demonstrating a range of alternatives. This has been described as identifying the four corners of an abstract frame within which a more balanced or compromised alternative may be selected (Harms et al. 1993). Or as the four points of a tetrahedron, indicating a more dynamic third-dimensional aspect to the alternatives (Forman 1995). Scenarios are not predictions; they are vignettes of possible futures, of what could be given specific assumptions and actions, as opposed to what will be.

Scenarios may also be classified according to such motivating factors as biodiversity protection (Harms et al. 1993); development control (Steinitz et al. 1994); visual impact management, resource allocation, or integration of several goals. Scenarios should be methodologically explicit and replicable to facilitate rigorous tests of accuracy and replication. They are common in European and particularly in Dutch planning and were the theme of a recent international symposium (Schoute et al. 1995)

Application of the Method: Open Space Plan for Orange, Massachusetts

The Open Space Plan for the town of Orange was conducted in a graduate landscape architecture studio directed by the author at the University of Massachusetts in 1996 (DLARP 1996). A participatory planning process, based on the framework method proposed in this chapter, was conducted with significant involvement of town officials, representatives of special interests, stakeholders, and the general public.

The goal of the plan was to provide the town with a basis for long-term, land-use decision making, with an emphasis on open space and recreation. The open space goal was broadly interpreted to comprehensively address the abiotic, biotic, and cultural issues that affect landscape pattern and process. Thus development, biodiversity, and economic planning were incorporated into the open space plan. The recreational component of the plan was also conceived at the landscape scale, focusing on those "extensive" recreational activities that can benefit from, and successfully coexist with, more conservation-based landscape planning and management.

Abiotic Resource Goals and Assessments

The town is located the northeast of the United States in North Central Massachusetts, on the Millers River, a major tributary of the Connecticut River. The town is bordered to the east and north by significant upland schist ridges with less resistant gneiss valleys and alluvial riparian corridors and wetlands. The soils formed on this rugged geologic base of Orange have limited agricultural potential.

An assessment of abiotic resources was conducted and identified the following as key resources to be protected in the open space plan: the upland ridges that define the character of the town, provide important wildlife habitat, and recreational opportunity; the Millers River and floodplain that provide flood protection, a wildlife habitat, and recreational and amenity benefits; a system of forested and non-forested wetlands that provide multiple benefits and functions; two lakes important for wildlife, recreation, and cultural amenity; and a large glacial outwash plain that provides a major portion of the town's drinking water.

Biotic Resource Goals and Assessments

The land cover of Orange is predominately forested (85%) with significant spatial heterogeneity (Figure 2.3). Forest ages vary as a function of timing of agricultural abandonment, natural disturbance, and hurricanes and periodicity of forest harvesting activities. Forest composition includes large patches (>1000 hectares) of hardwoods (Acer, Quercus, Fraxinus) softwoods (Pinus, Tsuga), and mixed hard and softwoods. The extensive forest in Orange is part of a large regional forest extending across north central Massachusetts into southern New Hampshire. Maintaining linkages with the regional forest was identified as a priority in the open space plan.

The biodiversity component of the plan relied largely on a target species approach. A target species is one determined to be an appropriate goal or "target" in biodiversity planning by virtue of its habitat requirements, position in the food chain, and compatibility with human occupation and disturbance. A target species is not the same as an indicator species, but is an acceptable representative of a particular habitat type, and associated species can be reliably assumed to also be present. The selection of target species for this plan was made in consultation with wildlife biologists from the University of Massachusetts and the U.S. Fish and Wildlife Service (DeGraff, personal communication).

Two target species were selected for this study, one for each of the town's non-developed extensive landscape types-forests and wetlands/riparian zones. The pileated woodpecker (Dryocopus pileatus) was selected as a target species for the town's forested landscapes, and the mink (Milstela vison) for the wetlands and riparian areas, including lakes rivers, and forested and non-forested wetlands. Both species are indigenous to the area and are present in viable populations.

In assessing the habitat quality for the pileated woodpecker, the following criteria were applied: 20 hectare minimum forest patch size, with a preference for wetland adjacency (Bent 1992). Lower suitability assessments resulted from smaller forested patch sizes and when the adjacent land use was cleared, agriculture or development. The assessment indicated that abundant areas of high quality habitat were present, especially on the town's upland forested ridges and lower riparian zones.

The mink is a predatory semiaquatic mammal that prefers riparian margins, lake shores, and marshes for habitat. Mink are moderately adaptable and will change their habitats for food and cover in response to human disturbance. The following criteria were applied in assessing mink habitat: most suitable habitats include palustrine wetlands over 400 hectares with permanent water and >100 meter woody buffer; palustrine, lacustrine, or riverine wetlands with <100 meter woody buffer were secondary; palustrine wetlands with <9 months of permanent water were considered marginally suitable (Allen 1986). In applying these criteria, significant amounts of habitat were found, and a basis for planning for protection was established.

Figure 2.3 The landscape of Orange, Massachusetts displays spatial heterogeneity within a forested matrix

Cultural Resource Goals and Assessments

The town of Orange is seeking a vision for its future that will protect its historical resources, and rural character, while providing a healthy economic future. To identify the town's cultural resources, a two part interview process was conducted. The goal of the interviews was to identify the town's demographic composition. to define special interests, and to spatially define areas of interest of individuals and special interest groups. The interviews were conducted with key informants-those known to represent special interests or those with special knowledge of the town's historical and cultural resources. Spontaneous interviews were also conducted to obtain a representative understanding of the resident's attitudes and values towards recreation, open space planning, and development. The interview results were compiled and cross tabulated to identify and map trends and areas of particular concern. The findings emphasized the residents' value of the town's center, historical resources, and remote natural areas, chiefly along the upland ridges. To determine the distribution and extent of land available for future development, an eliminative process was applied. Development planning is often absent from open space planning, resulting

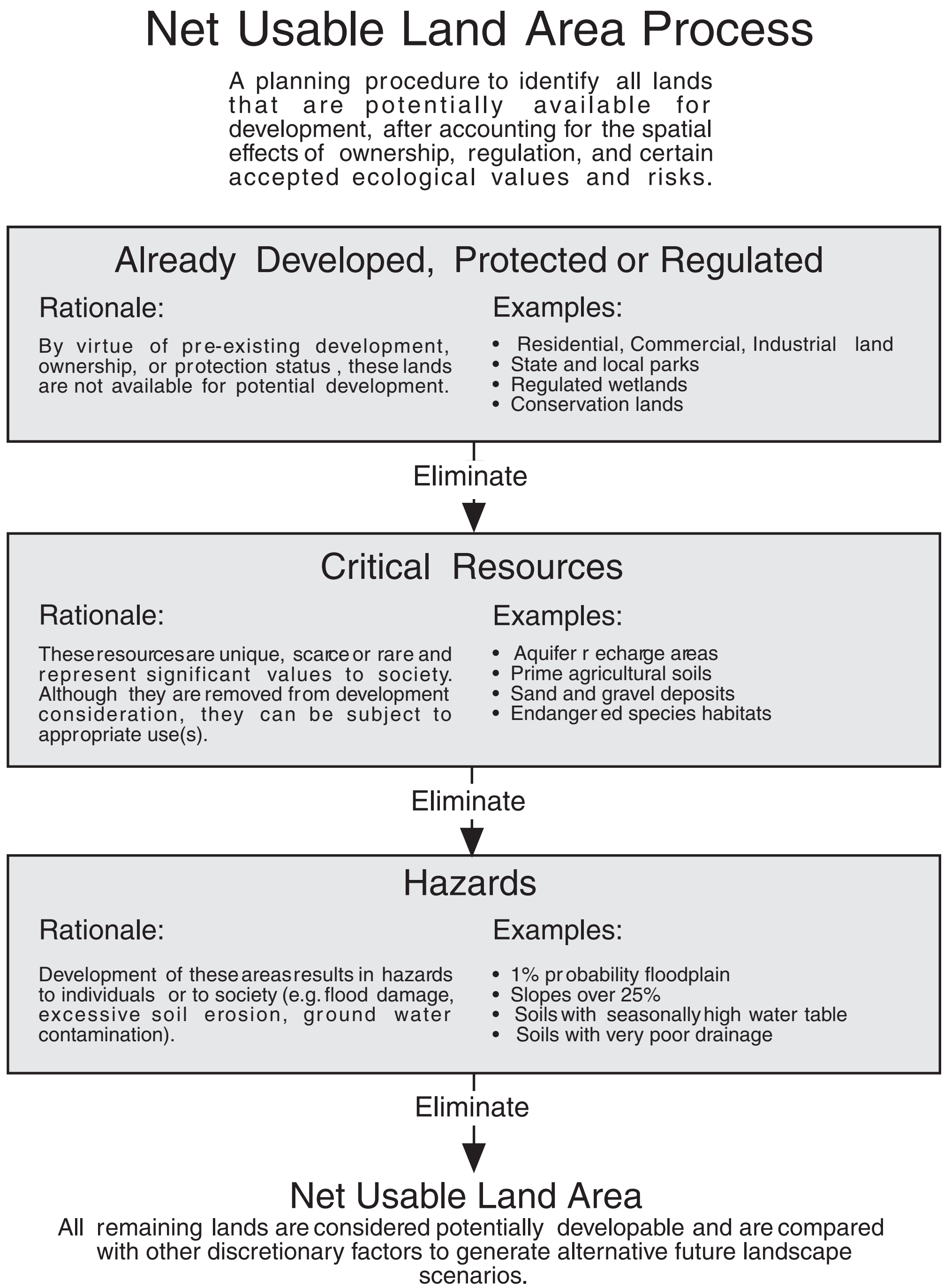


Figure 2.4 Net usable land area process (NULA)

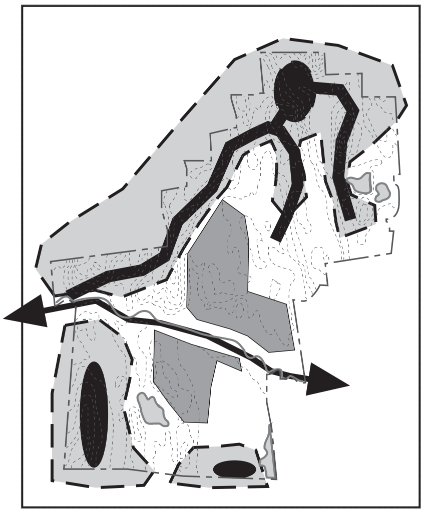
in a conservation bias that causes problems with public acceptance of the plan. The Net Usable Land Area Process NULA (Figure 2.4) first eliminates lands that are already developed, protected, or regulated against development. Next critical resources are eliminated. In Orange, these included aquifers and their recharge areas, prime agricultural soils, sand and gravel deposits, and endangered species habitats. The rationale for eliminating critical resources was based on a participatory process through which consensus was built on resource protection. Thus the definition of critical resources reflects the community's values. The last stage in the eliminative process involves the removal of hazardous areas including, 1% probability floodplain, slopes over 25%, soils with seasonally high water table, and soils with very poor drainage. These areas are eliminated because development would result in hazards to individuals or to society. The NULA process is a simple method for focusing, the planning activity on those areas where land use competition or conflict may exist. All of the lands that pass through the NULA process are potentially available for development.

Planning Scenarios

The comparison of mapped assessments of biotic, abiotic, and cultural resources identifies patterns of compatibility or conflict and provides a basis for the design of spatial concepts. Following the framework method, next alternative three scenarios with associated spatial concepts were generated (See Figure 2.5). These scenarios illustrate the consequences of varied resource assessments and spatial concepts.

The biodiversity scenario is based on a spatial concept of segregation of protection and development. Large patches of forest and wetland habitat for the indicator species are identified for protection. Regional linkages are planned. Recreational access is carefully controlled, and development is concentrated adjacent to the existing town center, enabled by additional urban infrastructure. In outlying areas of the town, development is restricted in wetlands and along lake shores to protect habitat. The scenario can be implemented through a major program of land acquisition and easements. Forest harvesting is to be carefully managed to preserve large habitat patches. An educational program is planned to assist understanding of the value the of biodiversity protection.

The recreation scenario emphasizes recreational opportunity, both within the town and the adjacent protected areas. The spatial concept is one of linkage of abiotic, biotic, and cultural resources. A planned greenway on the Millers River is promoted and is linked with other trails throughout the town. Development is encouraged in a more dispersed manner than in the biodiversity scenario, emphasizing the recreational value of the protected areas to the town's residents. Priorities identified through interviews have been integrated with the plan. The overall pattern of protection mirrors the town's distinct pattern of ridges, riparian corridors, and wetlands. The scenario can be implemented largely through easements to improve access to protected lands, with new public acquisitions proposed for areas of high recreational value, such as lakefronts. The potential economic benefits of increased recreational activity have been recognized in this scenario.

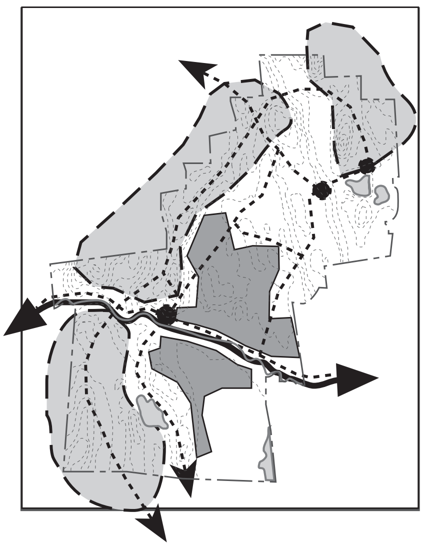


Biodiversity Scenario

Goal: To support a variety of recreational activitities that benefit fr om the town's natural and cultural resources, to provide linkages with r egional recreational resources, and to promot the economic potential of r ecreation in the town.

Spatial Concept: Biotic, Abiotic and Cultural linkages.

Implementation Strategies: Easement for trail and hunting access, public ownership of shorelines, protect historic districts, adopt zoning to encourage infill development and to protect scenic road corridors.



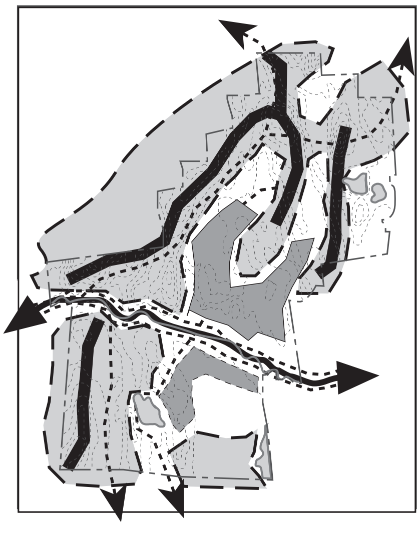
Recreation Scenario

Goal: To pr otect the town's unique biological resources, and to link with regionally significant wildlife habitats and movement corridors

.

Spatial Concept: Segregation of pr otection and development, buffering and linkage of large forest and wetland patches.

Implementation Strategies: Acquir e easements for large forest patches and buf fers, prepare forest harvest management plans, identify wetland and water resource management "gaps", integrate with educational and recreational programs.



Citizen's Scenario

Goal: To integrate the varied interests of the town, balancing development and protection, to preserve the town's rural character, to encourage regional linkages and to be a catalyst for economic development.

Spatial Concept: linkage and integration

.

Implementation Strategies: Increase public access and linkage to recreational resources, implement the town's greenway and heritage trail plans, encourage infill development and open space zoning.

Figure 2.5 Landscape planning scenarios for Orange, Massachusetts

The citizen's scenario is a based on the spatial concept of linkage and integration. It reflects more directly the ideas and values obtained from the citizen's during the interview process. The scenario includes an ecological framework to protect the habitats of the indicator species, but unlike the biodiversity scenario, integrates recreational uses (trails, hunting) with the habitat areas. The "fingers" of protected land that extend into the town are key routes to provide recreational access, while the larger patches to the north can remain less disturbed. The recreational component of this scenario put emphasis on increased public access and linkages. An innovative "heritage trail" is proposed to link the town's historical, cultural, and physical resources into a series of trails, for auto, bicycle, and foot travel. This trail benefits from the context of protected lands, and provides the greatest potential for recreationally related economic benefits for the town. Open space development is proposed as a means of financing the protection of large patches of forest and wetland and to manage the rural character of the town.

The scenarios were evaluated and a preliminary open space plan resulted. Specific recommendations were made for implementation and monitoring (i.e., to learn if the habitat suitability assessment is appropriate for the target species selected). Additional measures were identified to monitor the abiotic resources, particularly soil resources and surface and groundwater quality and quantity. A final step in this exercise was the initiation of an education program to raise awareness of landscape planning issues and to identify areas of mutual interest and opportunity.

Summary

This application illustrates how the proposed framework method can be applied to a routine landscape planning exercise. Through the abiotic, biotic, and cultural resource assessments, patterns of compatibility, and conflict were identified and served as a basis for the development of spatial concepts and scenarios. Each scenario includes strategies for implementation and collectively aided in the ultimate determination of the open space plan. Through specific recommendations for monitoring, adaptive management is promoted and new knowledge regarding the effectiveness of particular planning decisions is gained. This application illustrates but one application of the framework method, which is conceived so as to be adaptable across a range of scales, landscape contexts, and planning issues.

Conclusion

Several key principles have been presented concerning the evolving theory of landscape ecological planning. There is an assumed complementarity of rational and intuitive knowledge. Both types are essential to formulate and evaluate scenarios and plans for sustainable landscape. Spatial concepts provide a means of communicating the essence and intuitive intent of planners in a manner that informs and guides the rational component. Landscape ecological planning involves abiotic, biotic, and cultural resources. For each resource type, procedures for resource assessment and goal determination have been defined. This informs an awareness and understanding of a landscape's present and future pattern:process dynamic in a rigorous and informed manner.

Landscape ecological planning is a strategic process informed by landscape pattern:process knowledge and guided by goals determined by those with a stake in the outcome. Scenarios are useful in this strategic process to escape from thinking that is rooted in the status quo, and to offer alternative futures that may be both visionary and ecologically accountable.

Landscape ecological planning methods such as this proposed framework method can facilitate interdisciplinary cooperation between physical and social scientists and planners. This may result in more informed plans, but perhaps even more importantly, may advance the knowledge base as a new product of planning. An important next step in the evolution of this planning framework, and related methods, is to articulate the essential criteria for evaluating plans and scenarios against abiotic, biotic, and cultural resource management goals. Such criteria will, in turn, structure the evaluative models that are essential to realize sustainable landscape scenarios and plans.

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3 Greenways as a planning strategy

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Abstract

Greenways is a generic term that has been applied to a wide range of landscape planning strategies, concepts, and plans. While there is some consensus emerging on the benefits of protecting networks of land, there is little agreement on terminology. As a result, communication and knowledge exchange are limited. This paper offers an inclusive definition of greenways, discusses greenway characteristics, benefits and liabilities, and presents a typology for greenway classification based on scale, goals, landscape context, and planning strategy. This typology is applied to three case studies from the Netherlands and the United States which have been selected to represent a range of greenway types, to articulate similarities, differences, and to explore the transferability of knowledge and concepts. Through this discussion, greenways are considered as a useful strategy for planning, design and management of sustainable landscapes.

Introduction

In this century, global land use trends and landscape planning strategies have changed in fundamental ways. While the nature of these changes varies geographically, they all share some common landscape effects: as land use is intensified, (a) there is a decrease in landscape heterogeneity and (b) there is an increase in fragmentation of the landscape (Harris 1981, Schreiber 1988, Macintosh 1989, Turner 1989, Soulé 1991, Noss 1993). Both of these effects have negative biotic and abiotic consequences on the landscape (Wilson and Peter 1988). A unified global response to these trends seeks a more 'sustainable landscape' condition, in which the needs of the present are met without compromising the ability of future needs to be met (IUCN 1980, World Commission on Environment and Development, WCED 1987). This challenge for sustainable landscapes has inspired a dialogue between ecologists and landscape planners within the discipline of landscape ecology (Forman 1990a, Vos and Opdam 1993, Langevelde 1994).

A conceptual consensus is emerging from this dialogue suggesting that future landscapes be spatially structured by a 'patch and corridor' spatial concept which includes corridors and stepping stones to connect isolated patches and thus help to counter the effects of fragmentation (Forman and Godron 1986, Harris and Gallagher 1989). This spatial concept represents a departure from conventional 'constraint-based landscape planning' in that it (a) employs offensive strategies to counter landscape degradation, and (b) it emphasizes spatial connectivity in the landscape. This concept is based primarily on ecological research involving the survival of wildlife species in fragmented landscapes. While this 'patch and corridor' concept has already been adopted at policy levels in many countries (Netherlands Min.of Agriculture 1990, Bischoff and Jongman 1993), there is little agreement on any specific scientific bases for this type of planning, nor for the integration of other land uses within the patch and corridor concept (Forman 1990a, Smith and Hellmund 1993, Vos and Opdam 1993).

In remote areas of the world it may be possible to implement patch and corridor plans solely intended for the protection of biotic resources (UNESCO 1970). In the developed landscapes of the world, this is not possible, or appropriate. In cultural landscapes, and in the megalopolitan landscapes of the world (Gottman 1961), a multi-purpose greenway planning approach is more appropriate. Greenways require a new landscape planning approach. The multi-purpose focus demands that the planning process be multidisciplinary, inclusionary, and with a high level of public involvement. One of the key functions of greenway planning is to demonstrate alternative ways of combining compatible uses, and of separating incompatible uses in greenways. In this way, greenway planning becomes a form of strategic post-modern consensus building among many constituent interests (Meeus and Vroom 1986).

Much of the focus of contemporary landscape planning relates to the dynamics and impacts of the expanding global megalopolis (Steiner et al. 1988, Garreau 1991). Since the 1960's much landscape planning has been a form of 'constraint-based exclusionary planning', based largely on the work of McHarg (1969). In this defensive form of planning, resources are assessed and protected according to their intrinsic value. While this planning approach has been successful in many respects, it has proven to be ineffective in preventing landscape fragmentation. In recent years two theories from landscape ecology have entered a landscape planning discussion regarding sustainable landscapes, island biogeography and metapopulation dynamics. MacArthur and Wilson's (1967) theory of island biogeography has been extended to terrestrial landscapes and explains species decline and extinction resulting from fragmentation and isolation (Harris 1981, Schreiber 1988, Soulé 1991). From this and other landscape ecological research, several biodiversity-related reasons for maintaining a more spatially integrated, less fragmented landscape pattern can be identified: (1) it facilitates movement of certain species within and between preferred habitats, (2) such species movement over time enables genetic exchange, and may support metapopulations - assemblages of sub-populations which interact in space and over time across landscapes, (3) metapopulations enjoy greater survival prospects from higher levels of physical and functional connectivity in fragmented landscapes (Soulé 1991, Noss 1993, Opdam et al. 1993). These theories provide a means for describing the complex biotic causes and effects of fragmentation in real landscapes, and are beginning to suggest strategies for prescribing solutions for remedying them.

From the resultant dialogue between landscape ecologists and landscape planners a consensus is emerging that some form of ecological infrastructure is necessary to achieve a sustainable landscape condition with respect to both abiotic and biotic resources. A key component of such infrastructures is the recognition of the importance of some form of 'connections' which link isolated natural areas that remain in an increasingly fragmented megalopolitan landscape. From a landscape planning perspective, there is a distinct lack of a theoretical basis from which to make such planning decisions.

This consensus regarding ecological infrastructure has been challenged by some who question the wisdom of committing to this planning paradigm before it has been conclusively proven through empirical research (Daniels 1988, Groome 1990). However, in some countries, policies have already been adopted, plans have been made at many scales, and pilot projects are being implemented based on these theories from landscape ecology (Schreiber 1988, Bishoff and Jongman 1993). In Europe, these plans are often known as ecological infrastructure, biotope network, or ecological network plans (Figure 3.1). Ecological infrastructure plans are usually based on the habitat requirements of selected species and involve the designation of new nature protection areas, corridors, and 'stepping stones'. The rationale behind these recommendations is based on island biogeography and metapopulation theories from landscape ecology. At this time, there is not a comparable theoretical basis from which the necessary landscape planning decisions can be made. Without a stronger theoretical basis greenway planning can be expected to be hampered by recurrent debates and dominated by the perspective of biological scientists.

In North America, where centralized planning is less common, few such coordinated physical plans are in place. In the USA and Canada, a concept similar to ecological infrastructure is often part of a grassroots land use initiative known as greenways (Figure 3.1). Greenway plans are typically initiated at the local or regional level. As a result of grassroots initiatives, greenways tend to involve a broad and diverse constituency of support. They tend to be multipurpose plans based on combinations of spatially compatible uses (President's Commission on Americans Outdoors 1987, Little 1990, Flink and Searns 1993, Smith and Hellmund 1993, Ahern 1994). While these policies and plans in Europe and North America have originated from the same basic theories from landscape ecology, their interpretation and resultant physical form are quite different. In addition to the basic abiotic landscape variability, the plans are also influenced by the fact that each country has unique and specific landscape/land use issues, cultural values and legal/ planning systems. To further complicate possible comparisons, there are a wide range of names given to such plans, and the usage of this terminology is inconsistent. In recent literature there are numerous names given to 'greenways' including: ecological infrastructure, ecological framework (Kerkstra and Vrijlandt 1990, Van Buuren and Kerkstra 1993), ecological network (Bishoff and Jongman, 1993) extensive open space systems (Ahern 1991), multiple use modules (Noss and Harris 1986), habitat networks, wildlife corridors (Noss 1993), and landscape restoration framework (Fedorowick 1993). While there are significant differences between many of these terms, there is no term that is widely accepted which describes these concepts in a generalized fashion. Recent literature from the USA has moved towards an acceptance of the term 'greenways' (Little 1990, Flink and Searns 1993, Smith and Hellmund 1993, Fabos 1995). The net result of this inconsistency in terminology is that research and literature on the subject of ecological infrastructure/ greenways, is uncoordinated. A 'tower of 'Babel'is being created. There is a sense that many comparisons are of the apples-to-orange type, and therefore are inappropriate or irrelevant. This lack of coordination contributes to poor communication and a missed opportunity for new knowledge based on greenway planning and implementation 'experiments' worldwide.

In response to this global interest in greenways as a planning strategy for sustainable landscapes, this paper has three main objectives: (1) To present an inclusive definition of greenways as a basis for discussion; (2) To propose a typology of greenways to facilitate more explicit understanding of greenways, including their scales, goals, spatial concepts,

Term	Term Usage	Functions **B**iotic **C**ultural **M**ulti-functional	Scale **C**ontin-ental **N**ational **R**egional **L**ocal	Primary Spatial Basis **P**hysical **C**ultural **B**iological	References and Examples
Ecological Networks	Europe	B	C,N,R,L	B	Physical Plan, Province of Brabant, The Netherlands
Habitat Networks	Europe America	B	N,R,L	B	Noss & Harris 1986
Ecological Infrastructure	Europe	B	C,N,R,L	B	Netherlands Nature Policy Plan 1990
Greenways	America	B,C,M	R,L	P,C	Charles Little 1990 Smith & Hellmund 1993
Wildlife Corridors	America	B	R,L	B	Smith & Hellmund 1993 Quabbin to Wachusett
Riparian Buffers	Europe America	B,M	R,L	P	Binford & Bucheneau 1993
Ecological Corridors	America	B	R,L	P	Phil Lewis 1964
Environmental Corridors	America	M	R,L	P	Phil Lewis 1964 Winsconsin USA
Greenbelts	Europe America	C	R,L	C	London, England Ottawa, Canada
Landscape Linkages	America	B	R,L	B	Harris & Gallagher 1989 Florida USA

Figure 3.1 Ecological network and greenway terms

landscape contexts, and the transferability of these insights; (3) To apply this typology to case studies selected to illustrate variations in the typological classes, and to discuss how the typologies help to determine transferability of concepts, knowledge, and how greenways represents a strategic approach to landscape planning.

Greenway Definition

In recent decades, there have been many innovative ideas in landscape planning that express some aspects of greenways (MacKaye 1928, Lewis 1964, McHarg 1969, Newton 1971, Fabos 1986). In recent years however, the use of the term greenways has expanded significantly, especially in North America. From a review of recent literature on greenways in landscape planning (President's Commission on Americans Outdoors 1987, Little 1990, Flink and Searns 1993, Smith and Hellmund 1993), the following inclusive definition of greenways is proposed:

Greenways are networks of land containing linear elements that are planned, designed and managed for multiple purposes including ecological, recreational, cultural, aesthetic, or other purposes compatible with the concept of sustainable land use.

There are five key ideas contained in the above definition that warrant further discussion. First, the spatial configuration of greenways is primarily linear. Greenways are based on the particular characteristics and opportunities inherent in linear systems, which offer distinct advantages in terms of movement and transport of materials, species or nutrients. This is perhaps the most significant spatial characteristic of greenways, and certainly one which distinguishes greenways from other landscape planning concepts.

Secondly, linkage is a key greenway characteristic that defines the greenway and relates it to the larger landscape context, often at multiple scale levels. Greenways as integrated systems attempt to realize a synergy based on the advantages of linkages across spatial scales. One of the main arguments for greenways is that when a system is linked, it may acquire the synergistic properties of a network.

Thirdly, greenways are multifunctional, based on an assumed or negotiated spatial and functional compatibility of certain uses. Because of this characteristic, the process of establishing goals in greenway planning is particularly important, since all goals cannot be optimized, tradeoffs and compromises must be made to reflect the ecological, cultural, social and aesthetic goals associated with greenways. For example, the needs of recreation and wildlife habitat protection often conflict, and may require spatial segregation, specific management or elimination of one of the uses if compatibility cannot be achieved. These tradeoffs have important spatial and functional consequences, and therefore are particularly important in greenway planning. The decisions made on greenway goals should reflect social and cultural values and perceptions, as well as those of environmental protection.

Fourthly, the greenways strategy is consistent with the concept of sustainable development, in that it is based on an assumed complementarity between nature protection and economic development. Greenways are not only for the protection of nature - other human uses of the landscape are recognized and legitimized, and a balance between resource use and protection is attempted. Sustainability should be regarded as a special globally accepted goal and paradigm for the future (IUCN 1980, WCED 1987, Lyle 1994)

Finally, greenways represent a distinct spatial strategy based on the particular characteristics and advantages of integrated linear systems (Checkland 1989, Zonneveld 1991). Greenways should be considered as a complement to comprehensive landscape and physical planning, not a replacement. Efforts should be made to protect other important landscapes that are not linear and for those elements that may not benefit from linkage or multiple use. The focus on linear greenway elements should not cause less concern for other non-linear areas with equally important landscape planning issues, but as a strategy, it has much intrinsic merit.

The definition and the five key ideas described above provide a view of greenways as a complex and variable strategic approach to landscape planning. Perhaps greenways are appealing and successful to the public because of the simplicity of the concept, and because greenways do not attempt to transform or control the entire landscape - but by focusing on riparian corridors and other environmentally sensitive areas, greenways are more modest in their ambitions, while exploiting selected linear elements in a strategic and synergistic manner.

Arguments in Support of Greenways

Although there are a number of arguments in favor of greenways, some of which have been described above, it is important to acknowledge some of the challenges and arguments against greenways. Greenways are a strategy that offers certain benefits, yet it is certainly not a panacea to the challenge for sustainable development. Following is a brief discussion of the advantages and disadvantages of greenways.

Landscape function is a term used in landscape ecology to describe the flow of nutrients, species and energy between landscape elements (i.e., patches and corridors) (Forman and Godron, 1986). Biogeochemical cycling of nutrients and energy are natural processes. The nitrogen, carbon and phosphorous cycles are well understood. Species of animals migrate diurnally or seasonally between local or distant habitats. Ecosystems of plants and animals have evolved in response to these natural, or background flows of nutrients, species and energy. Under intensive land use however, these flows may be greatly accelerated or disturbed to the detriment of the sending or receiving ecosystem, or both. A common example is runoff from agricultural land use which transports sediment, nitrates, phosphates and pesticides to the riparian environment. These materials reduce water quality and alter stream structure through increased sediment loads. Urbanization usually also results in increased volumes of stormwater runoff which alters the hydrologic characteristics of riparian systems with greater peak flows and reduced base flows. Exotic or pest species of plants or animals may also thrive under intensive land uses to the detriment of adjacent communities. Greenways have the potential to moderate these flows to maintain more sustainable levels of landscape function through buffering. Conceptually there are two principle types of buffering that relate to greenways: riparian corridor/ wetland filtering and patch edge buffering.

Riparian systems and wetlands are generally situated downhill from terrestrial environments and are thus the recipients of materials moved by the mass flow processes of erosion and mass wasting. Often the ecological integrity of riparian ecosystems is affected by the nature of these materials. Greenway buffers located between disturbances and riparian corridors and wetlands can mitigate against these impacts by filtering sediments, controlling erosion, and regulating water temperature (Peterjohn and Correll 1984, Binford and Buchenau 1993).

In most temperate landscapes the drainage network assumes a dendritic or treelike form with headwater branches linking with larger downstream channels and finally to the main river channel. This system is perhaps the most immutable and continuous element of the landscape. It is the logical spine for a greenway (Ahern 1991). If the greenway is structured by the riparian network then it follows that it should buffer that network from excessive flows of nutrients, species and energy from adjacent landscapes. How much buffering is necessary? Lewis (1964) suggests that riparian corridor width and stream order should be related, with larger order streams receiving larger buffers More recent empirically-based research has attempted to define the effectiveness of various buffer widths and types to stabilize and protect riparian zones. Budd et al. (1987) observed the effects of riparian buffer width on stream structure, stream temperature, and soil erosion in the Pacific Northwest. Peterjohn and Correll (1984) evaluated the nutrient dynamics of agricultural runoff on riparian systems in the Mid-Atlantic region. Forman and Godron (1986) suggest that riparian corridors should include the floodplain and a continuous band of upland forest interior on one side. Unfortunately there is no simple answer to the obvious question - how wide does the buffer have to be?

Another function of greenway buffers is to protect patches of interior habitat from outside disturbances. This can be described as patch edge buffering. Interior habitats are non-fragmented patches of habitat for specialist species that cannot exist in highly disturbed and fragmented landscapes. Maintenance of suitable interior habitat is critical to the protection of biodiversity. In most temperate landscapes the key interior habitats are forest environments. As mentioned earlier, fragmented patches suffer increased susceptibility to numerous disturbances. The edge zones of important interior patches have the potential to buffer or eliminate certain of these external disturbance factors through appropriate planning, design, and management actions. For example, increased predation on native wildlife by domestic pets, especially dogs, is often a source of disturbance and stress. A proper buffer for an important interior habitat would include some form of physical barrier (fence, mound, moat, hedgerow) that would control the domestic animals. Another form of disturbance is the spread of invasive non-native plant species into interior habitats. These species may invade incrementally through vegetative growth or they may invade rapidly through efficient dispersal of propagules by birds or wind. Greenway buffers may control these invasions through stabilizing the ecological factors that favor the spread of the opportunistic invasive species. A coordinated program would address the following issues: stabilization of soil erosion and relief of soil compaction, stabilization of gaps with native species, control runoff to proper background levels, and manage human activity to be compatible with the issues described above.

Perhaps the strongest and most scientifically substantiated argument for greenways is based on their potential role in ameliorating the negative effects of landscape fragmentation. This argument is based on the benefits of connectivity as related to theories of island biogeography and metapopulations (Schreiber 1988, SoulÈ 1991, Noss 1993, Opdam et al. 1993). By providing higher levels of connectivity, greenways are assumed to enhance survival prospects for species, particularly those that exhibit metapopulation dynamics. Connectivity enables certain species to migrate, disperse and repopulate patches in heterogeneous landscapes which may be alternatively occupied and empty. The spatial concept of linking suitable patches of habitat into a network is a promising strategy to achieve a sustainable condition in terms of biodiversity, while acknowledging the need and reality for other land uses to exist around the protected areas.

Greenways may connect cultural resources into a type of network or system that may have greater value and higher use than the sum of the constituent parts - as a kind of landscape synergy. Cultural landscape resources are increasingly recognized for their interpretive and recreational values. Linking these resources makes them accessible to a larger region of users, and, through multiple use, may realize compatible uses within a single greenway.

Greenways have the potential to provide a visible structure and legibility to the landscape. Greenway planning, as a form of regional scale design, may have a profound impact on the physical and spatial character of the landscape. When a greenway produces a strong pattern and form in the landscape, certain natural features and processes may become more visible and legible. Lynch (1972) has described other advantages of linking open spaces into a system: The open space system not only makes the [city] visible, but also the larger natural universe. It can give the observer a sense of the more permanent system of which he and the city are only parts. ..... To convey a sense of the web of life, of the intricate interdependent system of living things, will be even more important. (p. 124).

Fabos (1995) challenges landscape architects to dream of a national scale greenway for the United States that should be as prominent on maps as the United States' interstate highway system - a clear physical expression of a national commitment to sustainable land use planning. Lewis (1964) has spent an ambitious career advocating environmental corridors for their role in raising environmental awareness and knowledge, from local to regional levels.

Arguments Against Greenways

Greenways also have been criticized. Although the greenways concept is currently enjoying great popularity, there are some convincing challenges to the concept that warrant consideration. It is equally important to understand these arguments and to arrive at a balanced and reasoned approach to planning based on the particular circumstances and the landscape context.

Greenways as wildlife corridors, however, do not enjoy universal acceptance among planners or ecologists. Daniels (1988) identifies three reasons why biological/wildlife corridors are not needed: (1) many species can disperse across the landscape without corridors, (2) there is little evidence that the intended species will use the corridors, and (3) the corridors may facilitate the spread of invasive species into protected areas. These serious challenges to the corridor concept are important reminders that there are no simple solutions to complex ecological problems (Groome 1990). Some important wildlife and plant habitats may well be better left isolated, although the growing body of recent literature cited above suggests otherwise, at least in most cases. While corridors may prove to be often useful, they should always be understood in the overall landscape context to determine if the linkage provided is desirable or even necessary

In the field of conservation biology there has been a long term debate on the relative merits of protecting single-large-or-several-small patches or ecosystems (SLOSS). Greenway opponents assert that the more appropriate strategic response to landscape fragmentation is to protect existing large patches in advance of fragmentation, through additional protection, or through nature 'creation'. Skeptics see strategies which advocate restoring and protecting connectivity as giving a kind of license to land use changes which may then continue to produce fragmentation of larger landscape elements. This argument is often valid, especially in unfragmented landscapes.

Imposing greenway corridors in a landscape may lead to greater uniformity, and a loss of cultural landscape identity. In open landscapes, forested corridors are unnatural and inappropriate introduction of forested corridors can radically change the physical, cultural and visual landscape. This is a criticism that has been voiced in landscapes where applications of island biogeography theory have already made an influence on landscape planning policy, as in The Netherlands (N. de Jonge, Renkum, Netherlands, personal communication, 1994). This point of view is more relevant in landscapes where the greenway network becomes a vertical element (i.e. forested) in an otherwise open cultural landscape.

Greenways planning strategy needs to be part of a larger and more comprehensive landscape/physical planning activity. The popularity of greenways raises the concern that many may view it as the only landscape planning action needed. Under certain circumstances the popularity of the greenway idea may obscure or diminish other legitimate landscape planning issues and priorities, such as the protection of scarce resources, or the avoidance of landscape hazards.

Greenways are often conceived and planned on the basis of abiotic and biotic patterns in the landscape. Large-scale digital databases provide much of the spatial data necessary for greenway planning processes. Land ownership, however, is a key factor that is often absent from these databases because of its inherent spatial detail and complexity, and due to legal issues relating to data accuracy. As a result, consideration of land ownership is often completely absent from the planning process and is first considered in the context of implementation. When this happens, the landscape's inhabitants - the owners - may view a proposed greenway as an encroachment on their property rights and may, with understandable cause, strenuously oppose the greenway. In the USA, a politically active special interest group the 'Wise Use Movement' represents a significant opponent of greenway planning in response to such perceptions of excessive government involvement with privately owned lands. When the landowners are involved earlier in the planning process, this type of opposition can often be avoided and a 'common ground' representing both sides of the issue may be identified (Schrader 1995).

It is important to consider and understand both sets of arguments regarding greenways. Clearly greenways have substantial merit and public appeal as a landscape planning strategy. This enthusiasm should not be transformed into a blind or dogmatic promotion of greenways, however. While the increasing global popularity of greenways attests to their benefits, there are several sound arguments against greenways. The decision to adopt any particular greenway strategy should always be made on the basis of the particular biotic, abiotic and cultural factors in the local landscape as well as the values and perceptions of the landscape's inhabitants.

Typology of Greenways

Although there is a great inherent diversity in greenways in terms of defining basic terms, scale, goals, landscape context and planning strategies, typologies of greenways can be defined. The value and utility of these typologies lies in their potential to support knowledge transfer and to facilitate cooperative planning and design of greenways.

Scale

Greenways can be classified by their spatial scale. In the proposed classification (Figure 3.2) greenways are classified in terms of the landscape area in which they are situated (not only by the lands that are physically part of the greenway). Figure 3.2 indicates a hierarchical classification of greenway orders, in the same manner that streams and rivers are classified in geomorphology and physical geography. The size classes proposed in this scheme are not absolute, but reflect an orders-of-magnitude approach to scale classification. The larger orders represent the more extensive land areas (continents, countries) while the lower order greenways are more associated with specific natural and cultural features (mountains, rivers, cultural features). Besides the obvious physical differences which are directly related to the size, there are corresponding differences in associated political units and in the functional orientation. Larger order greenways usually have a policy orientation, intermediate order greenways a policy and coordinating function, and lower order greenways an implementation and management orientation.

In this classification scheme there is an assumption of integration across orders. High order greenways involve extensive areas of land. The higher order greenways (Orders 3, 4) are more policy oriented and rely on lower order coordinating greenway plans for policy coordination and for implementation and management. Designation as a higher order

Order	Area (km^2)	Physiography	Political Units	Functional Orientation	Examples
1	1-100	Small Streams Ridges	Municipal	Implementation Management	Platte River. Minute Man
2	100 - 10,000	Rivers Regional Features	County Province	Coordination Policy	Quabbin N. Brabant
3	10,000 - 100,000	River Basins Mountains	States Small Nations	Policy	Netherlands Georgia
4	>100,000	Continental	Large Nations and Continents	Policy	EECONET

Figure 3.2 Greenway classification based on spatial scale and asociated attributes

greenway implies that the lower order greenways exist or will be formed, for greenways cannot be implemented and managed at such vast spatial scales. The same is not always true of lower order greenways, which often are grass-roots projects, especially in North America. Many of these local greenways are not yet linked with higher order greenways. The higher order greenways can be considered as meta-greenways, since they are, by definition, comprised of smaller constituent greenways.

Goals

Although the greenways concept is increasingly popular, there is little consensus regarding how greenways should be planned. In some cases, greenways are promoted primarily for their recreational benefits, while others are recognized for their role in biodiversity planning, others are recognized for their potential to control or direct urban expansion - and of course many are multifunctional in nature (Little 1990, Bennett 1991, Flink and Searns 1993, Smith and Hellmund 1993, Fabos 1995). Goal determination is especially important in greenway planning because of its multifunctional nature and strategic approach. Assessments are needed to formulate and revise goals, to define the spatial and functional consequences of compromises and to develop implementation strategies and plans. Multifunctional greenway planning must involve compromises, since all goals cannot be maximized. This is fundamental to the greenway concept. It is also important to appreciate that all goal-related compromises have spatial and functional consequences.

It is possible to classify goals into several categories to support a greenway typology:

(1) Biodiversity related: pertaining to the maintenance or enhancement of biodiversity

through habitat protection, creation, linkage, and management.
(2) Water resources related: relating to the protection, restoration and management of water resources including floodplains, stream corridors, groundwater recharge/discharge areas, and wetlands (Binford and Buchenau 1993, Ndubisi et al. 1995).

(3) Recreational: relating to opportunities for natural resource-based recreation, especially along linear corridors through rural and urban landscapes (Tzolova 1995).

(4) Historical and Cultural Resource Protection: relating to the linkage of cultural and historic resources, particularly those with strong natural resource/landscape associations (Little 1990, LaCour 1991, Smith and Hellmund 1993, Fabos et al. 1993)

(5) Development Control, Urban Containment: relating to the strategic use of greenways to control and define the urban-rural interface (MacKaye 1928, Ryder 1995, Walmsley 1995).

Landscape context

Greenways must be understood in the context of the landscapes in which they are situated. In landscape ecology, this context is called the landscape matrix, the most extensive element of the landscape which dominates landscape functions (Forman and Godron 1986). The landscape context helps to define the physical context, the associated landscape functions, as well as the driving dynamic processes which affect change in the landscape. This is obviously a key component of a greenway typology.

The landscape context can be described in terms of the predominant land use or land cover of the landscape. In Europe, the predominant landscape matrix is agricultural (Bischoff and Jongman 1993). Agricultural land uses have associated physical, visual, economic and social parameters which help to explain landscape pattern and process (Turner 1989). In general terms, agricultural landscape contexts can be said to have relatively slow rates of land use change, and higher rates of nutrient and material fluxes (Peterjohn and Correll 1984). In much of eastern North America the landscape context is rural-suburban or forested, significantly different with respect to the parameters described above. In suburban-forest landscapes land use change is often a continuing process - today's forest-as-wildlife-habitat becomes tomorrow's subdivision.

There are no simple categories to be defined for the landscape context component of this greenway typology. To oversimplify landscape context would only produce an illusory classification, and could lead to miscommunication, or to a misapplication of knowledge. In the typology therefore it is recognized that landscape context is an important factor to understand and to define as explicitly as possible, in terms of the structure, function and dynamics of the specific landscape.

Planning Strategies

The word strategy comes from military terminology: The science and art of military command aimed at meeting the enemy under conditions advantageous to one's own force.

(Merriam-Webster 1989, p. 709). Strategy differs from tactic, another term of military origin, which is 'the science of maneuvering forces in combat' (Merriam-Webster 1989, p 729). Strategies are thus more proactive, based on a plan, intended to effect the forces (causes) of conflicts and problems, more than as a specific reaction to a particular force, or to achieve a specific objective. Odum's proposed 'compartment model' (1969) describes a strategy for coordinating land use decisions regarding: urban, productive, protective, and compromise zones (Fabos 1986). Unlike the greenway concept, however, Odum's model is not spatially specific, and does not address the issue of spatial configuration (Turner 1989, Forman 1990a). In the context of greenways, the concept of planning strategy is particularly relevant. The strategic aspect of greenways is of fundamental significance (see greenway definition).

Greenways represent a distinctly strategic approach to landscape planning. It is not a model for comprehensive landscape planning, because it focuses on networks and linear areas, which are implicitly nested within a larger landscape context. While greenway planning is conscious of landscape context, it focuses on the strategy of achieving multiple benefits through combinations of spatially and functionally compatible land uses - within a network.

In the case of greenways, the strategic 'battle' is the struggle for sustainable landscapes, against the forces of fragmentation, land degradation, urban expansion and uncontrolled land use change. The strategic objective is to establish a durable network capable of supporting basic ecological functions, protecting key natural and cultural resources and permitting other uses which do not impair landscape sustainability. As a planning strategy, it substitutes the difficulty/futility of planning the entire landscape, with a strategic effort to build a linear network as a kind of sustainable framework (Sijmons 1990, Kerkstra and Vrijlandt 1990, Buuren van 1991).

According to this paper's definition of greenways, they represent a strategic landscape planning concept based on the particular advantages of linked linear systems. Within this overall view of greenways as strategic planning, there are four principal strategies that may be employed, individually or in various combinations . These strategies are defined as protective, defensive, offensive and opportunistic (Figure 3.3).

When the existing landscape supports sustainable processes and patterns, a protective strategy may be employed. Essentially this strategy defines an eventual greenway landscape pattern that is protected from change while the landscape around it may experience changes. This strategy employs planning knowledge, regulation, and land acquisition to achieve the desired goal.

When the existing landscape is fragmented, and core areas already limited in area and isolated, a defensive strategy is often applied. This strategy seeks to arrest the negative processes of fragmentation. As a last resort, the defensive strategy is often necessary, but it can also be seen as a reactionary and ineffective strategy which attempts to 'catch up with' or 'put on the brakes', against the inevitable process of landscape change, in defense of an ever-decreasing nature (Sijmons 1990, Vroom 1997).

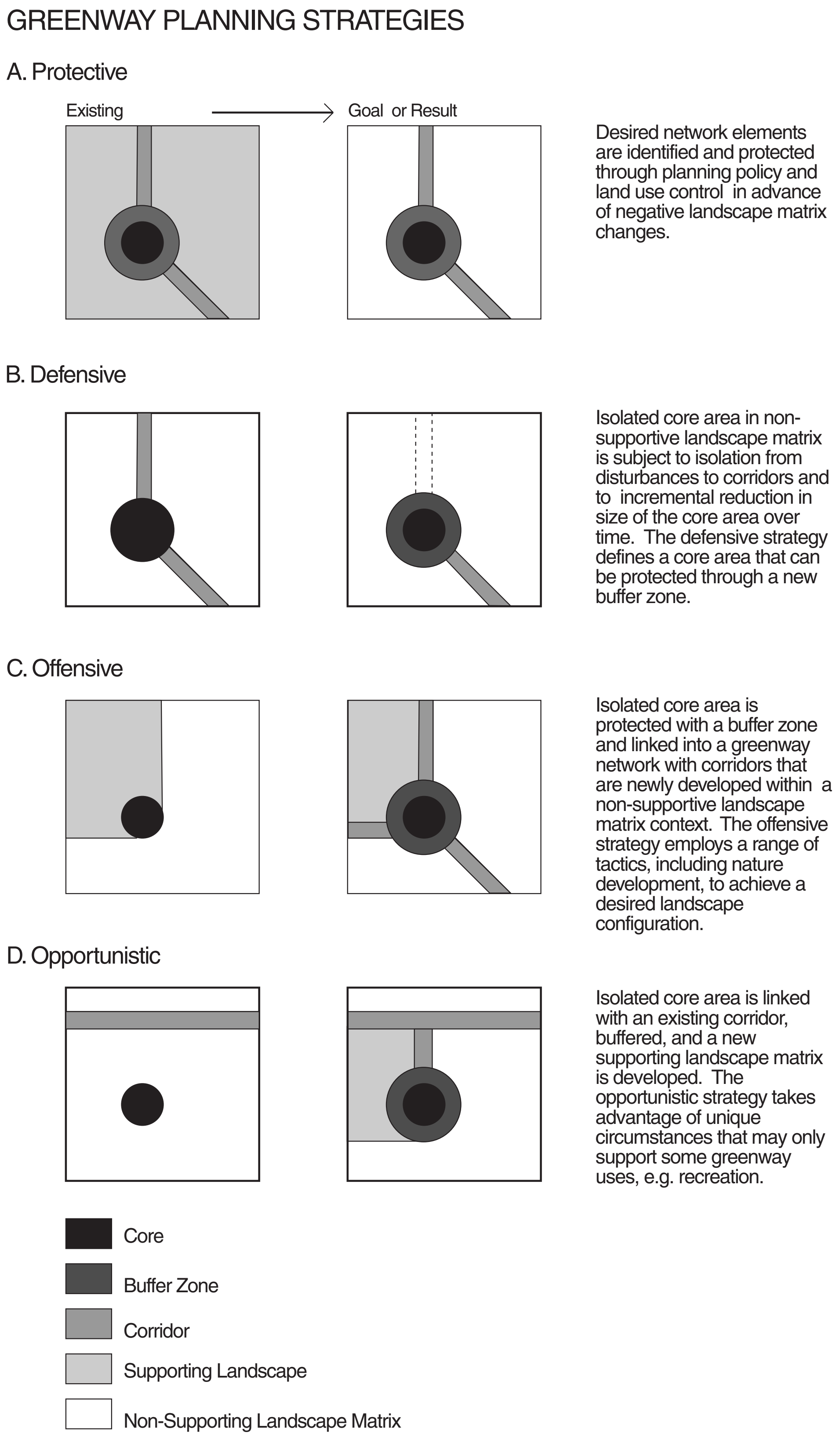

Figure 3.3 Greenway planning strategies

An offensive strategy is based on a vision, or a possible landscape configuration that is articulated, understood and accepted as a goal. The offensive strategy differs from protective and defensive strategies in that it employs nature development to build new elements in previously disturbed or fragmented landscapes. The offensive strategy relies on planning knowledge, knowledge of ecological restoration, and significant funding. This strategy is often practiced in Europe, where centuries of use have produced a cultural landscape with limited opportunities for nature protection or defense. The offensive strategy essentially involves putting nature back into the landscape, according to an accepted vision or plan.

Often the landscape contains unique elements or configurations that represent special opportunities for greenway planning. These unique elements may or may not be optimally located, but in some respects they are promising for greenway development. In the USA, the rails-to-trails movement is a good example of opportunistic greenway planning (Little 1990, Flink and Searns 1993). This strategy is, by definition, dependent on the presence of certain unique landscape elements, which are often in the configuration of a corridor. The opportunistic strategy involves recognition of such special opportunities and integrating them with other planning strategies.

These four strategies complete the typology of greenways offered in this paper. In a context of divergent terminology and great variations in scales, goals, landscape contexts and planning strategies it is proposed as an attempt to offer a more explicit basis for communication and exchange of knowledge and experiences in greenway planning.

Greenway Case Studies

Three case studies have been selected to represent a range of greenway projects. Following an introduction, each case study will be evaluated in terms of the proposed greenway typology, specifically in terms of: scale, goals, landscape context, and planning strategies. Then they will be discussed in terms of potential transferability of strategies and knowledge.

Case Study 1: North Brabant, Netherlands

As one of the world's most densely populated and intensively used landscapes, the Netherlands may be seen as a harbinger of landscape issues the rest of the industrialized world may encounter in the future. The Dutch planning and design response to their culturally-rich, intensively used landscape has been innovative and visionary. Their work addresses the larger scale environmental policy issues, as well as the implications for physical planning and design (Vroom 1992, Bailey 1991). Because of a history of uniquely intense interaction with the land, the Dutch landscape has been metaphorically described as an "experimental garden" (Vos and Opdam 1993). The Dutch have a lot to teach the world from their experiences in this garden.

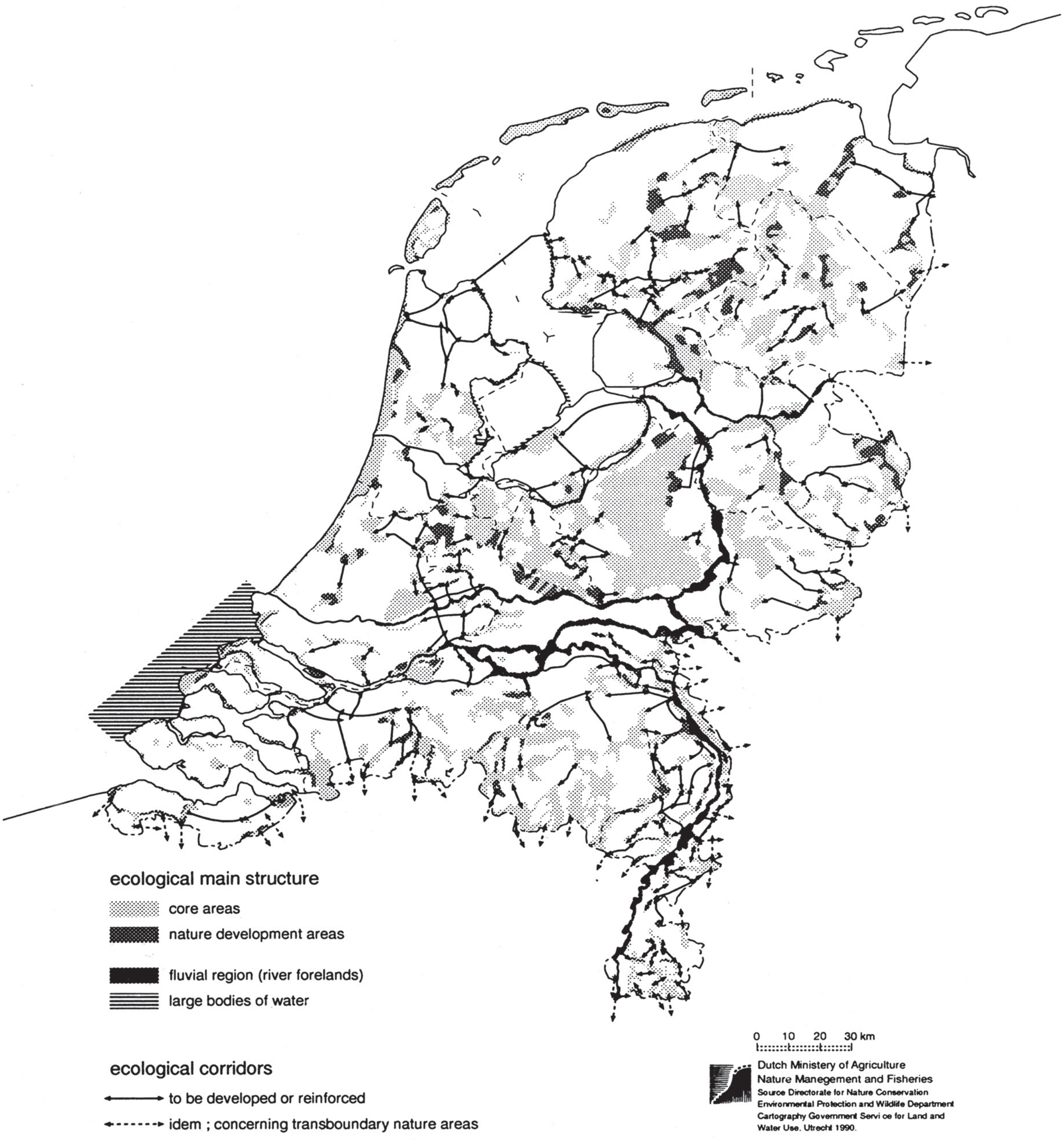

Figure 3.4 The National Ecological network of the netherlands (min. LNV, 1990)

The Netherlands has a highly structured three tiered planning system at national, provincial and municipal levels. At the National level, physical planning policy is decided by and coordinated between several ministries. The Fourth Policy Document on Physical Planning , the basis of current national physical planning policy, advocated spatial segregation of incompatible land uses to permit flexibility in agricultural use, and for an integration of nature conservation, recreation and forestry (Ministry VROM 1989, Langevelde 1994). The subsequent Nature Policy Plan of the Netherlands defined the National Ecological Network, in support of the Dutch nature conservation policy for the sustainable conservation, rehabilitation and development of nature and landscape in the Netherlands for the next thirty years (scale 1:2,000,000). The spatial strategy of the network is to protect, buffer and link core areas, nature development areas and corridors for the entire Netherlands, including international linkages with Germany and Belgium (Figure 3.4, Netherlands Min. Agriculture 1990). In terms of scale this plan can be described as a third order plan, primarily with a biodiversity protection/restoration goal, in an agricultural:developed matrix, and employing the full range of all the planning strategies identified: protective, defensive, offensive, opportunistic.

The next level of planning in the Netherlands is at the scale of the 12 Provinces. At this scale (1:100,000), the National Ecological Network is interpreted in greater detail and adapted to the specific landscape, political, cultural and environmental context of the provinces. The provincial plans are essentially coordinating plans to assure that local (municipal) plans are consistent with each other, and with the national plans. This case study focuses on landscape planning in the Province of North Brabant.

The North Brabant Streekplan (Physical Plan) addresses the landscape and environmental problems of the province including: water pollution, ground water drawdown, air pollution, and population pressure from the Randstad in the Netherlands and from the Rhur Area in Germany. These problems have increased significantly in the past decade. North Brabant has a desirable type of rural landscape in which the ex-urban "Randstad refugees" want to live. The land use change dynamics are somewhat characteristic of the process of decentralization, tending towards a megalopolis (Gottman 1961, Fabos 1985). North Brabant has much intensive agricultural activity which often conflicts with nature protection and residential land uses, and causes significant environmental stress through high rates of manure spreading and intensive drainage of agricultural soils.

The Streekplan for North Brabant is a type of umbrella plan for other, more specific, plans such as the nature policy plan, environmental plan, and housing plan. The North Brabant Streekplan was prepared at the same time as the National Environmental Policy Plan with considerable dialogue between the respective planners and governments involved (de Jonge, J. personal communication , 1994). It was the first provincial plan to be completed after the Fourth Report on Physical Planning and the National Environmental Policy Plan were adopted. The Streekplan is based on a concept plan which defines a spatial strategy including four land use-based accent areas: 1) Agriculture, 2) Nature, 3) Tourism and Outdoor Recreation, and 4) Urbanization, (Provincie Noord Brabant 1992) . This strategy recognizes the fact that development and nature protection are usually not spatially compatible in the landscape, and should be segregated even on a conceptual level. Since the less dynamic functions of nature benefit from temporal stability, and some benefit from connectivity, the spatial strategy proposes a kind of ecological network in which these less dynamic functions may exist in a permanent and connected system (Kerkstra and Vrijlandt 1990, Sijmons 1990, Buuren van 1991). The Streekplan (Figure 3.5) in turn includes four categories of "Green Main Structure":

Core nature areas: These are large areas which are presently nationally or provincially-significant landscapes or wildlife habitat. The core areas in Brabant include 130,000 ha, mostly determined by the presence of important wildlife species and habitats (e.g. Sitta europea, nuthatch; Parus palustris, marsh tit). In these core areas, 70,000 ha are already protected, and the remaining 60,000 ha are in private agriculture - of this amount 50% (30,000 ha) will be purchased over the next 25 years and the other 50% 1 will be controlled through regulation and management rather than through acquisition and subsidy.

Nature development areas: These areas are not as ecologically significant and are not to be protected at the same level as the core nature areas, but are important as connections between core areas and as buffer zones. Approximately 50% will be changed from agriculture to nature over the next 25 years, while the other half will have basic protection with the status quo maintained as much as possible. In these areas there may be some marginal concessions from agriculture to make conditions more favorable to nature development.

Wet and dry ecological corridors: These linear areas are primarily for linkage of the nature core areas and nature development areas. The wet corridors of course, follow streams and waterways. The dry corridors are located to strategically link the core areas and nature development areas. They are managed as protection, management or restoration areas. The waterschappen (local water boards) are now working with wet corridors and areas with small zones containing multifunctional uses. The process of land reallocation is a strategy for implementing both types of corridors in the landscape (see discussion below).

Multifunctional forests: These are existing forests, often monospecific plantations, which presently have limited nature value, but with a potential for improvement. They are often located near core nature areas, and provide buffer functions as well as providing opportunities for tourism and outdoor recreation. The specific management plans for these areas are decided on a case-by-case basis, depending on the characteristics of the core areas and nature development areas the multifunctional forests border. This category was not part of the National Ecological Network, but was added by the Province of Brabant.

The implementation of the Streekplan is presently being coordinated by the provincial planners in coordination with municipal planning, and through land reallocation projects.

Municipal government plans are the most important level for implementing policy plans as this is where the provincial plans become specific about how to implement the larger ideas that have "trickled down" from the national level of policy planning. The Province works with local governments to stimulate coordination with the streekplan. There are problems and opportunities inherent in this situation. When specific lines are drawn on maps, affected property owners can be expected to resist changes. Since the full implementation of the streekplan will involve change in ownership of over 60,000 ha in the Province, and other changes in regulations and management, significant opposition has been expressed. However there are also opportunities inherent in this more detailed planning scale in which new information is available for municipal decision makers, and opportunities may be realized to combine compatible goals. The multifunctional forest is an example of such a provincial policy that can be effectively implemented at the municipal

Figure 3.5 Elements of the Green Mainstrucutre, North Brabant, Netherlands (Provincie Noord Brabant, 1992)

level. Because the local planners have more detailed knowledge about the local landscape, land use issues, and politics, they often can find a strategy, acceptable to local landowners and supportive of the provincial and national policy plans (de Jonge, J. personal communication, 1994).

The process of land reallocation also provides opportunities to implement provincial physical planning policies. Land reallocation is a comprehensive planning practice which has traditionally been conducted to improve physical conditions for modern agriculture. In older cultures like the Netherlands, generations of agricultural use tend to produce a fragmented land ownership pattern with outdated agricultural infrastructure (e.g. drainage systems, parcelization, road networks). The land reallocation process begins with a form of cooperative agreement between farmers, usually with a combined land ownership of some hundreds of hectares. The process takes several decades and results in a major reconfiguration of the landscape in terms of field sizes and layouts, road networks, drainage systems and other uses and infrastructure. Until recently this process was aimed primarily at increasing agricultural efficiency and productivity. Increasingly, land reallocation promotes a more multifunctional approach, including nature protection, cultural landscape protection, tourism and recreation. Since there are typically a percentage of farmers (10-20%) who want to stop farming, land reallocation provides special opportunities to introduce nature protection. In this context, land reallocation provides a special and unique opportunity to reintroduce corridors and multifunctional forests into the Brabant landscape, and to meet other policy goals of the Streekplan. In the future, extensification of agriculture is estimated to affect between 10-20% of the agricultural landscapes of Europe. This significant land use change will create unprecedented opportunities for multifunctional

greenway planning.
This case study of the North Brabant Streekplan illustrates how the integration of several levels of planning can be accomplished, and describes a unique and contemporary application of landscape ecological knowledge to planning. In the context of a comprehensive sustainable landscape planning goal, it provides the important link to larger policy plans, and it coordinates local scale decision making. It incorporates the latest knowledge from landscape ecology, and employs a strategic approach towards implementation, including spatial concepts of segregation and integration.

Evaluation

Typology

This case study can be accurately and meaningfully classified according to the typological scheme presented earlier. The Brabant plan is scale-integrated from national to local levels, but is primarily a second order plan. The landscape matrix context is largely agricultural, except for the urban areas designated in the plan. The goals are multifunctional based on the four part accent plan, but with a strong emphasis on biodiversity. The planning strategy is a hybrid combining defensive aspects in terms of protecting existing core nature areas, with distinctly offensive aspects in terms of nature creation of new corridors, and major landscape reconfiguration through the process of land reconsolidation. The implementation strategy could also be described as opportunistic, in terms of the European Union (EU) from which it may be seen as one model for extensification of agriculture, an issue that the rest of Europe is expected to address in the future.

Transferability

Unlike most landscape and land use planning in the US, which is decentralized, the Brabant Streekplan is part of a well established, centrally-controlled and empowered planning system. Most other countries would fall between these two extremes. The Brabant Plan benefits from the existence of a national plan, and from funding for planning and plan implementation (e.g. land acquisition). Unlike much greenway planning in the US, the Brabant Plan is basically a top down approach, operating within the well-established traditions and responsibilities among the various levels of planning. Ironically, because of the long established and empowered nature of Dutch planning, the plan is viewed as "just another plan", or a routine planning exercise, in comparison with the US where the creation of such a plan would be more likely to be seen as innovative and visionary.

At a fundamental level, the Brabant plan is driven by the process of fragmentation, a global environmental issue (IUCN 1980). In principle it is like many wildlife corridor-type plans in the US in that it links larger habitat patches with others via a network of corridors, using a target species based approach, and supported by island biogeography and metapopulation theories.

The conceptual strategy of balancing conflicting land uses via the accent areas is a transferable strategy for other greenways. The Brabant plan is an example of the spatial concept of segregation applied at a coordinating second order policy level. The broad-based and strategic approach to implementation combining a range of implementation techniques is not unlike that employed in the US under a fundamentally different, decentralized planning context. In terms of an advanced example of applying landscape ecological approaches to landscape planning, it is uniquely innovative. As the Streekplan progresses from policy to implementation the lessons learned will be important tests for greenway plans in other countries and provinces.

Case Study 2: Minuteman National Historic Park

Minute Man National Historic Park (MMNHP), owned and managed by the United States Department of Interior (USDI) National Park Service(NPS), was established by Federal Act in 1959 to commemorate the location of the first battle of the American Revolution, which started at the North Bridge in Concord and followed the retreating British along the "Battle Road" on their retreat to Boston. Minute Man National Historic Park is located approximately 20 kilometers northwest of Boston, Massachusetts, USA (Figure 3.6). The largest land unit of the Park, the "Battle Road" Unit, is a linear corridor that traces part of the Battle Road for approximately 5 kilometers and occupies approximately 300 ha.

The Park is currently in the second phase of a "Cultural Landscape Management Plan" which involves a multitude of landscape planning issues and objectives considered in the context of an ambitious cultural landscape interpretive plan (Gavrin et al 1993, Andrus 1992, McClelland 1991). In part because the park has a linear spatial configuration, and in part because of the multifunctional planning approach used which combines cultural, historical, recreational and ecological goals, it is considered a greenway. It illustrates an integrated strategic approach to greenway planning in a partnership between the Federal government, the state government, and local municipalities. In the current plans, the NPS seeks to make connections with existing protected areas and corridors, thereby linking the Minute Man greenway with other regional greenways.

Minute Man is a unique park in that it was the first time the National Park Service (NPS) acquired land in a suburban environment and systematically removed structures including residences and businesses to "recreate" a historic landscape. Minute Man is a type of "living history" park in the manner of Colonial Williamsburg in Virginia (Birnbaum 1996, USDI 1992). Unlike Williamsburg however, Minute Man is not in the "village-as-stage set" mode, rather it is more serious and ambitious about its interpretive agenda (Ball, 1993). In addition to telling the "story" of the battle of April 19, 1775, NPS has a vision of the Park, in which a series of parallel and interacting cultural and historic themes are interpreted - with the landscape itself as the primary interpretive tool. These themes include the story of the Running Battle itself, the landscape history of the area, its natural history, and interpretation through a recreational trail system.

The present landscape of MMNHP is substantially different from the colonial landscape

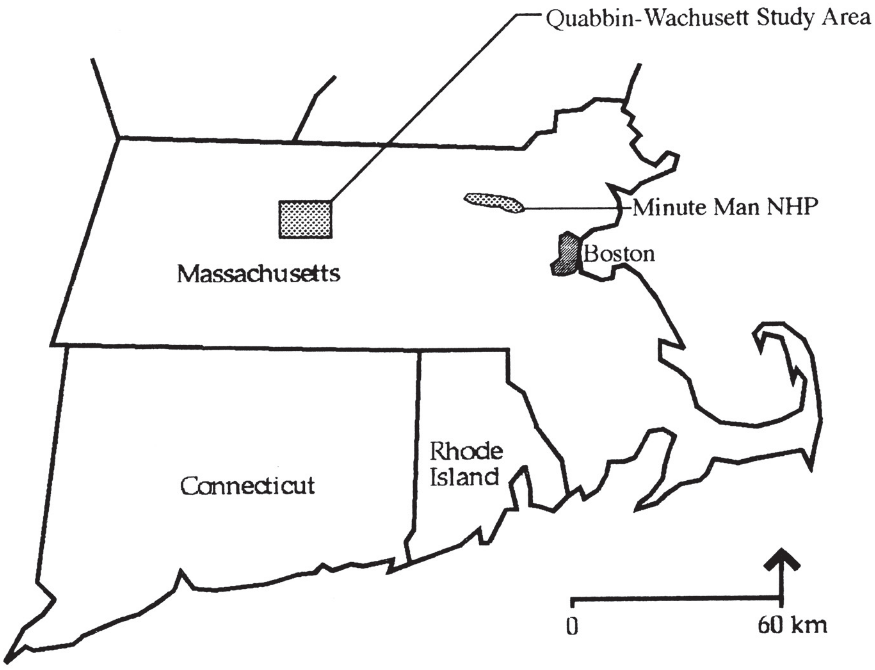

Figure 3.6 Context: Minute man National Historic Park and Quabbin to Wachusett Wildlife Corridor and Greenway, massachusetts, USA

of 1775 (Malcom 1985). In 1775 agricultural land use was dominant. Today, even after removing over 175 homes and businesses, the landscape is significantly different from 1775 because it is more forested now than in the colonial period. Figure 3.7 shows the change in forest cover and land use over the past three centuries. In the first phase of the MMNHP Cultural Landscape Management Plan, the suitability of MMNHP lands for agricultural reintroduction was assessed. The Park's General Management Plan recommends that the landscape be rehabilitated2 by reintroducing agricultural uses as a land use that reinforces the Park's primary period of significance - during the revolutionary war, circa 1775 (Figure 3.8). Factors considered in this assessment included soil capability class based on U.S. Soil Conservation Service mapping which identified the best lands for agricultural reintroduction, from a potential crop-yield standpoint. According to NPS policy, active agriculture located within a national park, must employ best management practices including integrated pest management. Next, wooded wetlands and rare species habitats were added as eliminative factors for agricultural reintroduction. Stone walls were also mapped as factors that might also influence or limit potential agricultural reintroduction.

The relevant factors were identified, mapped, and assessed based on explicit landscape planning criteria to arrive at recommendations for agricultural reintroduction (Gavrin et al 1993). However, conflicts were identified between historical interpretation objectives and contemporary agriculture and land use regulations. In the case of forested wetlands, which occur in the eastern half of the park, the issue of agricultural reintroduction became more complex. Under current regulations in Massachusetts, forested wetlands cannot be

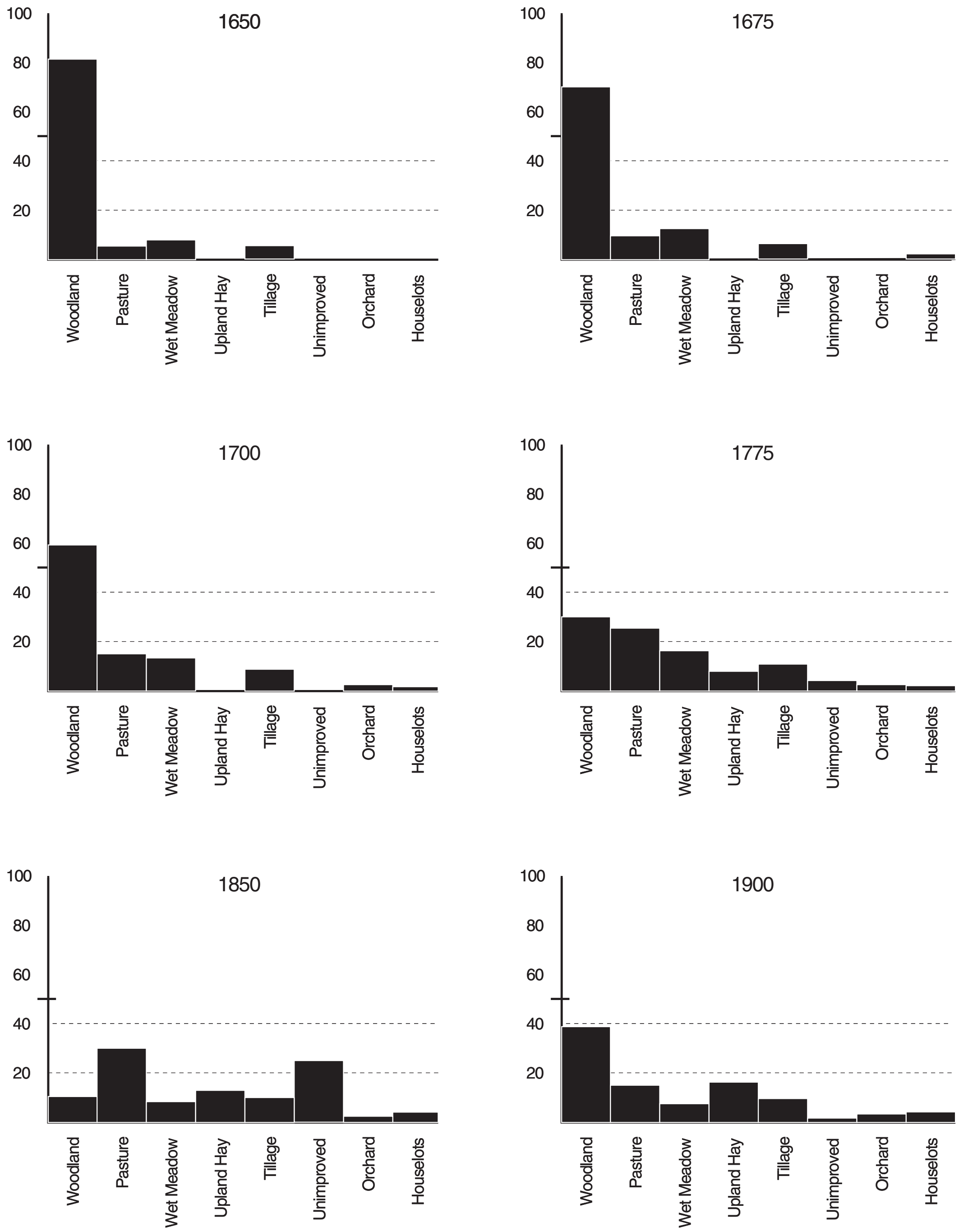

Figure 3.7 Historical land use changes, Minute Man National Historic Park (Donahue, 1993)

cleared for agriculture - even though these areas may have been used historically for agriculture. Further, in the case of Minute Man, a key to understanding colonial agriculture relates directly to the harvesting of hay from freshwater marshes. Because the fresh marshes were key elements of the agricultural landscape, and had profound effects on settlement patterns, they are essential to interpret from a cultural landscape perspective, yet they are

Figure 3.8 Active agriculture inside Minute Man National Historic Park, combining compatible uses in support of cultural landscape interpretation..

important linkages to maintain for the ecological components of the greenway plan.

The graphs in Figure 3.7 describe the mix of agricultural land uses typical of the years 1775, 1850 and 1900 respectively. They were generated from town-wide information such as census data and tax reports: however they are generalized data and not spatially specific. They are valuable, however, in showing the evolution of this agricultural landscape over time. Taken together as a series, they help to explain both change and continuity in a landscape that has been continuously settled for over 300 years (Donahue 1993, Cronon 1983). In addition to the history of the battle of April 19, 1775, the Park will have an opportunity to interpret the entire cultural and landscape history for over 3 centuries. In addition to these interpretive goals, the Minute Man Park will become more of a greenway through linkage with other trails and ecologically-significant corridors, for protecting and linking threatened and endangered species' habitats, and through increased recreational opportunities (Gavrin et al. 1993).

Evaluation

Typology

The Minute Man National Historic Park can be classified as a first order greenway, although

Figure 3.9 Synthesis of historical, agricultural and natural resources, Meriam's corner, Minute Man National Historic Park, Massachusetts, USA

it is well integrated with other greenways which collectively represent an emerging second order greenway system (Figure 3.2). The landscape context of the Minute Man greenway is low density suburban, with a significant percentage of the landscape in regenerated forest fragments. The strategies employed in the plan are diverse. The plan is protective in terms of its policy towards unique and threatened biological resources. It is offensive in terms of establishing new landscape types and linkages through habitat creation and modification. Perhaps the most notable strategy employed at Minute Man is its opportunistic aspect - in terms of re-conceptualizing a type of single-purpose outdoor landscape museum as a new model for integrating cultural, historical, recreational and ecological resources along a linear greenway corridor.

Transferability

Minute Man is a unique greenway, yet may be a precursor of future greenway opportunities. Its linear configuration derives from a cultural event of extremely short duration, yet now, more than two centuries later, it provides exceptional opportunities for cultural landscape interpretation, protection of biodiversity, recreation, and for sustainable agriculture as a strategy to maintain the historic character of the landscape. The plan for Minute Man has multiple goals but emphasizes cultural resources. It demonstrates the advantages of linking linear elements in terms of cultural landscape interpretation, biodiversity management, and recreation. Minute Man provides a new way of thinking about greenways, of deliberately stretching the scope of a single-purpose cultural landscape planning project, to consider the full range of greenway possibilities and to demonstrate the distinct synergy that is often present in landscape corridors, especially when they are linked with others to form a greenway network. In concept, this multiobjective, opportunistic approach to greenway planning is not place-specific and therefore largely transferable.

Case Study 3: Quabbin to Wachusett Wildlife Corridor and Greenway

This study describes a research project conducted by the Department of Landscape Architecture and Regional Planning at the University of Massachusetts, Amherst in collaboration with Massachusetts Audubon Society, interested in extending their conservation planning efforts beyond isolated wildlife refuges to make larger scale connections across heterogeneous landscapes. In the course of the project, other greenway objectives were added to this initial biodiversity-orientated project.

The study area is located in the USA in Central Massachusetts, between the Quabbin Reservoir and Wachusett Mountain Reservation, two of the largest public land holdings in Massachusetts (Figure 3.6). The study area includes approximately 1000 square kilometers, including numerous conservation areas in public, private, and not-for-profit ownership. The area was selected as a greenway planning prototype for the following five reasons: 1) it represents one of the best opportunities to establish a forest-based wildlife corridor network in Massachusetts because it is presently 80% forested, which is 20% above the state average, 2) the area's high percentage of protected lands (35% versus 10% statewide), 3) the location on an expanding urban fringe of Boston - the northern end of the BosWash megalopolis (Gottman 1961), 4) a representative land use mix of rural Massachusetts, and, 5) sufficient area to include several drainage basins, thus challenging planning to provide inter-basin corridor linkage.

Planning a greenway network through a diverse landscape requires certain assumptions. If the habitat requirements of all wildlife species were protected, it is most likely that the landscape would need to be vacated by people. In response, this study adopted an indicator species approach. Indicator species are those which are assumed to represent larger complexes of species dependent on particular ecosystems (Pace 1991). Although widely used in wildlife research and planning, the indicator species concept has been criticized because it fails to address inter-species competition and differential response to habitat changes (Smith and Hellmund 1993). This study accepted the recommendation of the Massachusetts Audubon Society's wildlife biologists to use the river otter, Lutra canadensis, and the fisher, Martes pennanti, as representative indicator species (Mass. Audubon 1988,

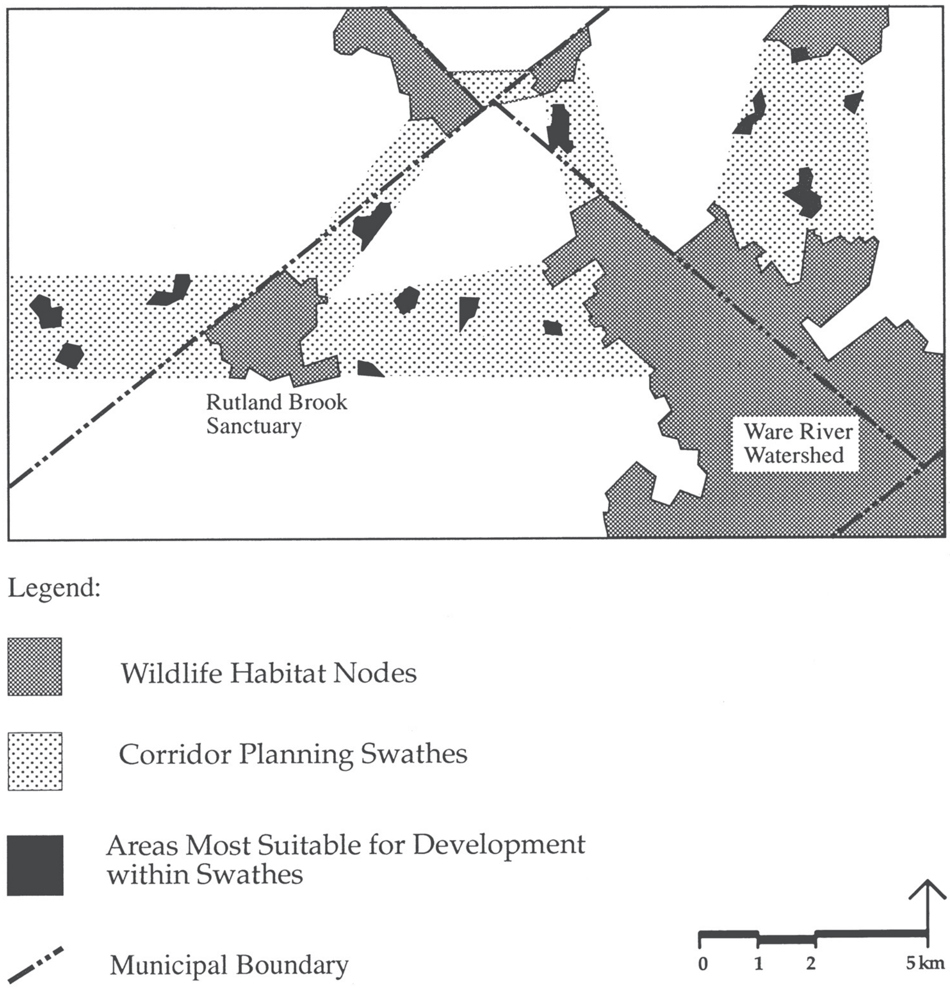

Figure 3.10 Target area: habitat nodes and corridor swathes

1989). Both species are fragmentation-intolerant and have relatively specific and complementary habitat requirements - the river otter in riparian environments and the fisher mostly in upland habitats. Since both species are high level carnivores, their presence affirms the existence of a complex food chain, another important environmental indicator. Finally, both species have extensive home ranges, thus necessitating movement corridors. It is therefore assumed that establishment of an otter-fisher wildlife corridor network would be inclusive of many other species habitats.

A landscape approach was used to assess habitat suitability for the two indicator species selected. Fisher habitat consists of continuous-canopy upland forests with a mix of hardwood and softwood species (Allen, 1983). Otter habitat consists of stream corridors bordered by forested land (Allen, 1985). This habitat assessment in turn was compared with existing conservation lands to derive a relative habitat value for the otter and fisher. This step effectively defined and rated the nodes of the wildlife corridor network. Next, broad planning zones or swathes, were defined linking the nodes with the highest habitat value (Figure 3.10). Within the swathes, the actual corridors would subsequently be located. The swathe approach promotes a more focused evaluation of potential corridor configurations within a broad corridor linking two important nodes. A more complete discussion of this methodology can be found in Smith (1993) and Ahern (1994).

The interests and values of people must be understood as part of the greenway planning process. The premise of the socio/cultural component of the study was that integration of the perceptions, interests and values of the landscape's inhabitants should be integral to decisions regarding the use and management of the landscape. Interviews with area residents, visitors, key informants and others professionally involved with the study area were conducted. Key informants were identified with the aid of regional and local land use and planning professionals. The goal of this research was to identify who lives in the region, what their views on land use issues are, and how they are organized to represent these interests (Berger 1978). A key element of this research was the mapping of the discrete areas of land use interest of the individuals and organizations interviewed. In the larger study of which this case study is only a part, a suffer:benefit analysis was conducted which informed the development and evaluation of scenarios (LARP 1990).

Protection of visual resources is important to the residents of the study area, and was considered as an integral part of the greenway planning process. The premise of this part of the study is that by integrating an assessment of visual resources in the greenway planning process, multiple planning objectives can be realized. If people are convinced that the wildlife corridors will help to maintain their image of rural quality, they are more likely to support the concept. This hypothesis was tested through a review of visual assessment literature and the application of an assessment method that identified prominent landscape features, and confirmed through interviews which were part of the social/cultural resource assessment. The findings of the assessment clearly defined large open areas which contrasted with surrounding wooded areas, bodies of water, and upland ridges as prominent landscapes. This assessment was later used to evaluate concurrence between the proposed corridors and visually significant lands to verify the hypothesis that wildlife corridors and protection of scenic landscape resources are compatible goals (LARP 1990).

Next an assessment of development suitability was made. The premise behind this assessment was that wildlife corridors can be integrated into a landscape without unduly prohibiting development. The procedure developed for assessing development suitability is an exclusionary one based on the METLAND landscape planning model (Fabos et al. 1978). After eliminating several categories of unique, scarce and rare resources, the remaining lands are assessed for their relative development suitability based on desirability factors including, proximity to existing roads, and favorable microclimate and views.

Upon completion of the four-part assessment of landscape planning issues, the study changed scales to plan actual wildlife corridors within the target area. A representative corridor swathe was selected for this more detailed investigation (Figure 3.10). The first step in planning the actual corridors was to evaluate conflicts with development, based

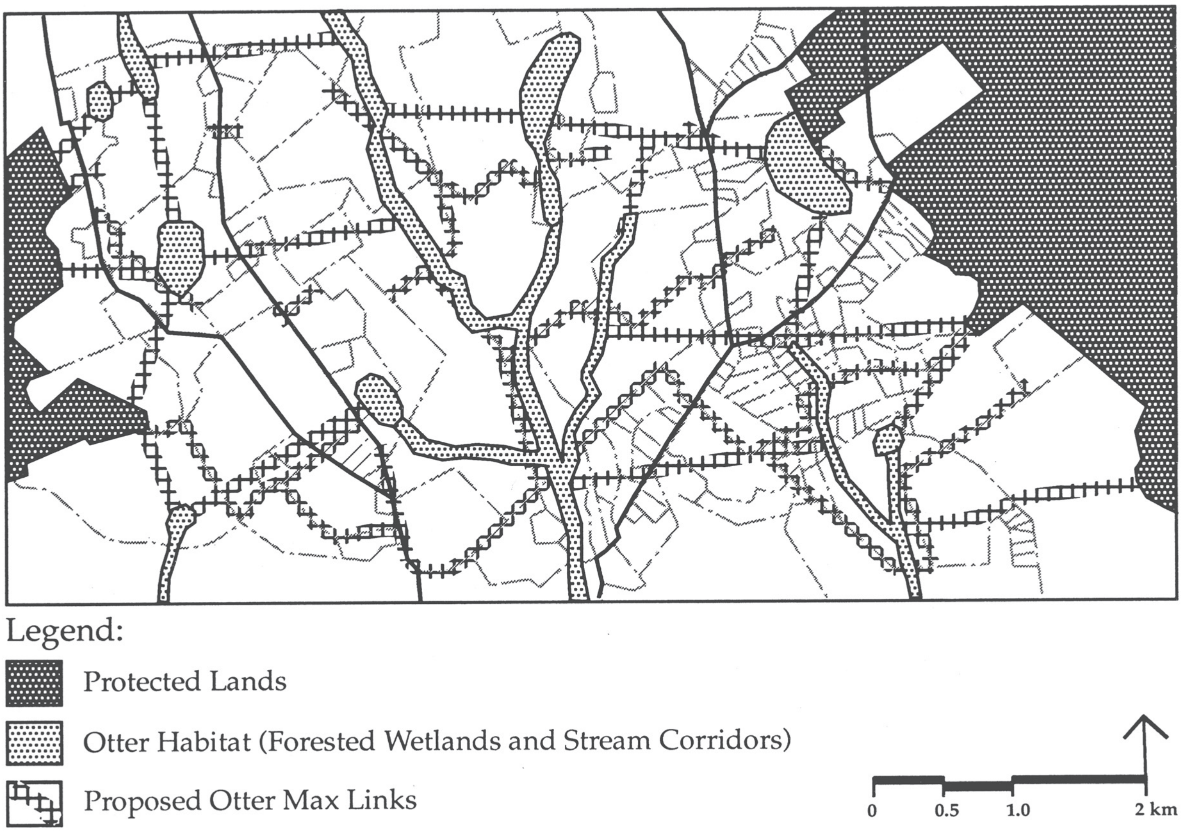

Figure 3.11 Otter max scenario

on the preceding assessment of development suitability. This analysis clearly indicates the feasibility of establishing a corridor within the swathe without significant impact on the development potential.

At this point in the study another change in scale became necessary. In order to realistically evaluate the feasibility of corridor options, property boundary information was added to the data base. Since this information was difficult to obtain, a reduction in the area of the target area was made to that of an individual swathe (Figure 3.11). At this scale, specific barriers and assets to wildlife corridor linkages were identified and specific corridor alternative scenarios were generated. The study developed criteria to generate and evaluate two distinct corridor networks conceived to represent fundamentally different values regarding wildlife habitat requirements and impacts on development potential. The scenarios thus are not represented as optimal planning solutions, rather they should be understood as two possible "corners of an abstract frame" within which a discussion of options can be more focused (Linehan et al 1995, Harms et al. 1993)

The first scenario named, "Otter Max", used wildlife habitat requirements as the main determinant for establishing corridor linkages (Figure 3.11). The second scenario, "Least Property Impact", emphasizes linkages between existing public and undevelopable land (Figure 3.12). Proposed corridors in this scenario follow existing property lines to minimize

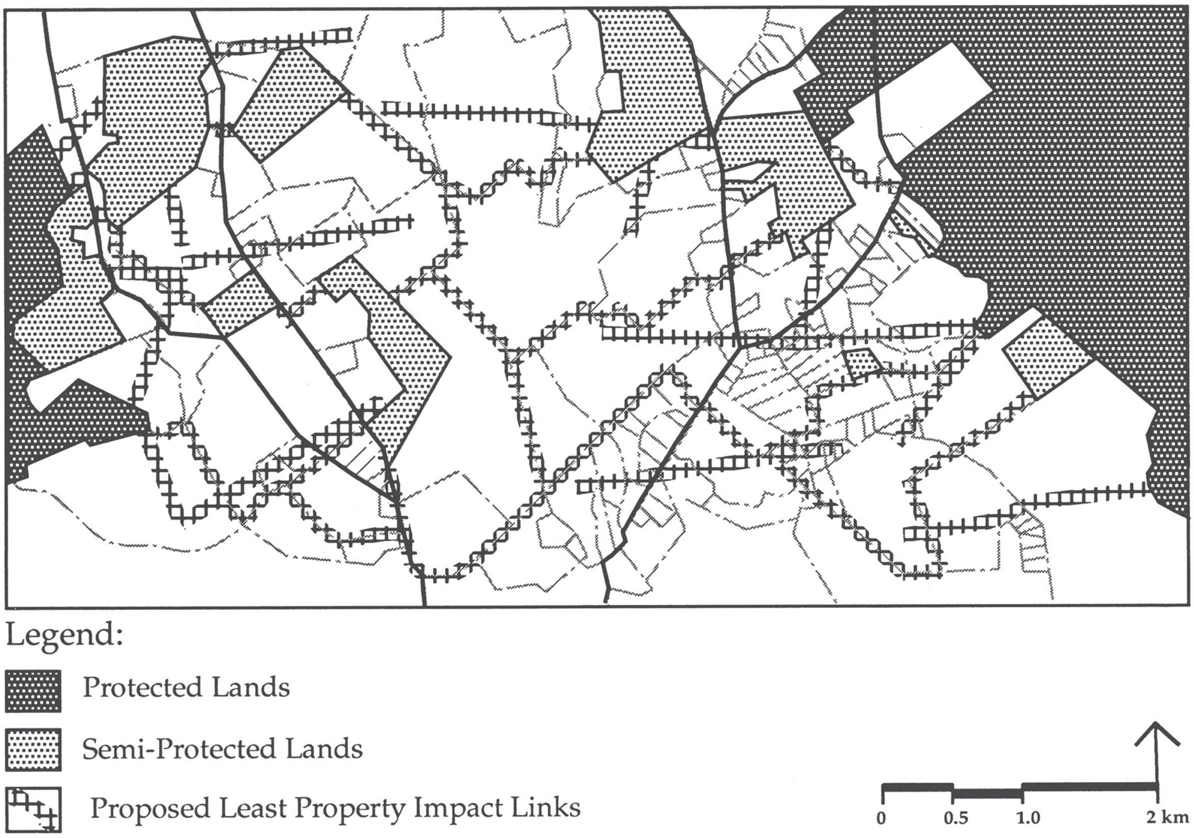

Figure 3.12 Least property impact scenario

disruption of land use on the parcels.

The two scenarios were then evaluated to compare their effectiveness from a wildlife habitat perspective, and their efficiency in terms of land use impact. Six measures were applied to evaluate the scenarios for efficiency and effectiveness; 1) total length, 2) percentage of suitable habitat, 3) percentage of already protected lands, 4) number of parcels crossed, 5) impact on development suitability, and 6) number of barriers crossed, (LARP, 1990). The "Otter Max" scenario was predictably more effective from a wildlife habitat perspective, with shorter and more direct linkages. The "Least Property Impact" scenario was most efficient in terms of the least number of parcels crossed, the least effect on parcels that are suitable for development, and the greatest amount of already protected land connected.

The two scenarios "Otter Max" and "Least Property Impact" represent two extremes of a continuum between a wildlife bias and a land use bias in greenway planning. Each option has its strengths and weaknesses as previously described. Neither option is represented as an actual plan or proposal, and of course, there is a real danger in viewing either as a viable plan. Just as the process described in this research argues for differential strategies and methods at different planning scales - so to are different issues raised when a scenario advances to a design scale at which implementation may be seriously considered. In this context a host of aesthetic issues are raised. What is the relationship of the network to the physical landscape? Is there a hierarchy to the proposed linkages, or should they be uniform? What is the relationship of this network pattern with other contemporary and historical landscape patterns?

This study does not specifically recommend either option, or any specific technique for implementation. Rather it envisions a continuing planning process in which the nature and configuration of the greenways is decided with input from wildlife ecologists, landscape planners, landscape architects and concerned/affected citizens (Hay 1991, Lyle and Quinn 1991). A geographical information system would facilitate accurate and impartial evaluation of compromise alternatives generated. The planning process has been designed with this in mind.

Evaluation

Typology

This greenway study can be classified as a second order greenway, with a first order implementation scenario. The goals are multiple, including all five of the goals described in this typology, but the biodiversity goal, as represented by two indicator species, is primary (Figure 3.2). The landscape context is an extensive regenerated forest, representing a special opportunity to realize a greenway through a protective strategy. Its functional orientation is coordination, in a research mode - to generate knowledge to influence the development of new greenway planning policies under which all of the planning strategies could be used.

Transferability

The Quabbin to Wachusett Wildlife and Greenway Corridor study describes a multi-objective greenway planning project with an emphasis on the biodiversity goal. Although it engages a particular landscape and two specific indicator species, the assessment and planning procedures were conceived to be generic and transferable. The study is structured by four themes which were the basis for assessment and subsequent scenario generation and evaluation; 1) biodiversity, based on the indicator species approach which has already been widely adopted in diverse landscape contexts, 2) socio/cultural, based on anthropological research methods which are also fundamental, 3) visual/aesthetic based on normative aesthetic values and preferences, and 4) development suitability based on the established METLAND procedures for assessment and plan formulation (Fabos 1986). Of the three case studies cited in this paper, this is the most comprehensive and multipurpose.

Just as the greenway concept can be seen as a framework for strategically guiding larger landscape decisions, case studies like this are useful models and frameworks for developing procedures appropriate to the scale, goals, context, and strategies appropriate for any given greenway planning project.

Discussion and Conclusions

This paper has addressed three greenway related objectives: to provide an inclusive definition, to propose a typology, and to apply the typology to selected greenway case studies. The paper's greenway definition provides a useful starting point to understand the breadth and variability of greenways. The central thesis presented is that greenways offer a promising planning strategy to address the challenge of making landscape planning sustainable, primarily through recognition of the unique characteristics and benefits associated with networks. Greenways should be considered as a complement to comprehensive landscape and physical planning, not as a replacement. Efforts should be made to protect other important landscapes that are not part of linear networks and for those elements that may not benefit from linkage or multiple use.

Under the proposed definition, greenways may vary according to: scale, goals, landscape context and planning strategies. The greenway typology presented offers an explicit basis for understanding similarity and variability among greenways. It facilitates clearer communication and knowledge exchange and thereby contributes to understanding the transferability of strategies, spatial concepts and goal decisions.

The case studies present three greenways which differ with respect to: scale, goals, landscape context and planning strategies. They collectively demonstrate the utility of the proposed greenway typology. Through which, the case studies can be understood more clearly and the issue of transferability can be addressed, at least at the conceptual level.

In terms of sustainable landscape planning, biodiversity is a most important greenway goal. If greenways are to be a key element of sustainable landscapes, biodiversity must be a dominant and fully integral component throughout the landscape planning process. While the value of biodiversity may be beyond dispute, the means for protecting it are still being hotly debated. The major threat to biodiversity in the world is the destruction of habitat through development (WCED 1987). While the biodiversity issue is often directed at such "hot spots" including tropical rainforests and other remote areas of the planet, it is no less important in the temperate zones of Europe, Asia and North America that support the greatest human populations in the world. It is in these megalopolitan landscapes that greenways offer a promising strategy to provide an ecological infrastructure that can provide a measure of stability within which biodiversity and dynamic natural processes may be managed allowing other greenway goals to be realized in a sustainable way.

If greenways are to legitimately support the concept of sustainable land use, they must also include social and cultural goals, not only those of environmental protection. Multiple use is central to the greenway concept. Just as greenways benefit from the connectivity inherent in networks, a synergy of multiple greenway goals is possible. If greenways are to become a part of twenty-first century cultural landscapes, they must integrate historic, cultural, aesthetic and recreational goals. In this way the basic abiotic patterns could provide a sustainable greenway framework upon which appropriate uses and management practices may be integrated.

Acknowledgements

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4 Greenways as ecological networks in rural areas

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Introduction

In this century, global land use trends and landscape planning strategies have changed in fundamental ways. While the nature of these changes varies geographically, common landscape effects may be defined. As land use is intensified; there is a decrease in landscape heterogeneity and an increase in fragmentation of the landscape. Both of these effects have negative biotic and abiotic consequences on the landscape. An international consensus to these global land use trends seeks a more "sustainable landscape" condition, in which the needs of the present are met without compromising the ability of future needs to be met (WCED 1987, IUCN 1980). This challenge to plan for sustainable landscapes has, in part, inspired a dialogue between ecologists and landscape planners within the discipline of landscape ecology (Vos and Opdam 1993).

A conceptual consensus is emerging from this dialogue suggesting that future landscapes be spatially structured by a "patch and corridor" model which includes corridors and stepping stones to connect isolated patches and thus mitigate the effects of fragmentation (Harris and Gallagher 1989, Noss 1993). This model is based primarily on island biogeography and metapopulation theories. These theories attempt to explain the patterns and processes affecting wildlife species in fragmented landscapes (MacArthur and Wilson 1967, Opdam et al. 1993, Opdam 1990).

In most of the world, it is not possible or appropriate to implement "patch and corridor" plans solely intended for the protection of biotic resources because of competing land use demands. In the world's cultural landscapes, a multi-purpose conservation network or greenway planning approach is more appropriate (Flink and Searns 1993, Houck 1991, Little 1990, Smith and Hellmund 1993). In this research greenways are defined as connected systems of protected lands that are managed for multiple uses including; nature protection, recreation, agriculture, and cultural landscape protection. Because of the multifunctional nature and emphasis on connectivity, greenways require a landscape planning approach which should be multidisciplinary, and with a high level of public involvement. The key challenges for greenway planning are to first establish the importance of landscape connectivity and to demonstrate alternative ways of combining compatible uses, and of separating incompatible uses. In this way, greenway planning and design becomes a form of post-modern consensus building among many constituent interests (Meeus and Vroom 1986).

In a participatory planning process, it is often desirable to generate scenarios which illustrate the consequences of the values represented, or the assumptions made in the planning process. These scenarios will also provide a basis for discussion among the various disciplines and interests represented or affected by the plan. The scenarios may then be evaluated against multiple criteria (e.g. spatial, ecological, economic, visual). New tools are needed to conduct the preliminary assessments, to generate scenarios and to evaluate them against the appropriate criteria. With the benefit of digital spatial data bases, geographical information systems can provide the basic functionality required to support a participatory planning process (Burrough 1986).

It is the thesis of this research that greenway planning should be integral to a comprehensive landscape planning effort, including consideration of development suitability, open space resources, wildlife species protection, and scenic resource management. In this larger context greenways may be seen as the connecting elements in a network which links protected lands. The chapter reviews the relevant literature from landscape ecology and landscape planning, and applies a method for multifunctional greenway planning to a case study in. Central Massachusetts, USA. Greenway implementation strategies and techniques are discussed in terms of their effectiveness and appropriateness for the two scenarios generated.

Landscape ecology and greenway planning

A basic premise in the resource assessments conducted is that principles from landscape ecology can inform intelligent land use planning decisions by articulating the link between the landscape structure and its associated functions, across a range of spatial and temporal scales.

In the past decade, the field of landscape ecology has established itself in the USA, primarily in the biological sciences. The European academic and land-use planning professional communities realized the potential value of the landscape ecological perspective years ago and have applied it successfully to a large number of local, regional, and national planning policies (Schreiber 1990). Landscape architects and regional planners are currently discovering the potential utility of the landscape ecological perspective to contemporary planning and design projects in the USA (Forman 1990a).

A main area of concern in landscape ecology is that of landscape function. Forman and Godron (1986) define landscape function as "the flow of energy, species and nutrients" between landscape elements. These flows are both "natural" and human-induced and provide a useful tool for evaluating the consequences (i.e. landscape function) of land use changes (i.e. landscape structure). Finally, the landscape ecologist views these relationships in a dynamic context, as part of a changing landscape, or a shifting mosaic of land use patterns (Forman, 1990b). The explicit recognition of the concept of landscape change through various forms of disturbance, including the role of humans is somewhat unique to landscape ecology among the ecological sciences.

Although the principles of landscape ecology hold great promise for landscape planning they have yet to be widely applied in the USA for two reasons. First, landscape ecology is an emerging field that is still in the process of achieving self-identity. Secondly, most of the active landscape ecologists in the USA are from the biological sciences and have yet to fully embrace the concept and practice of applied research, as practiced by landscape architects and planners.

Procedures for the assessment of biophysical, social/cultural, visual-aesthetic, and development suitability resources/concerns of the study area landscape were developed and implemented using a geographic information system (GIS). These assessments were based on published literature and were tested on portions of the study area at various scales. Supplemental original data was collected and used in the assessments to generate more locally-meaningful results. These assessment procedures were independently conducted and mapped, then compared through spatial overlay to determine patterns of congruence and conflict among the various land use interests.

Case Application: Quabbin Reservoir to Wachusett Mountain Reservation

This research was conducted in collaboration with Massachusetts Audubon Society, a prominent private sector conservation organization. Audubon is interested in extending their conservation planning efforts beyond isolated refuges to make larger scale connections across heterogeneous landscapes.

The study area is located in the USA in Central Massachusetts, between the Quabbin Reservoir and Wachusett Mountain Reservation, two of the largest public land holdings in the state (Figure 4.1). The study area includes approximately 1000 square kilometers, including numerous conservation areas in public, private, and not-for-profit ownership. The area was selected for the following five reasons: 1) it represents one of the best opportunities to establish a forest-based wildlife corridor network in Massachusetts because it is presently 80% forested, 20% above the state average 2) it has a high percentage of conservation lands 3) it is on the expanding urban fringe yet still relatively intact as a forest matrix, 4) it provides a representative land use mix, and 5) it includes an east-west area sufficient to include several drainage basins, thus challenging planning to provide inter-basin corridor linkage. Within the study area a smaller target area was identified for more intensive and detailed analysis (Figure 4.1). This area was selected to represent the biophysical and cultural diversity of the study area. The majority of the research discussed in this paper was performed at the target area scale (Ahern et al. 1992, LARP 1990).

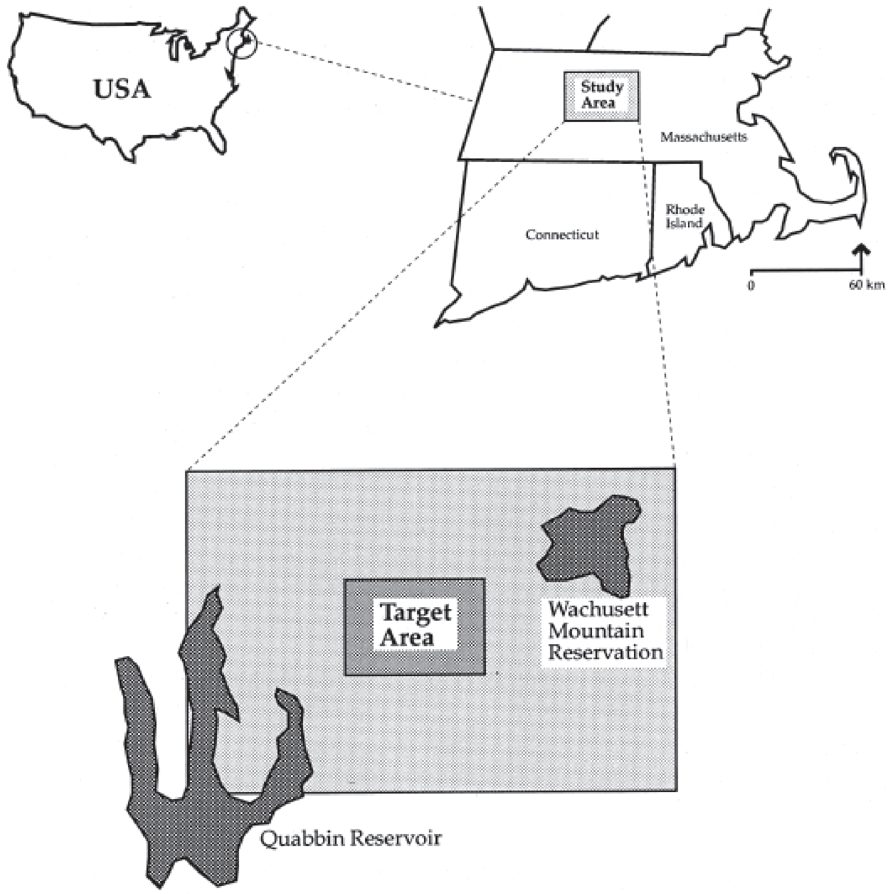

Figure 4.1 Context: Quabbin Reservoir to Wachusett Mountain Reservation study and target areas

Planning a greenway network through a diverse landscape requires making certain assumptions (Smith 1993). If the habitat requirements of all wildlife species were protected, it is most likely that the landscape would need to be vacated by people. In this study an approach based on indicator species was adopted. Indicator species are those which are assumed to represent larger complexes of species dependent on particular ecosystems (Pace 1991). Although widely used in wildlife research and planning, the indicator species concept has been criticized because it fails to address interspecies competition and differential response to habitat changes (Verner 1984 in Smith and Hellmund 1993). This study accepted the recommendation of the Massachusetts Audubon Society's wildlife biologists to use the river otter, *Lutra canadensis*, and the fisher, *Martes pennanti*, as representative indicator species (Mass. Audubon 1988, 1989). Both species are fragmentation-intolerant and have relatively specific and complementary habitat requirements - the river otter in riparian environments and the fisher mostly in upland habitats. Since both species are high-level carnivores, their presence indicates the existence of a complex food chain, another type of environmental indicator. Finally, both species have extensive home ranges, thus necessitating movement corridors. It is thus assumed that would be inclusive of establishment of an otter-fisher wildlife corridor network would be inclusive of many other species habitats.

A landscape approach was used to generate an evaluation habitat suitability for the two indicator species selected. Fisher habitat consists of continuous-canopy upland forests with a mix of hardwood and softwood species. In addition, fishers prefer to travel along ridgelines (Allen 1983). Otter habitat consists of stream corridors bordered by forested land (Allen 1985). Habitat suitability for both species was assessed on the GIS and aggregated as combined habitat suitability. This assessment in turn was compared with existing conservation lands to derive a relative habitat value for the otter and fisher. This step effectively defined and rated the nodes of the wildlife corridor network. Next, broad planning zones, or swathes, were defined linking the nodes with the highest habitat value. Within the swathes, the actual corridors would subsequently be located. The swathe approach promotes a more focused evaluation of potential corridor configurations within a broad corridor linking two important nodes. Zooming-in to a swathe is a useful method for changing scales to a pre-selected target, while maintaining an important functional link with the larger scale. A more complete discussion of this method can be found in Hellmund (1993).

Resource assessments for collateral benefits

Social-cultural resources

It is ironic that word ecology is increasingly used to refer only to the abiotic and biotic elements of the landscape. This bio-centric approach is prevalent especially among professionals with a strong environmental bias. While this perspective may be useful in certain disciplines that deal exclusively with the physical environment, it has limited utility with respect to comprehensive landscape and land use planning. The interests and values of people must be understood as part of the greenway planning process.

The premise of the socio/cultural component of the study was that integration of the perceptions, interests and values of the landscape's inhabitants should be integral to decisions regarding the use and management of the landscape. These perceptions, interests, and values are represented by formal and informal organizations with specific areas of interest that have distinct spatial definition. Interviews with area residents, visitors, key informants and others professionally involved with the study area were conducted. Key informants were identified with the aid of regional and local land use and planning professionals. The goal of this research was to identify who lives in the region, what their views on land use issues are, and how they are organized to represent these interests

(Berger 1978). A key element of this research was the mapping of the discrete areas of land use interest of the individuals and organizations interviewed. In the larger study of which this paper is only a part, a suffer:benefit analysis was conducted which informed the development and evaluation of scenarios (LARP 1990).

Visual-aesthetic resources

Protection of visual resources is important to the residents of the study area. The premise of this part of the study is that by integrating an assessment of visual resources in the greenway planning process, multiple planning objectives can be realized. If people are convinced that the wildlife corridors will help to maintain their image of rural quality, they are more likely to support the concept. This hypothesis was tested through a review of visual assessment literature and the application of an assessment method that identified prominent landscape features, and confirmed through interviews which were part of the social/cultural resource assessment (see above). The assessment was primarily based on topographic relief, openness, water features and edge complexity. These visual attributes were further ranked based on their susceptibility to change. The findings of the assessment clearly defined large open areas which contrasted with surrounding wooded areas, bodies of water, and upland ridges as prominent landscapes. This assessment was later used to evaluate concurrence between the proposed corridors and visually significant lands to verify the hypothesis that wildlife corridors and protection of scenic landscape resources are compatible goals (LARP 1990).

Development suitability

The premise behind this assessment was that wildlife corridors can be integrated into a landscape without unduly prohibiting development. The following landscape planning principles guided this assessment:

1. Development should be discouraged in areas of significant resource value.
2. Development should be discouraged in areas of natural and human-caused hazards.
3. Development should be encouraged in areas best suited for it.

The procedure developed for assessing development suitability is an exclusionary one based on the METLAND Landscape Planning Model (Fabos et al. 1978), (Figure 4.2).

In the first Phase, already developed and restricted lands are eliminated from further consideration. In Phase Two, critical resources including aquifer recharge areas, prime agricultural soils and sand and gravel deposits are identified for protection or preservation. Phase Three identifies landscape hazards such as floodplains, unsuitable slopes, and unsuitable soils and recommends prohibition of development. In Phase Four, all remaining

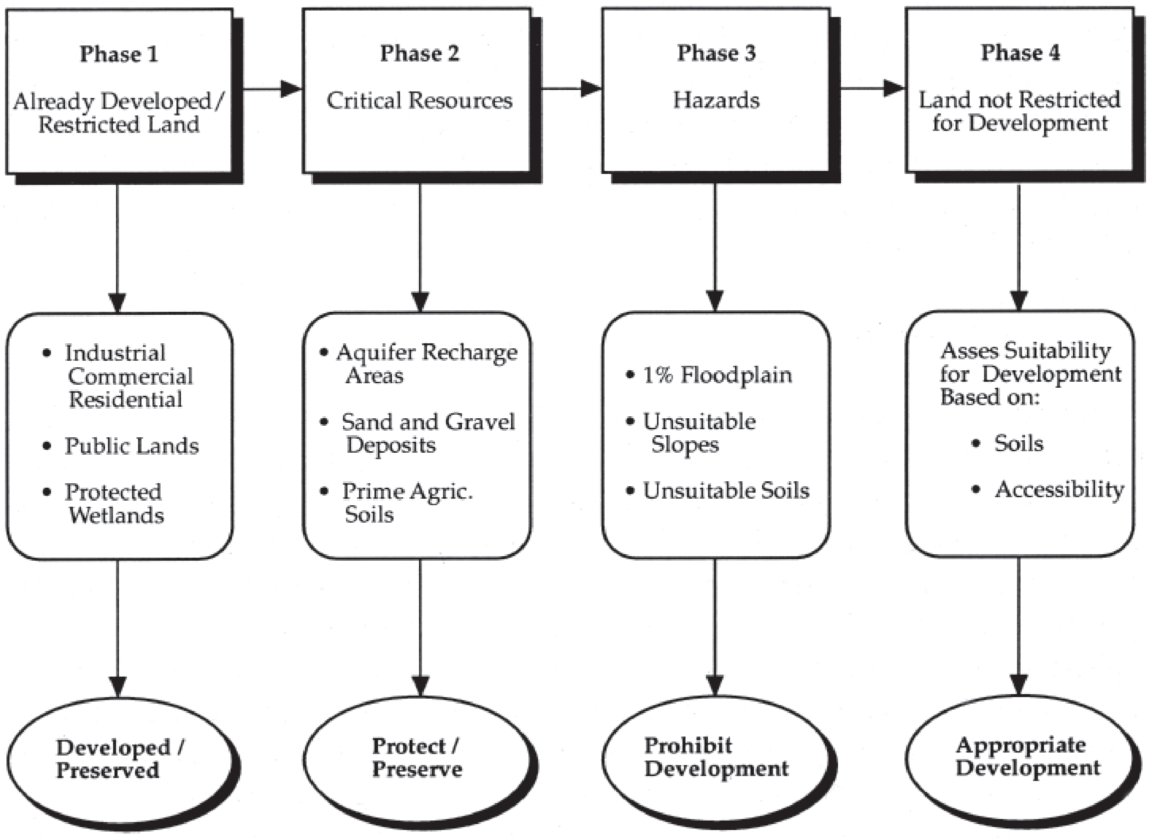

Figure 4.2 DevelopmentsSuitability method

lands are rated for development suitability based on soils and accessibility. This procedure was adapted; because it is based on reasonable and defensible environmental values; for its ease of comprehension by the public, and because it can be replicated or modified easily with a GIS.

Planning the greenway network

Upon completion of the four-part assessment of landscape planning issues, the study changed scales to plan actual wildlife corridors within the target area. A representative corridor swath was selected for this more detailed investigation. As diagrammed in Figure 4.3, the swathes were established based on a rating of existing conservation lands for wildlife habitat as well as for barriers to the corridors. The swath selected for this research was located between Rutland Brook Sanctuary, a Massachusetts Audubon property, and the Ware River Watershed area, managed by The Metropolitan District Commission in Boston. The first step in planning the actual corridors was to evaluate conflicts with development, based on the preceding assessment of development suitability (Figure 4.3).

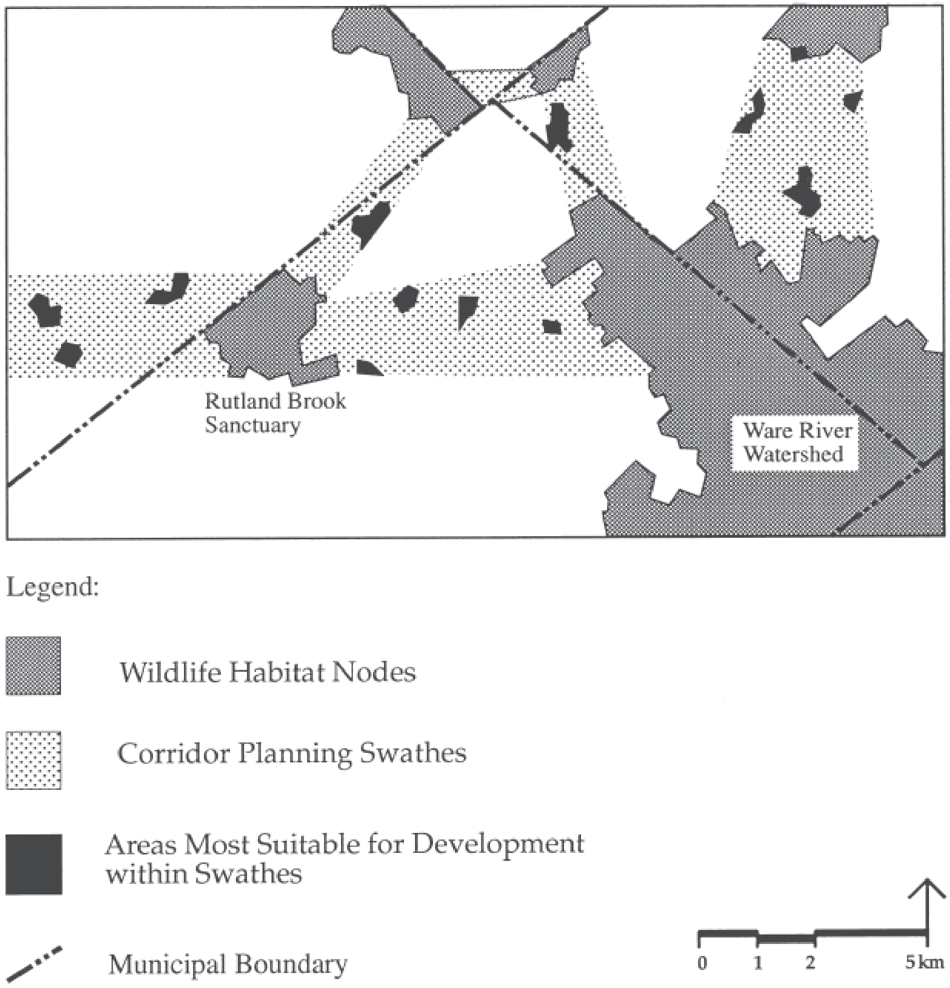

Figure 4.3 Target area, nodes, and development suitability conflict

This analysis clearly indicates the feasibility of establishing a corridor within the swathe without significant impact on the development potential.

Wildlife corridor linkage scenarios

At this point in the study another change in scale became necessary. In order to realistically evaluate the feasibility of corridor options property boundary information was added to the data base. Since this information was unavailable from the Massachusetts Geographical Information System (MassGIS) the study manually digitized the data from tax assessors maps. This procedure was highly labor intensive and necessitated a reduction in the area of the target area to that of an individual swathe (Figures 4.4 and 4.5). At this scale, specific barriers and assets to wildlife corridor linkages were identified and specific corridor

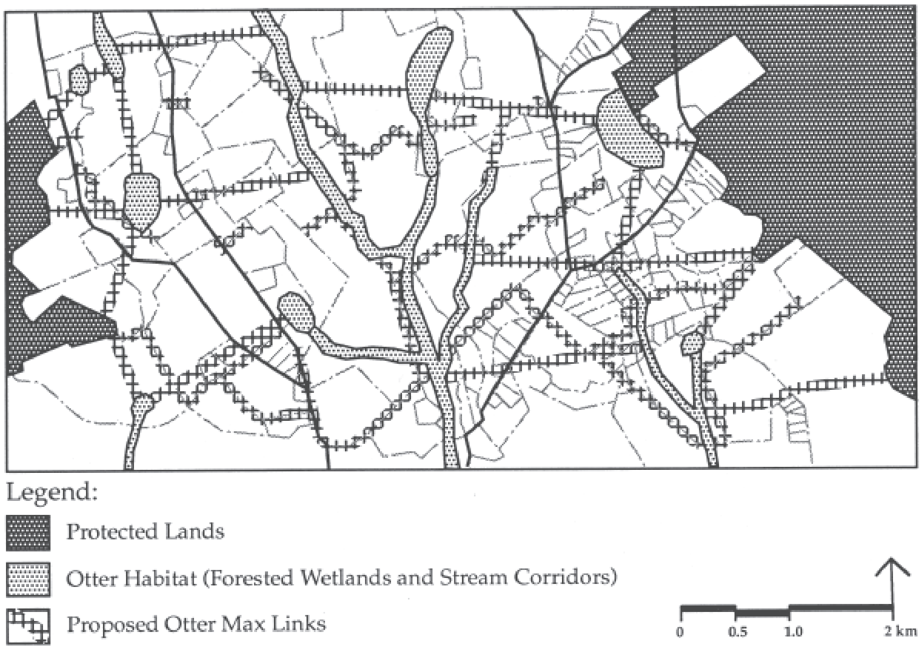

Figure 4.4 Otter max scenario

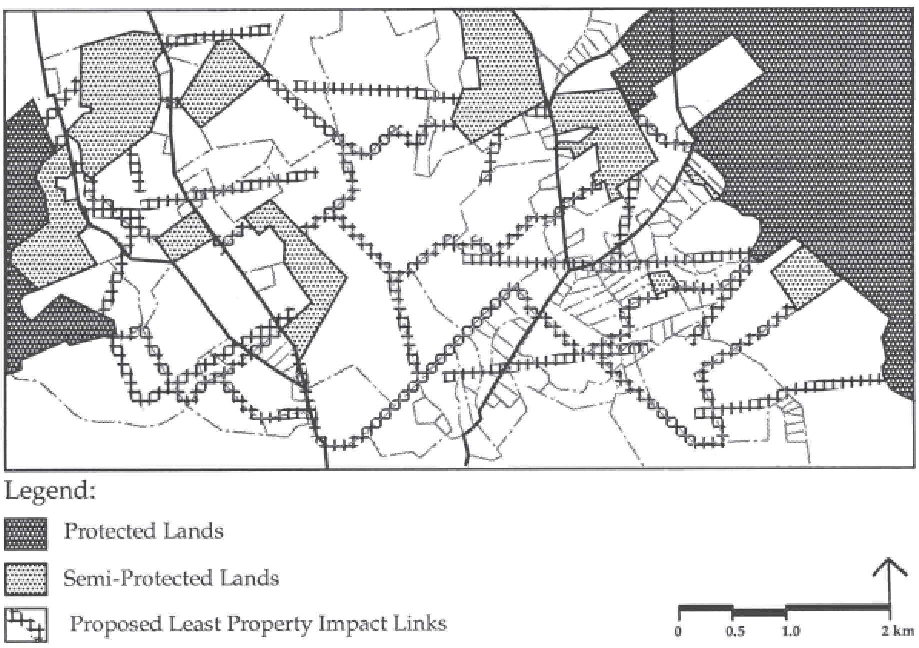

Figure 4.5 Least property impact scenario

alternative scenarios were generated. The study developed criteria to generate and evaluate two distinct corridor networks conceived to represent fundamentally different values regarding wildlife habitat requirements and impacts on development potential. The scenarios thus are not represented as optimal planning solutions, rather they should be understood as two possible "corners of an abstract frame" within which a discussion of options can be more focused (Harms et al. 1993).

From the outset, the study was based on two indicator species with complementary habitat requirements: the otter as a riparian species and the fisher as an upland species. Corridors for otters predictably follow stream corridors and can be easily identified an mapped on the GIS. Habitat requirements for fisher are far more fuzzy, especially in the study area where vast areas of suitable upland habitat exist (i.e. mixed hard and softwood forests with continuous canopy). While otter habitat can be linked through the surface drainage network, it also should contain inter-basin connections. These connections could enable otters to migrate across the north-south grain of the landscape by way of minimal-distance upland connections between tributaries of separate drainage basins. The inter-basin connections could also promote more genetic exchange between distinct otter populations and thereby contribute to species protection in a more sustainable manner (Noss and Harris 1986, Soulé and Simberloff 1986). Both of the scenarios generated include inter-basin connections, which are assumed to facilitate the needs of both indicator species, and by assumption many other associated species.

The first scenario used wildlife habitat requirements as the main determinant for establishing corridor linkages. The wildlife habitat Otter Max linkages map (Figure 4.5) emphasized wildlife habitat over property boundaries. The Otter Max scenario assumes that the drainage network is a given in the greenway by virtue of wetlands and floodplain regulations that effectively designate the riparian corridors for conservation purposes only.

The Otter Max linkages were based on the following assumptions and criteria:

1. Assume that all streams and wetlands are protected
2. Use the shortest routes between habitat areas
3. Provide inter-basin linkages
4. Avoid barriers if possible
5. Establish a minimum of three routes to mitigate against future disturbance of linkages, i.e. corridor reserves.

The second scenario, Least Property Impact, emphasizes linkages between existing public and un-developable land (Figure 4.5). Proposed corridors in this scenario follow existing property lines to minimize disruption of land use on the parcels. The linkages were based on the following assumptions and criteria:

1. Assume that permanent control is obtained over lands which are now only semi, or temporarily protected.
2. Do not assume that all streams and wetlands are protected.
3. Straddle existing parcel lines to minimize private property impact.
4. Connect existing protected and un-developable lands.

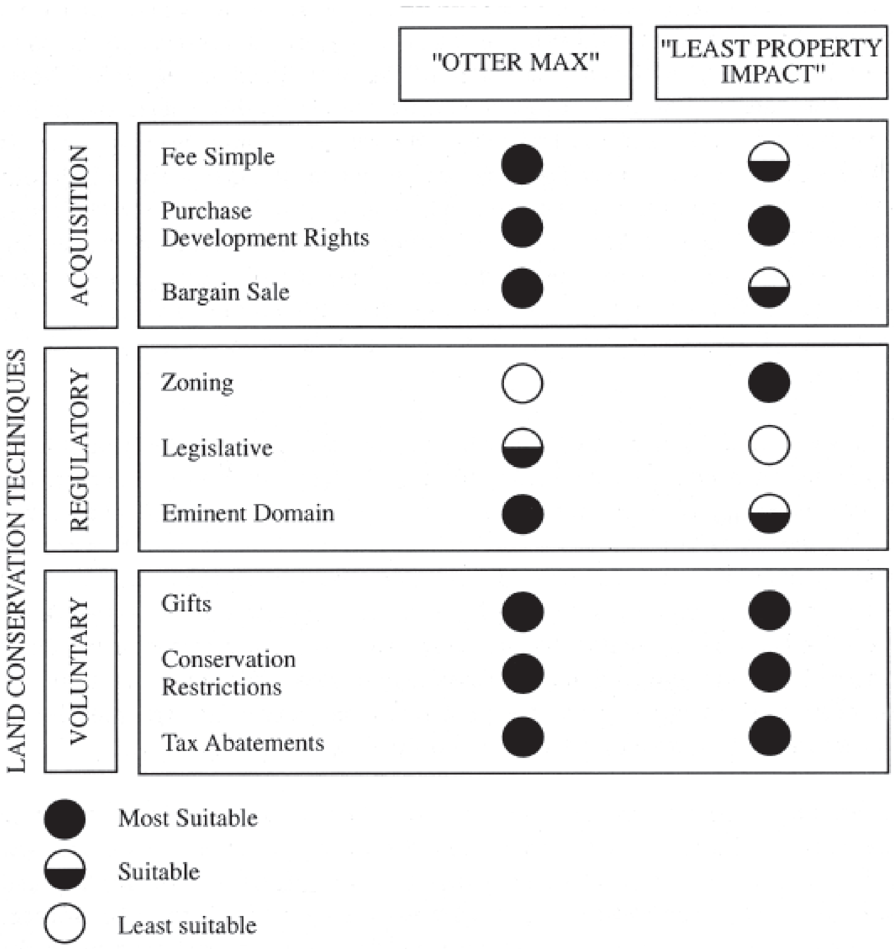

Figure 4.6 Suitability of land conservation techniques for greenway implementation

5.Avoid barriers if possible.

6.Establish a minimum of three routes to mitigate against future disturbance of linkages, i.e. corridor reserves.

In both cases the wildlife corridors were planned at 100M wide, based on existing literature and consultation with wildlife experts (Allen 1983,1985, DeGraff and Rudis 1983). To help to assure the success of the IOOM corridor, a 15M limited-use buffer was proposed for both sides, effectively increasing the width to 130M. This buffer is intended to provide for multiple use of the corridor for recreational trails and as a visual buffer - thereby contributing to a public consensus of support. The buffers also create opportunities for vegetation management which may enhance the ecological value of the corridor, from a wildlife habitat perspective (Ahern 1991, Ranney 1981). The 130M width was used in both scenarios. The determination of corridor width was, of necessity, somewhat arbitrary. The state of knowledge in landscape ecology is not advanced to the point of providing definitive planning standards of this sort (Budd et al. 1987, Noss 1993). Until the state of knowledge can be more specific on this matter, and in lieu of the lack of locally specific knowledge, an adaptive management approach is recommended in which policy decisions are structured as experiments which will contribute to the generation of new knowledge to inform future policy (Hollings 1978, Walters 1986). If these corridors are implemented as proposed, monitoring should be performed to verify the effectiveness of the corridors and contribute new knowledge for future refinements. In this case, the 130M corridor and buffer, is an assumed to be arbitrary but reasonable planning decision based on existing knowledge.

The two scenarios were then evaluated to compare their effectiveness from a wildlife habitat perspective, and their efficiency in terms of land use impact. Six measures were applied to evaluate the scenarios for efficiency and effectiveness; 1) total length, 2) percentage of suitable habitat, 3) percentage of already protected lands, 4) number of parcels crossed, 5) impact on development suitability, 6) number of barriers crossed, (LARP, 1990). The Otter Max scenario was predictably more effective from a wildlife habitat perspective, with shorter and more direct linkages. The Least Property Impact scenario was most efficient in terms of the least number of parcels crossed, the least effect on parcels that are suitable for development, and the greatest amount of already protected land connected.

Interestingly, both scenarios were equal with respect to the number of major roads crossed. These crossings are unavoidable in any inhabited landscapes, and require some form of viaduct or underpass to avoid greenway discontinuity and road-kills. Through careful planning, the number of these crossings may be reduced. Where the crossings are necessary and unavoidable, there is special opportunity for a more meaningful or symbolic design response. If a wildlife viaduct is conceived as a metaphor for the interaction of humans with their environment, it becomes something more than a simple physical solution to the problem. The world's great bridges do more than get traffic across rivers, they represent a special expression of aesthetics, nature, technology and culture - they have become important symbols and icons. If wildlife viaducts are designed in this manner they may cause people to appreciate the need for the wildlife habitat network or to reflect on the basic human:nature relationship.

Tools and options for implementation of the greenway network

The two scenarios generated can be easily differentiated in terms of their efficiency and effectiveness. Each has specific impacts on wildlife habitat and land use potential. In order to implement either of these scenarios, ownership or regulation of the corridor lands is essential. In deference to shrinking public funding sources for conservation acquisition, the study examined a broad range of land conservation techniques for implementing the greenway (NPS 1992). These techniques can be generally classified into acquisition, regulation, and voluntary options (Figure 4.6). The techniques identified are:

Acquisition techniques

Fee simple

Assuming adequate financial resources and a willing seller, any public or private interest can purchase land outright and maintain it as a wildlife habitat area. This is perhaps the most effective and permanent technique, but also the most expensive. In light of decreasing funding for land acquisition, fee simple acquisition should be used with great discretion, and only for exceptionally important parcels, or when no other options are available.

Purchase and lease back

A substantial subsidy for land acquisition can be realized through this technique. It requires a lease after purchase that will assure land uses compatible with the conservation objectives. This technique has tax benefits that are attractive to certain landowners and has been widely used in agricultural preservation programs in the USA.

Bargain sale

If an land owner is willing to sell his land to a governmental agency or conservation organization at below market rate, the landowner can deduct the difference between bargain rate and market rate from income tax. Bargain Sale is also considered as a voluntary technique (see below).

Regulatory techniques

Zoning

In most of the USA, municipal governments are empowered to regulate local land use through zoning. Towns in the study area could target suitable lands for a wildlife corridor network within the context of an overall master plan. Zoning could then specify appropriate lot sizes, and wildlife corridor "setbacks" that would minimize the impact of development on the wildlife corridor. Flexible zoning would further enable the protection of the corridors by encouraging cluster and limited development which can integrate the wildlife corridors as community open space lands. This option would work best with the "Least Property Impact Scenario".

Legislative

Legislative measures are those implemented by the state government, which are justified because they represent a significant public interest. Depending on the circumstances, they may or may not involve compensation for limitations on land use. Floodplain and wetland laws are examples of legislative actions with important benefits for conservation and greenway planning.

A proposed law in the Massachusetts legislature would require 65M buffers along all tributary streams of major water supply reservoirs in Central Massachusetts. This would effectively provide a 130M corridor as recommended by this study for most of the riparian lands in the study area. The legislation has generated mixed responses from metropolitan Boston water consumers, who favor it, @nd central Massachusetts residents who see it as a taking of their development rights without compensation. Clearly a balance of metropolitan need and rural resource protection is in the long term public interest and would contribute significantly to the proposed wildlife corridor network (Houck 1991).

Eminent domain

The taking of private property for a legitimate public purpose is known as eminent domain. This approach should be considered as a last resort since it leaves the landowner out of the greenway planning process and can alienate members of the community. It usually involves long delays and expensive court proceedings. If used excessively, this technique could transform the public's perception of the greenway network from a community benefit to a divisive nuisance. It is also not clear that the courts would allow an eminent domain taking for greenway purposes.

Voluntary techniques

Conservation restrictions

A conservation restriction is a legal agreement between a land owner and public/private conservation interest through which the landowner gives up the right to development. The restriction may involve the entire parcel, or only a portion through which the corridor passes. The restrictions may be of specific duration or in perpetuity, as assured through a deed restriction. Tax benefits may be realized from permanent restrictions, based on a measurable decrease in property value.

Gifts

Any public or private entity with a conservation program can accept gifts of land for conservation purposes. If the gift is made to a private organization it may become tax exempt if the organization places permanent restrictions on the use of the land and provides public right of access.

Easements

Easements are similar to conservation restrictions but usually involve only a portion of a land parcel. Easements may be granted for right of access or for right of land use such as for utility rights-of-way. in the case of wildlife corridors, conservation easements that limit forest and riparian corridor disturbance would be most desirable.

Tax abatement programs

Tax abatement programs have been created to promote resource conservation by taxing land on its use rather than on its development potential. This technique provides only voluntary and temporary restrictions on the land. The program has renewal periods of various intervals which provide the landowner with the option of selling at renewal time. In the event of sale, the state or local government often has the right of first refusal, but often cannot afford the purchase. Both of these land uses are not intrinsically compatible with the wildlife corridors proposed in this study since they promote land use activities that are potentially disruptive to the wildlife corridors.

Summary of implementation recommendations

The two scenarios Otter Max and Least Property Impact represent two extremes of a continuum between a wildlife bias and a land use bias in greenway planning. Each option has its strengths and weaknesses as previously described. Neither option is represented as an actual plan or proposal, and of course, there is a real danger in viewing them as such. Just as the process described in this research argues for differential strategies and methods a different planning scales - so to are different issues raised when a scenario advances to a design scale at which implementation can be seriously considered. In this context a host of aesthetic issues are raised. What is the relationship of the network to the physical landscape? Is there a hierarchy to the proposed linkages, or should they be uniform? What is the relationship of this network pattern with other contemporary and historical landscape patterns such as hedgerows, shelter belts and vernacular settlement patterns? These are all interesting and relevant questions but are beyond the scope of this research to discuss.

A wide range of acquisition. regulatory, and voluntary techniques are available to implement either option. Figure 4.6 evaluates both scenarios against the land conservation techniques available. Otter Max relies more on acquisition techniques because its impact on land parcels often renders them un-developable. Least Property Impact is intrinsically more compatible with the regulatory approach since it is based on property boundary configurations.

This study does not specifically recommend either option, or any specific technique for implementation. Rather it envisions a continuing planning process in which the nature and configuration of the greenways is decided with input from wildlife ecologists, landscape planners, landscape architects and concerned/affected citizens (Hay 1991, Lyle and Quinn 1991). A GIS would facilitate accurate and impartial evaluation of compromise alternatives generated. The planning process has been designed with this in mind. Since there is no existing public or private agency with appropriate expertise, authority and representation to oversee a greenway planning process, a public:private land trust should be established. The trust should include private landowners, private non-profit groups, business interests, and public officials. The trust should employ a full suite of land conservation techniques to achieve the desired level of landscape integration, linkage and land use control.

As can be seen, the present course of land use control and regulation is ineffective at preventing fragmentation. Countering this trend will require the support and participation of a broad public and professional constituency. The emerging theories from landscape ecology and the capabilities of GIS systems can facilitate an ongoing, accurate and impartial evaluation of alternatives with meaningful public participation. This study has helped to articulate the problem of landscape fragmentation and has suggested an approach to its resolution that balances biophysical and cultural concerns and values.

Acknowledgments

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5 Time, space, ecology and design: landscape aesthetics in an ecological framework in The Netherlands

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INTRODUCTION

As a contribution to this forum on “Ecology, Aesthetics and Design” we start from the premise that landscape aesthetics should support and provide visible expression of the concept of sustainability. Recent international agreements on sustainability are perhaps the closest the world has ever come to a consensus on environmental policy (note 1) , and provide a sound conceptual foundation for developing a new landscape aesthetic. But what does sustainability imply for landscape architecture? Is it only a policy issue which affects large scale environmental plans? Is it a paradigm which may be expressed in physical form at multiple scales through landscape design? Is it both? or something else?

Our thesis is that landscape architecture is uniquely poised to address the challenge of sustainability in the realms of both planning and design, at multiple scales, by advancing a landscape aesthetic and spatial strategy which:

1) allows for stability and change in the landscape - structured by a landscape framework
2) provides a context for cultural and aesthetic expression
3) enhances the understanding and experience of landscape processes.

In our discussion we use concepts, theories, and case studies from the Netherlands. As one of the world’s most densely populated and intensively used landscapes, the Netherlands may be seen as a harbinger of landscape issues the rest of the industrialized world may soon encounter. The Dutch planning and design response to their culturally-rich, intensively used landscape has been innovative and visionary. They have explicitly acknowledged that their landscape is not sustainable in terms of maintaining biodiversity and environmental health (Vos and Opdam 1993). Their work addresses the larger scale environmental policy issues, as well as the quest for a “sustainable aesthetic” in the physical design of the landscape at multiple scales (Meeus and Vroom 1986, Vroom 1992, Bailey 1991). Because of this history of uniquely intense interaction, the Dutch landscape has been metaphorically described as an “experimental garden” (Vos and Zonneveld 1993). The Dutch have a lot to teach the world from their experiences in this garden.

A SPATIAL AND CONCEPTUAL FRAMEWORK FOR LANDSCAPE STABILITY AND CHANGE

In ecology, economics, sociology and in other natural and social sciences - change is understood more as a characteristic process than as an aberration. Change and uncertainty are fundamental in natural and cultural systems. The landscape is no different - change is also fundamental - and uncertainty is a “given”. This is the paradox of time in landscape planning. Nature needs time and certainty in some places - yet cultural and economic forces demand flexibility in others. The framework concept in the Netherlands is a spatial strategy for addressing this paradox in the realms of planning and design. It guarantees nature a long term stability, and allows more flexibility for land use change in the other areas - this is the framework's *quid pro quo* (Bruin et al. 1987, Kerkstra and Vrijlandt 1990, Sijmonds 1990). In the Netherlands the framework concept is known as 'casco' in reference to a Spanish building practice in which buildings are designed and built with only a main structural framework, allowing users to modify and adapt the interior partitioning and design to their changing needs. The word casco comes from the Spanish language, and means something like a protective shield or structure. In the context of this discussion, casco is both a spatial and a conceptual framework for landscape planning and design.

To resist landscape change unilaterally is like "putting on the brakes" against unstoppable ecological and global economic forces in defense of an historically and continually diminishing nature. Resisting change is a defensive position that maintains a polarization between the "doers" and the "protectors" and denies opportunities for more creative and proactive solutions - in both landscape planning and design (Sijmonds 1990, Vroom 1997). An acceptance of change is essential to balancing economic and environmental forces, and creates new strategic opportunities to address the paradox of time in the landscape.

Perhaps it is wise to accept the need for landscape change and proceed to ask the obvious questions: What are the respective forces and rates of change? Which processes are more susceptible to change and disturbance? Which are the most dynamic forces in the landscape in biological, abiotic, and cultural terms? Where should change be promoted, and where should it be minimized? Some land uses support ecological processes which operate slowly and require stability in time and space. These are the "slow turning" wheels of the landscape such as nature conservation, watershed management and river floodplain dynamics. Other land uses and processes are influenced more by cultural and economic forces and depend on an ability to change in response to market and technological factors. Changes in land use for increased industrial production, for new housing, or soil and drainage alterations to support different agricultural systems are representative of the landscape's "fast turning wheels" (Sijmonds 1990). The framework concept recognizes the fundamental and particular needs of both.

Landscape planning and design have an obvious and direct influence on *landscape pattern* - the spatial configuration of landscapes at many scales, and an integrally related influence on landscape processes. Landscape ecology has been described as the study of the effect of landscape pattern on process, and is therefore relevant to this discussion (Turner 1989, Soulé 1991, Ahern 1991). Landscape ecologists have defined three landscape characteristics which can be used to understand landscapes in both space and time. *Structure* describes the physical configuration and form of landscapes. *Function* describes the interactions between landscape elements, or ecosystems, in terms of flows of energy, species and materials. *Change* refers to the dynamics of structure and function over time (note 2) (Lyle 1985, Forman and Godron 1986, Lyle 1991). These landscape characteristics are significant because they help to explain the interactions between landscape pattern and process, and enable a valid linkage with ecological research.

The current state of the world demonstrates clearly that the future of the landscape cannot be determined solely by a free interplay of social and economic forces (Sijmonds 1990, WCED 1987, Brown 1993). When land uses change is uncontrolled, or influenced primarily by economic forces, the natural landscape often becomes fragmented into smaller and more isolated landscape elements. Fragmentation and habitat loss are the primary reasons for the global loss of biodiversity (Wilson and Peter 1988, IUCN 1980). The spread of suburban development into a forested landscape, or the clearing of the rainforest for agriculture are classic examples of fragmentation related to land use changes. In both cases the remnant patches of forest become smaller and more isolated (Harris 1981). MacArthur and Wilson's theory of island biogeography has been extended to terrestrial landscapes and explains species decline and extinction resulting from fragmentation and isolation. (Soulé 1991, Harris 1981, MacArthur and Wilson 1967, Noss 1993). From this and other landscape ecological research, several biodiversity-related reasons for maintaining a more spatially integrated, less fragmented landscape pattern can be identified: 1) it facilitates movement of certain species within and between preferred habitats 2) such species movement over time enables genetic exchange, and may support metapopulations (note 3), 3) metapopulations enjoy greater survival prospects from higher levels of physical and functional connectivity in fragmented landscapes (Soulé 1991, Noss 1993, Opdam et al 1993). This rationale, based on landscape ecology in general, and island biogeography and metapopulation theories in particular is the scientific and spatial basis of the National Ecological Network of the Netherlands as shown in Figure 5.1 (Netherlands Ministry of Agriculture, Nature Management and Fisheries 1990). This plan is unique as an application of landscape ecological theories in a spatial plan on a national scale. Presently, the national plan is being coordinated with plans at the provincial level, and implemented in local plans and designs (Provincie Noord Brabant 1992). At this point in time, the Dutch are committed to the framework concept as the appropriate strategy for landscape and nature policies.

Additionally, many of the environmentally-sensitive and hazard-susceptible landscapes have been found to occur along linear corridors which also have a high percentage of cultural and visual landscape resources (note 4) (Lewis 1964). Because of these unique properties of linear networks, they represent a useful strategy to promote spatial integration, to link pattern and process, and to facilitate flows in the landscape. Networks that connect landscapes create a synergy of desirable landscape functions and processes. Spatially-integrated linear networks offer physical

Figure 5.1. The National Ecological Network of the Netherlands, 1990, proposes an integrated network of core areas, nature development areas, and connecting corridors, to link nationally and internationally significant ecosystems . (Netherlands Ministry of Agriculture, Nature Management and Fisheries 1990)

advantages for the movement or flows of certain materials, such as rainfall runoff in stream channels, and certain groundwater flows. The corridors in such networks are useful when they offer a distance or gradient advantage, or a reduced number of barriers that must be crossed, and when they may be managed for multiple benefits, combining biotic, abiotic and cultural benefits.

The paradox of time and uncertainty identifies the need for stability and change, in space and time. Landscape ecology provides an understanding of the spatial and temporal dynamics in landscapes, and of the advantages of spatial integration and connectivity. It also provides a basis for determining which land uses and functions require stability and which may or should be more dynamic. There are also compelling reasons in abiotic terms to promote or maintain spatial integration in landscapes. More specifically, the framework concept promotes a spatially integrated network of lands, managed for "low dynamic" functions and uses, based primarily on abiotic factors (Figure 5.2). It is often based on the hydrologic landscape structure, in which discrete geo-hydrological units can be identified (Buuren van and Kerkstra 1993). Within this network structure are opportunities for " high dynamic" functions and uses, and opportunities to provide the biodiversity-related functions described above.

Kevin Lynch has described other advantages of linking open spaces into a kind of system:

> The open space system not only makes the city visible, but also the larger natural universe. It can give the observer a sense of the more permanent system of which he and the city are only parts. ..... To convey a sense of the Web of life, of the intricate interdependent system of living things, will be even more important. (Lynch 1972, p 119)

The framework builds on Odum's compartment model concept (Odum 1969) and Lewis' environmental corridors (1964) and is similar in some respects with the many greenway plans and designs in North America (Little 1990, Smith and Helmund 1993, Flink and Searns 1993). Like Odum's compartment model, the framework is a strategic approach that confronts the differing needs of nature and culture, but unlike Odum's model, it includes a specific spatial dimension. The framework differs from most greenways in that it is a spatial strategy for entire landscapes, in contrast with greenway's more exclusive strategic focus on corridors as important linear landscape elements. A consensus is emerging around the ecological framework concept as an appropriate spatial strategy for planning and designing sustainable landscapes (Buuren van and Kerkstra 1993, Smith and Hellmund 1993).

The landscape framework approach advocated here is not a specific proposal or tactic, but rather is a spatial strategy. A spatial strategy articulates, often through metaphors and images, fundamental planning decisions around which a consensus is formed, and as a framework for more concrete decisions (Zonneveld 1991). The "Green Heart" in the Netherlands is a good example. It is a spatial strategy to maintain a "green core" of agriculture, forests, and recreation within the densely populated western Netherlands.

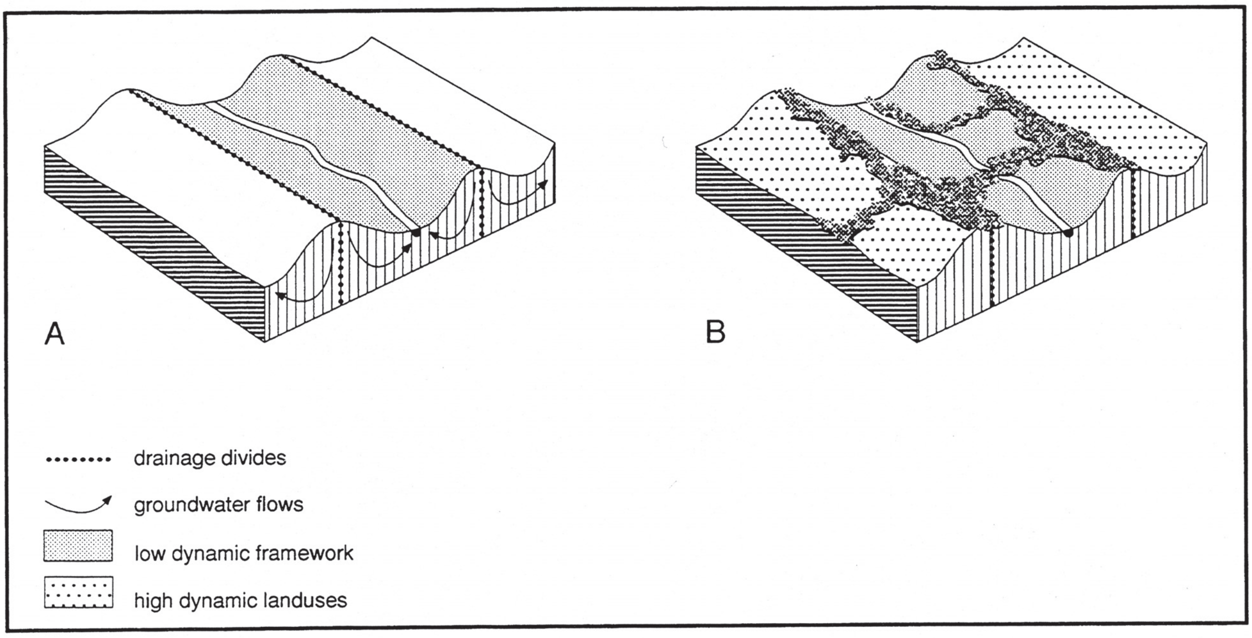

Figure 5.2. (A). The framework concept is based principally on abiotic geo-hydrologic patterns in the landscape which can be isolated and managed to provide stability for "low" dynamic functions. (B) When discrete geo-hydrological units are defined, they form a logical spatial basis for the low dynamic portion of the framework . Within the "mesh" of the framework are opportunities for the "high" dynamic uses and functions. (adapted from Buuren van and Kerkstra 1993).

The core is surrounded by the Randstad (Ring City), which is a kind of reciprocal strategic spatial concept. The "green heart" concept has significantly guided Dutch planning and development strategies since the 1950's, during a major period of population growth and land use change. In recognition of fundamental changes in landscape issues, perceptions, values and visions of the future the green heart concept is now being reconsidered (note 5). The framework concept is a different spatial strategy based on the need for spatial integration and connectivity, on the particular advantages of linear networks, and in response to the paradox of time in the landscape. Next we will discuss implications of the framework concept for a landscape design aesthetic which expresses landscape processes, and cultural meaning.

CONTEXT FOR CULTURAL AND AESTHETIC EXPRESSION

A challenge for landscape architects is to express the sustainability concept through designs which respond to both the cultural need for aesthetic expression and meaning, and the urgent need for ecological fitness or "sustainability" (Lyle 1991, Thayer 1989, Olin 1988, Spirn 1988). We argue that these two "needs" are not mutually exclusive, but rather are symbiotic, when viewed in a larger context of space and time. New icons, physically rooted in the landscape may shape and define a new basis of "sustainable" expression, just as the built works of the Renaissance expressed enlightenment and humanism and those of the Baroque expressed absolute power and order, a sustainable landscape aesthetic could inspire landscapes which engage and express ecological process, cultural meaning, and aesthetic value (Lyle 1991, Thayer 1989).

The dynamics of natural systems are increasingly understood, are often measurable, and perhaps are even controllable. The Dutch have a long history of intensive landscape manipulations, traditionally applied as a defense against sea and river flooding, and for the creation of new land in the polders. This inclination towards large scale landscape intervention is presently being redirected in a uniquely Dutch approach to nature restoration/development and management. Without entering a rhetorical discussion of whether "nature" can be created or not, perhaps we can say that when the ecological goals of a nature creation project can be clearly defined, increasingly these same goals may be reached. But what is the place of the cultural and aesthetic landscape in this process? Much of the Dutch landscape that appears and is widely regarded as "natural" - like the heathlands- is actually a cultural landscape, formed in response to centuries of human managed grazing. In landscapes which include multiple layers of history, which is the proper point of reference? Which criteria for aesthetic quality is to be used? The goals in this case are not so easily defined. Unlike natural processes, which operate according to natural and physical laws, the cultural system is continuously and rapidly evolving, as are the "rules" which govern changes in response to social issues, technology, and economics.

But cultural landscapes are important in any discussion of aesthetics because they connect us with our past, and reflect our history of values towards the land, and our concept of nature. Cultural landscapes can be understood as:

> .....the record of human relationships with the land. They encompass all that has been altered by humans and represent the real, physical, tangible legacy of one generation passed down to another generation. Therefore they are significant reminders of the past. They are reflections of the common everyday history of the country. (Melnick 1983, p. 87)

Figure 5.3 In Texel, Netherlands, the framework is primarily based on the low dynamic landscape elements including stream valeys and dunes.

Since there is no given harmony between the natural and cultural landscapes, the framework concept looks to the conflict itself for new opportunities, sensitive to their context, and their relationship with the framework. There are opportunities for new forms of expression that may relate to the surroundings in a number of ways; dominance, subjugation, contrast, co-existence, or harmony. These possible forms of expression serve to emphasize that the casco is not a rigid dogma, but rather a flexible background against which designers may respond differentially depending on their context, world view and values. The aesthetics of sustainability do not have to disguise or shun human influence, and need not be hostile towards historical aesthetic norms (Lyle 1991, Thayer 1989, Olin 1988).

When cultural landscapes are spatially located within the "low dynamic" part of the framework, they may enjoy another layer of significance and protection. In this case they may be assumed to represent sustainable landscape patterns by virtue of their existence over time in some form of presumed or understood balance with nature. It is possible to learn from such cultural landscapes as analogs - to be borrowed and replicated, and as metaphors - to be adapted in more abstract and less literal ways, for other ways of conceptualizing our relationship with nature. These are the patterns of the human ecosystem that have demonstrated sustainability (Lyle 1991). The landscape of the island of Texel in the northern Netherlands is largely structured by a network of tree plantings based on the geomorphologic pattern of ancient creek beds. Texel thus displays a sustainable framework, derived from natural patterns, and reflecting cultural traditions and values (Figures 5.3, 5.4).

Figure 5.4 A portion of the low dynamic framework in Texel structured by creeks and related woodlands.

Aesthetics, as expressions of fundamental cultural values are integral to the framework concept. Consider the United States interstate highway system as a different kind of framework. Conceived purely for functional needs, it became a powerful icon that influenced virtually every facet of American culture including; music, art, architecture, and perhaps most importantly - the American landscape. All this from a transportation network! Then consider the potential for an equally powerful landscape-based framework. Conceived initially to provide sustainable ecological functions, but which could inspire and nurture a new landscape aesthetic - based on ideas about the fundamental human-nature interrelationship. The framework should be a stimulus to design, not a dogma or constraint. It should be like the outline of a story that could be completed by many authors, or similar blocks of stone given to different sculptors for carving. The resulting works in both cases would bear traces of their origin and collectively would explore some larger or more general themes, but each would also express uniquely individual solutions. Implicit in this analogy is an assumption that a proper or acceptable balance between an imposed order and opportunity for individual expression can be realized. Critics of the framework concept fear a "formulaic" approach to design and a resulting loss of regional identity. Proponents counter that the framework should be based on local patterns, and therefore is expressive of "vernacular" processes and cultural values .

It is possible to describe a range of possible design responses to the framework. First, there will be those that physically and functionally contribute to and reinforce the actual physical framework, such as with hedgerow networks or greenway corridors. In these designs there is a strong emphasis on spatial integration and on physiographic natural patterns and processes. These designs express the "forms of expression" of harmony or coexistence. There is a physical and conceptual fit between them and the "low dynamic" landscape. The framework from the island of Texel illustrates this type of framework.

The Ooievaar plan was the winning entry in a 1985 competition sponsored by the Eo Wijers Foundation to promote design at the regional scale in the Netherlands (Hamhuis et al 1992). The focus of the competition was the river district in the central Netherlands including the Rivers Rhine, Waal and Maas. The project name 'Ooievaar' (Black Stork) was selected for its symbolic significance, as the stork has been a species associated with fertility and nature, and it has been extinct in the Netherlands for several centuries. It is an apt metaphor for the simultaneous potential and fragility of nature. This dichotomy is quite fitting for a plan which advocates a strategy for balancing the needs of nature with human use of the land. The plan is an early example of the framework concept, applied on the regional scale. The basic proposal was to designate the river areas as low dynamic landscape and through changes in floodplain management, to allow river dynamics to return and enable a floodplain forest to regenerate. In return for this increased commitment to nature, the plan proposed that other high dynamic areas, be given more freedom and flexibility to develop more dynamically for new forms and patterns of agricultural use. (see Figure 5.5)

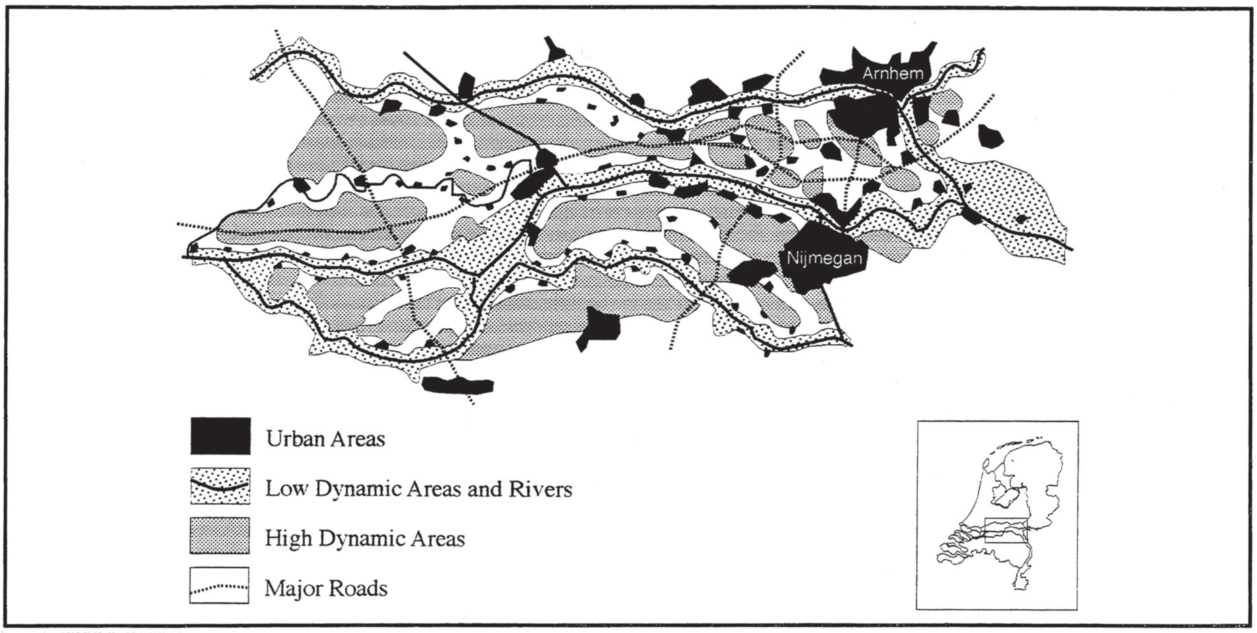

Figure 5.5. The Plan Ooievaar is an example of the framework concept applied at the regional scale in the river district in the Netherlands. It provides stability along the rivers and a return of natural dynamic processes, and enables other areas, away from the Rivers more flexibility to change to meet the evolving needs of modern agricultural production. (adapted from Hamhuis et al. 1992)

Next, there will be design responses which are less functionally related to the framework, but still expressing sustainable or regenerative values and processes, such as the Institute for Regenerative Studies by John Lyle et al in Pomona California, the wind farms by Thayer, or the "living machines" of John Todd (Lyle 1991, Thayer 1989, Oor 1992). In the Netherlands there are similar examples of projects which combine biological wastewater treatment with wildlife habitat and recreation. These may be sited in either high or low dynamic landscapes, depending on their needs for long term stability. In either case, these uses both contribute to and benefit from the existence of the framework, as physical manifestations of sustainable processes actively functioning in the landscape.

Finally there will be those designs that stimulate a wide range of more abstract forms of cultural expression, from harmony and co-existence, to contrast or even dominance and subjugation. These expressions may derive inspiration from the framework, or intentionally challenge it, asking fundamental questions about the basic human:cultural relationship, or about the value of networks. What distinguishes these abstract landscape statements from other forms of abstract artistic expression, is that they are a didactic on the human perception and control of nature, and engage the issue of linkages across scales of space and time. In these works the landscape is itself the media of expression. The environmental works of Christo, Nancy Holt and George Trakas provide examples of existing art works that ask similar questions (Beardsley 1984).

Fragmentation effects not only biological values, but aesthetic values as well including; loss of visual diversity, local and regional identity - which was the result of natural and cultural diversity. The framework constitutes a stable background, like the set on a theatrical stage, which symbolizes nature as the basic resource for all human activity. Within this set, culture can play an ever-changing role. Based principally on abiotic patterns, the framework expresses the basic natural and visual structure of the landscape.

UNDERSTANDING AND EXPERIENCE OF LANDSCAPE PROCESSES

In the earlier section, we discussed the inseparability of landscape pattern and process. Thus it follows that a new aesthetic of sustainability not only address the spatial landscape framework, but also its formative processes which link a place with its past and present. The framework concept focuses on the formative processes and patterns in the landscape and is expressive of the fundamental "low dynamic" processes that structure and support sustainable landscapes over time. These processes can be defined as; nutrient cycles and energetics, hydrological flows and movement and growth of species and communities. This relationship between a spatial framework and dynamic landscape processes has been described by Spirn:

> "....The solution lies in an understanding of the processes that underlie these patterns and there are some principles that can be described for [urban] design: establish a framework which lends overall structure - not an arbitrary framework, but one congruent with the "deep " structure of the place; define a vocabulary of forms that express natural and cultural processes; then encourage a symphony of variations in response to the conditions of a particular locale and the needs of specific people. The result should be a dynamic, coherent whole that can continue to evolve to meet changing needs and desires and that also connects the present with the past." (Spirn 1988, p 124)

The lessons of environmental insensitivity and poor planning are well known and convincing arguments which support a respect for fragile and hazardous landscape processes (McHarg 1969). Failure to respond to these processes in planning and design not only exposes us to these hazards, but denies the positive benefits to be gained from acquiring a deeper understanding of a place. Landscape designs which make the underlying natural processes legible, connect us with the deep structure of a place, of its daily and seasonal rhythms, and with ecological changes - as ephemeral as the dynamics of stormwater runoff, or over a human lifetime, during which the processes of succession

Figure 5.6. Dense mass plantings on the Island of Walcheren by Nico de Jonge, provide spatial enclosure and shelter for farmsteads, and respond to and make visible the presence and power of the wind.

and plant growth may be experienced in the landscape (Lyle 1991, Thayer 1989, Spirn 1988).

This is not to say that communication of natural processes should be an overriding design determinant. An experience of natural processes may be strengthened when it is seen or understood as a foil to other, more geometrical or other culturally-related forms (Spirn 1988). The framework provides opportunities for both forms of expression in the landscape.

In the Netherlands design responses relating to natural processes often relate to the primal forces of wind and water. The historical and cultural response to these forces is clearly seen in the basic structure of the Dutch landscapes, and is integral with their landscape aesthetic. In seeking a new aesthetic, the nature and patterns of response to these primal forces is fundamental. The replanting schemes of Nico de Jonge on the Island of Walcheren after war-related flooding both respond to express the strong prevailing westerly winds from the North Sea (Vroom 1992, Steiner 1989). Like the sweeping forms of the dunes along the Dutch coast, and in a manner reminiscent of the aerodynamic architectural and planting forms at Searanch in California, the farmsteads in Walcheren were replanted with dense mounds of native trees and shrubs. The resulting forms of these mass plantings,

Figure 5.7. In addition to expressing the force of the wind, the farmstead plantings relate the farmsteads to the larger framework of plantings throughout Walcheren.

modified and battered by the winds over the years, express these dynamics clearly in the larger landscape, and create within their massings private worlds on a smaller scale that are equally expressive of natural process (Figures 5.6 and 5.7). The flooding, which killed virtually all the trees on the island, provided de Jonge with the opportunity to create a kind of framework structure for the landscape based on geomorphological and soil features and expressing a basic transportation and spatial pattern, within which individual design responses could be made. De Jonge would prefer to describe his approach as “headline” planning, due to his belief that the framework concept imposes regular patterns in diverse landscape and thereby diminishes regional and local identity.

The Blauwe Kamer is a recent pilot project, inspired by Plan Ooievaar, to restore river dynamics and natural grazing as landscape creating processes in the floodplain of the Rhine River, which like most Dutch rivers, has been “harnessed” behind dikes for centuries. An open connection between the foreland and the river was established by digging a creek and removing part of the summer dike, a symbolic and unprecedented act attended by Queen Beatrix! In the lower areas, alluvial forests with willows, black poplars, and thickets are emerging, on higher ground a more structured forest rich in oaks, ashes, and elms is developing. A special type of wild European horse, the Konik, was introduced to graze the meadows - favoring the spontaneous generation of a mosaic of herb-rich grasslands, thickets, and alluvial forests. As an early project to demonstrate and test the framework concept, the Blauwe Kamer can be understood as a part of the "low dynamic" landscape framework. It engages the paradox of time in that it has been "guaranteed" long term stability in terms of land use, which in turn provides the opportunity for the river and the grazing animals to once again interact with the land. Here the dynamics of natural processes can be seen and experienced in several time frames; actively "in real time" during the floods which can be experienced firsthand; in the resulting patterns of erosion and sedimentation which can be experienced as seasonal changes in topography and vegetation, and through longer term changes in the mosaic of vegetation and physiography resulting from the ongoing interaction of the formative processes of flooding and grazing. The Blauwe Kamer demonstrates the possibility, informed by ecological and hydrological knowledge, to successfully restore natural processes to the landscape. The experience of these processes is one part of an emerging aesthetics of sustainability - providing a context for cultural expression and meaning is another. In this respect, the Blauwe Kamer is less successful and has been criticized for lacking a clear spatial structure and organization, and for not integrating cultural icons and artifacts into the project (Vroom 1997).

CONCLUSION

As a spatial strategy, the framework concept is not place or location-specific, thus it is transferable to any landscape, at least in principle. Since the framework concept recognizes the need to provide for changing economic uses of the land as a *quid pro quo* for increased landscape protection, it holds promise to build a viable constituency of political support - an essential aspect for the USA which has much less centralized and empowered planning in comparison with the Netherlands.

The framework concept is not a planning formula or design style, it is a strategic approach for "getting ahead" of the process of change - a cooperation of the "doers" and the "protectors" with a vision for a future landscape structured by a spatially integrated network of low dynamic uses. It recognizes nature as an independent creative force, and reflects the regional structure of fundamental natural patterns. It provides space for natural abiotic and biotic patterns within the framework's "interstices" and maintains a clear distinction between natural and human pattern languages; based on the abiotic structure of the landscape, specifically, the geomorphology, hydrology soil and the biotic response to the landscape. The human pattern language communicates the fundamental way that humans express their relationship with nature, in terms of subjugation, harmony, co-existence, contrast, or dominance.

Sustainability exists as a vague and abstract notion defying precise definition, open to diverse and conflicting interpretations, yet still, or perhaps because of this, it is a concept widely embraced as the world's environmental paradigm. Sustainability cannot be meaningfully realized and expressed only through policy plans, nor can it be realized only through isolated design projects, regardless of their intrinsic merit. Sustainability depends on an integration of design and planning across scales. Landscape architects have a unique opportunity to be the pathfinders for developing a sustainable landscape aesthetic because of their understanding of natural and cultural systems, and by virtue of their professional involvement across scales - and from the professional realms of planning and policy to those of design and management. The framework concept provides a promising spatial strategy for integrating and coordinating these efforts across scales of space and time. It should be understood as an inspiration, rather than a constraint to new forms of design expression in support of sustainability.

End Notes

1. Sustainability as defined by the Bruntland Commission: "Humanity has the ability to make development sustainable - to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs ". (WCED 1987, p. 8). Implicit in this definition is an assumed complementarity between economic development activities and environmental protection.

2. Lyle's three modes of ecosystem order: structure, function and location are not significantly unlike the three landscape characteristics defined by landscape ecologists (structure, function and change). In Lyle there is perhaps a stronger emphasis and orientation on the significance and utility of these modes in design, and planning (Lyle 1985, Lyle 1991

3. Metapopulations are assemblages of sub-populations which interact in space and over time across landscapes. The metapopulation theory of Opdam et al (1993) explains the respective roles of large habitat patches (sources), and smaller occupied or unoccupied habitat patches in supporting metapopulations in fragmented landscapes over time.

4. Lewis classic study in Wisconsin found that a high percentage of over 200 categories of sensitive ecological resources and important cultural features were located within the "environmental corridors" that he defined (Lewis 1964).

5. The Eo Wijers Foundation has sponsored several international competitions to stimulate design at the regional level. The current competition (1994-95) "Green Heart Metropolis: Urban Peripheries" seeks new spatial and design concepts for the Randstat and the Green Heart in the western Netherlands.

6 Greenways in the USA: theory, trends and prospects

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Introduction

Developments in Europe and the USA have common roots, but for a great deal they went their own way due to geographical, political and scientific differences. While ecological networks are common in Europe, greenways are much more an American product. This chapter is organised to address several objectives:

- To compare classic and emerging definitions of greenways.
- To articulate greenway theory, and to link definitions with theoretical principles
- To review the origin and evolution of greenways in the USA
- To discuss future prospects and research needs for greenways.

Greenways is a "new" word with many meanings. Much confusion still exists around its definition, yet it continues to gain in popularity and to appear regularly in popular language and planning policy in the USA and internationally (Fabos and Ahern 1995). The many differing perspectives on greenways are reflected in these definitions and serve to emphasize the complexity of the greenway concept. A brief review of these definitions provides a useful introduction to the subject of greenways, and underscores the need for a common definition and taxonomy, to support international, interdisciplinary communication and collaboration.

Perhaps the most widely accepted contemporary definition/statement on greenways in the USA was included in the report of the President's Commission on Americans Outdoors in the USA, (1987). The Commission advocated a greenways network:

> "to provide people with access to open spaces close to where they live, and to link together the rural and urban spaces in the American landscape. Threading through cities and countrysides like a giant circulation system."

This definition/statement emphasizes the concept of spatial connectivity, of an integrated functional network, managed for multiple purposes linking rural and urban environments. It also reflects the late 20th century orientation in contemporary American land preservation, which focuses on open lands that are directly accessible to population centres, in contrast with the 19th and early 20th Century emphasis on the great, but more remote, national parks and other protected landscapes (Zube 1995).

A comprehensive set of definitions on greenways was provided by Charles Little, the author of the popular 1990 book, *Greenways for America*. In his definition a "Greenway" is:

1. A greenway is a linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, scenic road, or other route.

2. Any natural or landscaped course for pedestrian or bicycle passage.
3. An open-space connector linking parks, nature reserves, cultural features, or historic sites with each other and with populated areas.
4. Locally, certain strip or linear parks designated as parkway or greenbelt. (Little 1990, preface)

Little's definitions share the same fundamental ideas as the President's Commission, in addition, he recognizes specific types of greenways depending on their location, spatial configuration, and purpose. Many other authors of greenway books, journal articles and reports cite the definitions of Little and the President's Commission (Smith and Hellmund 1993, Flink and Searns 1993, Erickson and Louisse 1997)

I proposed another greenways definition in the 1995 book *Greenways the Beginning of an International Movement* based on literature review, and research/applications experience with greenway planning projects in the USA:

> "Greenways are networks of land that are planned, designed and managed for multiple purposes including ecological, recreational, cultural, aesthetic, or other purposes compatible with the concept of sustainable land use" (Ahern 1995, p. 134).

This definition is intended to be comprehensive and inclusive. In this cited reference, I also propose a typology of greenways, structured to enable explicit, comparative, description and communication of greenways across physical, spatial, cultural, and political contexts. The typology classifies greenways according to: spatial scale, purpose/goals, landscape context, and planning strategy (Ahern 1995, pp. 137-140).

These definitions illustrate the diversity that is inherent in greenways in concept and in reality. This diversity helps to explain the popularity of greenways, and also emphasizes the need for a greenway classification or typology to assure a clear and accurate communication between researchers and professionals. Figure 6.1 relates greenway definitions with significant questions raised. The definitions and questions lead to three theoretical principles that are posed as representing a theoretical basis in support of greenways: 1) the hypothesis of co-occurrence of greenway resources; 2) the inherent benefits of connectivity; and 3) the compatibility and synergy of multiple use in greenways. The following section discusses and explores these three greenway principles, which represent an emerging theoretical basis in support of greenways.

Definitional Themes	Questions/Issues Raised?	Theoretical Principles
Greenways are a linked, or spatially - integrated network of lands that are owned or managed for public uses including: biodiversity, scenic quality, recreation, and agriculture	Does this network produce an advantage Due to an intrinsic pattern of resource distribution?	1. Hypothesis of co-occurrence of greenway resources
A presumed advantage, or synergy, resulting from spatial connectivity and linkage.	How do the determining functions affect the spatial form and configuration of the greenway? Is there sufficient knowledge and information available to plan for connectivity?	2. Inherent benefits of connectivity for humans and for biodiversity.
Planned to accommodate multiple uses and to achieve multiple goals.	If the greenway is multipurpose and multi-objective, which are the primary or determining uses/functions? Are the uses spatially compatible or conflicting? Who decides which uses take priority? Is the greenway spatial configuration, intentional and deliberate, or is it opportunistic?	3. Compatibility and synergy of multiple use(s)?

Figure 6.1 Linkage of greenway definitions with theoretical principles

Greenway Theory

Hypothesis of Co-occurrence of Greenway Resources

One of the common arguments in support of greenways is the hypothesis of co-occurrence of greenway resources. When discussing greenway resources, it is important to distinguish from earlier, conventional conceptions of protected landscapes. The USA's National Park system is well known for its spectacular natural scenery, typically remote from urban regions. Greenways embrace the concept of protected lands within urban regions, explicitly and intentionally located in close proximity with where people live and work. Greenway resources thus include the riparian/drainage network, large patches, small "bits of nature", and linking corridors (Forman 1995). The hypothesis of co-occurrence posits that in any cultural landscape greenway resources are spatially concentrated along corridors. Cultural landscapes in the USA are understood differently than those in Europe. As a younger culture, American conceptions of cultural landscapes are still emerging, rooted in the traditions of colonial agriculture, vernacular rural and suburban landscapes, and greenway corridors typically include riparian and linear upland areas, such as regional topographic ridges and small mountain ranges. Although the hypothesis warrants further and continued testing, several investigators' results support this hypothesis across a range of scales and contexts in the USA and in Europe. If the hypothesis is valid, greenways offer three strategic advantages:

- Spatial Efficiency: because they consist largely of corridors, where resources are concentrated, greenways can protect the most resources with the least amount of land area;
- Political Support: political consensus and support is more likely to occur due to the mutual benefits that diverse interests can realize from greenway protection (e.g. recreational, biodiversity, water quality);
- Connectivity: if greenway resources are concentrated in corridors, the benefits of connectivity will be expressed in ecological, physical and cultural terms (see Section 6.2 for a discussion on inherent benefits of connectivity).

The earliest research on the hypothesis of co-occurrence of greenway resources is usually attributed to Philip Lewis, a landscape architecture professor and practitioner from Wisconsin, USA. Lewis' classic study for the Wisconsin Outdoor Recreation Plan, surveyed and mapped the locations of 220 ecological, recreational, cultural and historic resources. Lewis' study found that over 90% of these resources occurred along corridors which he labeled "environmental corridors" (Lewis 1964). These corridors were used as the basis for the Wisconsin Heritage Trail Proposal (Figure 6.2). Lewis' work is well-known in the USA as a precursor to modern greenways. Lewis recognized the importance of this co-occurrence, not only as a means towards efficient land protection, but also to show diverse public constituencies that their respective interests are often spatially coincident. The environmental corridors have also proven important for education by increasing awareness of connections among a variety of natural and cultural resources that tend to co-locate along greenway corridors (Lewis 1996).

A more recent study in the state of Georgia, USA, produced findings that also support the hypothesis of co-occurrence. The 1976 Environmental Corridor Study by the Georgia Department of Natural Resources included an extensive, statewide inventory of intrinsic (natural) and extrinsic (social) landscape resources (Dawson 1995). The study's research method included four steps: 1) resource analysis, 2) corridor selection and priorities, 3) corridor planning and management options, 4) summary and conclusions. The resource analysis was followed with a series of assessments and map overlays that identified the preliminary corridors where the most significant greenway resources were located. These corridors became the priorities for greenway land acquisition. The mapped concentrations of greenway resources led to a statewide greenway plan, which has since begun to be implemented.

Since 1994, the Metropolitan Region of Lisbon, Portugal has been developing a greenway plan (Machado et al. 1995). The plan has developed according to a broad and inclusive understanding of greenway resources, both natural and cultural. This work builds on the earlier work of GonÁalo Ribeiro Telles, in his "Continuum Natural" and the more recent "Plano Verde de Lisboa" which articulated a continuum in which the spatial distribution of natural and cultural resources can be understood in a cultural landscape (Telles 1975, 1997). Telles' work anticipated the greenway concept, and identified the importance of green corridors, where resources are concentrated, to link natural and cultural landscapes in the region, including the city of Lisbon (Machado and Ahern 1997).

In the first phase of greenway planning for the Lisbon Metropolitan Area (¡rea Metropolitana de Lisboa, AML), broad scale spatial databases were used to identify "greenway corridors" where natural resources were expected to be concentrated. The corridors were defined as: coastlines, river and stream valleys, and major ridgelines. Several nationally significant and one UNESCO World Heritage Landscape (Sintra) are located in the AML region. Through spatial overlay analysis these cultural resources were found to co-occur within the "greenway corridors" defined. A large gap in the data existed, however, because the spatial locations of cultural resources were not available for GIS analysis. Working with the Portuguese National GIS agency (CNIG), Ribeiro (1998) compiled a spatially-explicit data base of over 3000 cultural resource sites in the North Bank of the Lisbon Metropolitan Area (AML). Ribeiro's analysis not only identified the corridors in which the significant cultural resources were located, but also articulated the causal linkage with the natural features and regions that influenced the historical development of these cultural resources, and pointed towards strategies for their interpretation in a regional greenway plan. His work also verified the hypothesis of co-occurrence of greenway resources at the regional scale – with particular emphasis on the spatial distribution of cultural greenway resources.

The Minute Man National Historic Park in Massachusetts, USA provides another examination of the hypothesis of co-occurrence of resources in greenways. This park was established along a linear corridor that was determined and delineated for its historical and cultural significance relating to an early battle in the American Revolutionary War. In the context of a multi-purpose planning exercise, it was learned that a very significant

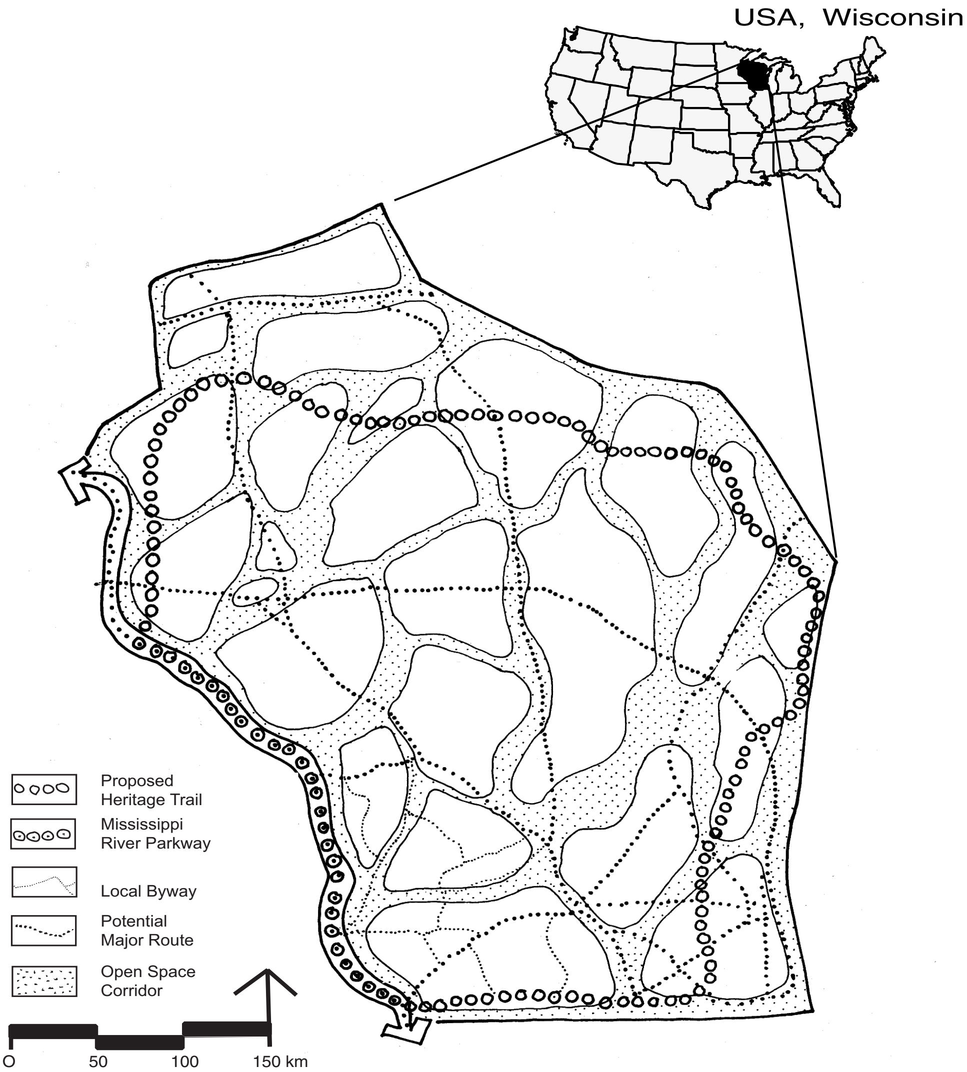

Figure 6.2. Lewis' Wisconsin Heritage Trail Plan, includes over 300 km of Environmental Corridors where ecological, recreational, cultural and historic resources are concentrated. (From Fabos 1985, p. 118).

concentration of biological (rare species habitats, unique or rare ecosystems) and abiotic greenway resources (prime agricultural soils, mature vegetation patches) occurred along the corridor. Subsequently a greenway plan was developed to delineate an interpretive route with the goal of interpreting both the natural and cultural history of the landscape (Gavrin et al. 1993, Ahern 1995).

These selected cases illustrate where the co-occurrence of greenway resources has been demonstrated through planning projects of differing scales and contexts. No contradictory findings were identified in a thorough review of greenway literature. However, it is recognized that additional research, structured by a clear hypothesis and executed in accordance with a consistent and replicable method would yield a necessary examination of the hypothesis. For the purpose of this chapter, it is assumed that the hypothesis of co-occurrence is a reasonable and valid working hypothesis.

Inherent Benefits of Connectivity

Connectivity is defined here as a spatial characteristic of systems (i.e. landscapes) which enables and supports specific processes and functions to occur, through adjacency, proximity or functional linkage and connection. The sustainability of certain landscape processes is dependent on connectivity. These processes include, for example, the movement of wildlife species and populations, the flow of water, the flux of nutrients, and human movement. Given this definition, it is argued here that providing or maintaining connectivity in a landscape supports particular processes and functions that may not otherwise occur. If these processes are beneficial and valued by humans, and are dependent on connectivity to some extent, then it can be argued that connectivity is an important characteristic of, or a pre-requisite for sustainability.

The nature of the "connection" implicit in the term connectivity is a function of the process or function that is being supported. For the flow of water, for example, a continuous, physically-linked system is needed, because water moves according to physical laws under the influences of gravity and topography. For wildlife movement the nature of connectivity is species-dependent. As conscious, mobile organisms, wildlife species demonstrate preference for, or avoidance of, certain landscapes or landscape features (Bennett 1999, Forman 1995). Some species, (e.g. birds) can move across great distances between habitat patches using intermediate "stepping stones" while other species (e.g. mammals) are often dependent on a physical corridor connection to facilitate movement. A habitat network for birds then may be comprised of a series of patches, each separated by kilometers of unconnected landscape. However when the distance between the "stepping stones" becomes too great, connectivity ceases to exist. A corresponding network for aquatic mammals (i.e. river otter *Lutra canadensis*) needs to have a virtually continuous, physically-linked habitat. Connectivity must be understood in terms of the process or function that it is intended to support (Bennet, 1999, Langevelde, van 1999).

A great deal of the literature of landscape ecology addresses the inherent value of connectivity with respect to biodiversity (Langevelde van 1999, Bennett 1998, Forman 1995, Vos and Opdam, 1993, Saunders and Hobbs 1991, SoulÈ 1991, Turner 1989, Schreiber 1988). Much of this literature focuses on the importance of connectivity for maintaining biodiversity in landscapes that are urbanizing, or otherwise experiencing a reduction in area or a fragmentation of species habitat. This argument has been criticized by others who maintain that the benefits of connectivity have yet to be scientifically established, and that connectivity may, in fact, inadvertently enable the spread of disturbance, disease and invasive species, and that conservation funds may be more wisely spent on the acquisition of habitat patches (Simberloff and Cox 1987, Hess 1994). In a recent review article, Beier and Noss articulate a position, based on review of the empirical research, which supports the value of connectivity for habitat corridors in biodiversity protection as follows:

> "The evidence from well-designed studies suggests that corridors are valuable conservation tools. Those who would destroy the last remnants of natural connectivity should bear the burden of proving that corridor destruction will not harm target populations." (Beier and Noss 1998, p. 1241).

This argument is consistent with the "Precautionary Principle" contained in The Rio Declaration on Environment and Development, the comprehensive international policy statement which supports the international goal of sustainability:

> "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. (IUCN 1992, Principle 15)"

The value of ecological corridors has been widely accepted in recent European conservation planning and policy. The European Union's Habitats and Species Directive, adopted in 1992, proposes connectivity via corridors and stepping stones to link and to assure favourable status for species and special areas for conservation (SAC's). The directive includes the plan "NATURA 2000" which identifies the core areas and linkages necessary to maintain favourable status for the SAC's:

> "European Union Member States should endeavour in their land-use planning and development policies to encourage and manage features of the wider landscape which are of importance for wild fauna and flora. Linear features, such as rivers and hedgerows, and isolated elements, such as lakes and ponds, are essential for migration, dispersal and genetic exchange of wild species" (Nowicki et al. 1996).

The more recent "Pan-European Biological and Landscape Diversity Strategy of 1995 was prepared to enable European implementation of the CBD in all Europe It has been signed by 54 countries and is supported by the European Union. The strategy specifically proposes ecological network elements like corridors, buffer zones and stepping stones to reduce the effects of isolation and to increase viability for small areas (Nowicki et al. 1996). This strategy explicitly addresses cultural and economic issues as part of the planning context.

In this manner, they are similar to greenways in spatial organization and function. The spatial planning response to these policy directives and strategies are most often labeled ecological networks, often with rivers and streams as their principle spatial organizing element, or backbone.

> "An ecological network is successful if it sustains biological transition and landscape connectivity at all levels where fragmentation, isolation, and barriers to movements and fluxes occur. Rivers and water flows in general can play an important role in this because of their function in supplying water and transporting sediments, nutrients, and organisms" (Jongman 1998).

Bennet (1999) points to a common confusion between connectivity and corridors, noting that connectivity can be achieved in some landscapes without "corridors" per se. Others define this distinction as functional versus actual connectivity (Langevelde van 1994). This broader, conception of connectivity in landscapes is a characteristic that is more widely accepted, and that is compatible with the greenway concept. National and international plans have been made, and are being implemented, based on the importance of connectivity (Nowicki et al. 1996). The precautionary principle supports this approach.

The time scale needed to scientifically test the efficacy of habitat corridors in large landscapes is decades or centuries. In the time that would elapse during such a study, most landscapes would have changed fundamentally in terms of structure and function. This "moving target" for research creates a fundamental dilemma for landscape planning. How can plans be made to address contemporary concerns and short-term goals with incomplete or imperfect knowledge? The concept of adaptive planning/management offers a conceptual solution to this dilemma. It is a flexible scientific framework for re-conceiving landscape plans, or management actions, as experiments, which may, over time, yield new knowledge regarding the effectiveness of the plan or action. The adaptive approach is well-suited to testing the efficacy of corridors in varying landscapes contexts and for differing purposes (Peck 1998). A rigorous application of the adaptive planning approach is dependent on a proper monitoring protocol, adequate data, a robust analytical design, and a mechanism for the incremental knowledge gained to influence the future planning and management of the landscape in question.

Connectivity in hydrological systems is a key attribute. Water flows across landscapes under the influence of gravity, influenced by vegetation, geology, topography, and human engineering. The physics of hydrological flows across landscapes over time results in the formation of discrete channels and stream networks. These networks have been described as the river continuum in which hydrological, physical and biological processes and structure change according to the position in the watershed (catchment) (Vannote et al.

1980, Naiman et al. 1987). For example, in the headwaters (i.e. low order streams) food chains are based primarily on detritus, water temperature is cool, and stream flow rapid. In the lower sections of the watershed (i.e. higher order streams), the food chain is based on micro and macro-invertebrates, water temperature is warmer, and flows slower. The channels of the river continuum, and their associated border zones of hydrological influence, are together defined as riparian corridors which in most landscapes support a distinct floodplain vegetation adapted to the soil, hydrology and disturbances characteristic of the riparian zones. Riparian corridors contain important longitudinal and transversal ecotones (Pinay et al. 1990). The functions of these riparian ecotones include: movement and retention of nutrients, exchange of organic material, and development of floodplain vegetation. The physical and functional connectivity inherent in riparian systems supports movements of materials and organisms between the main fluvial channel and its secondary channels and oxbow lakes. Through this process, nutrient spiralling, downstream nutrients are absorbed, utilized and released by organisms. Nutrient spirals are linked to regulate longitudinal movement and retention of nutrients in fluvial systems. These movements are critical for fish habitat. These functions are susceptible to interruption through dam or dike construction which can reduce or eliminate the riparian zone bordering the channel, and may interrupt the movement of materials and nutrients downstream.

The riparian zone contains, by definition, the zone of intersection of the surface and subsurface hydrological systems. Riparian corridors are fundamental to Greenways since they provide connectivity, contain many resources, and support multiple uses and functions. Forman argues that riparian corridors anywhere in the world, are “indispensable” for the sustainable functioning of any landscape because the functions they provide cannot be provided by any other means or location in a landscape (Forman 1995).

The laws of physics dictate that hydrological systems cannot be interrupted, since the water that flows downstream must be conveyed in a channel, or it will form a new channel. Human disturbance in riparian zones tends to constrict the channel, and “disconnect” the riparian zone from the channel. In this common case, the channel provides only a conveyance function. The focus of much greenway work is to restore riparian zones along channels, thereby supporting the other functions and processes that occur when a continuous, riparian zone exists. These co-lateral functions include: stabilizing surface and groundwater flows (recharge and discharge), wildlife habitat and movement corridors, nutrient and sediment buffering, human recreation, and support for cultural landscapes. The width of riparian corridor required to support these functions will vary as a function of the order of the stream channel (i.e. watershed position), the degree of human hydrological control, and hydrologic flow and disturbance regime (Forman 1995).

Other benefits of connectivity that can be supported by greenways include alternative forms of transportation, trail recreation, and for the human need/preference for nearby nature and recreation (Kaplan et al. 1998). Comprehensive state-wide greenway plans have been develop that integrate these benefits explicitly (Florida Greenways Commission 1994). Transportation, by definition, involves locomotion between an origin and a destination. Connectivity is essential for transportation to function. Greenways are often planned and implemented to support alternative forms of transportation, particularly pedestrian and bicycle travel. The benefits of this may be significant in terms of traffic reduction, reduced air pollutants, and a healthier population. In many regions of the USA, continuous, integrated bicycle trails are unusual, but when provided, prove to be immensely popular (Flink and Searns 1993). The same kinds of benefits occur from trail linkages. When greenways provide walking trail connections with other trail systems, their level of use and value is increased. Many greenways in the USA begin as single-purpose trail systems.

Perhaps the most abstract benefit of greenway connectivity is the psychological one – of linking people with nature, close to where they live and work. This goal is reflected in the President's Commission Report (1987). Kaplan et al. (1998) address the human need and preference for "nearby nature", to experience the natural world as matter of course in everyday life. Providing this benefit has been shown to improve personal and social health. Historically, human-nature interaction was provided through large parks in cities (Fabos 1995). The greenway concept brings a new strategy to bear on this issue. By establishing "fingers of green" in the urban and suburban areas where people live, a physical connection is made which supports this philosophical or spiritual need for human-nature contact. When the human-nature access links with other resources, the benefits are multiplied in a synergistic manner – at least in terms of space utilization. This provision of multiple benefits is the subject of the next section.

Compatibility of multiple use

The final assertion of this section on supporting theory states that greenways are viable because they provide multiple functions within a specific and often limited spatial area, and that these uses can be planned, designed and managed to exist compatibly or synergistically. This argument is presented in three parts: 1) presumption of compatibility, 2) economic benefits, 3) building base of political support through multiple use.

Presumption of compatibility. The claim that multiple uses can exist within a corridor of protected land presumes some degree of compatibility between the uses, for if the combination of two or more uses compromises the value or function of all, then no net benefit is gained. Testing this presumption is possible when the spatial requirements of the combined functions are well known. For example, protected wooded riparian corridors can provide emergency flood control function and routine recreational and scenic uses. In this case there is an inherent compatibility between the uses, with only an occasional disruption during periodic floods. A more complex, but common, combination occurs when wildlife habitat functions are integrated with recreational access in greenways. Few species' spatial and habitat requirements are sufficiently understood to be represented and modelled in a spatially-explicit manner in greenway planning. Most species are not understood to this degree, making habitat planning a complex and uncertain process. Further, it is important to acknowledge that all habits are not equally adaptable to multiple uses. For example, forest-interior, disturbance sensitive species are difficult to integrate into a greenway plan. When greenway management permits, timing of recreational access can reduce the impact of human presence/disturbance by managing the time, place, and intensity of the use. For example: restricting access during nesting or breeding periods, or restricting access to forest patch margins or perimeter areas.

Economic Benefits. The spatial efficiency inherent in the co-occurrence of greenway resources has an economic dimension. When multiple functions are provided in a single corridor, less land is pre-empted from other uses for these purposes, In addition, there are economic efficiencies in land acquisition, planning, design, management costs and expenses.

The broad economic benefits of protecting land for public use (including greenways) have recently been summarized by the US Trust for Public Land (TPL) (Lerner and Poole 1999). The TPL's report, "The Economic Benefits of Parks and Open Space" identifies three categories of economic benefits related to land protection. Firstly, it is the "Smart Growth" argument. Open land protection promotes more concentrated development patterns, thereby reducing the costs of providing infrastructure for low density, or sprawl-type development. This is a timely issue in the USA where unplanned, decentralized urban development, or "sprawl" is an important issue on the national agenda. Planning for integrated, linked protected lands within new urban developments is promoted as a prime " quality-of-life" issue. Numerous studies cite access to natural areas, and recreation as primary factors in people's preference for residences (Lerner and Poole 1999).

The test of compatibility of multiple uses is fundamental in greenway trails. New expertise is developing regarding the design of greenway trail corridors to support multiple functions, particularly wildlife habitat. Following is a summary of the key emerging concepts relating to greenway trail planning, design and management:

A. Understand trail impacts. Greenway trails have specific zones of influence which need to be planned with awareness of the timing, nature and intensity of trail use, and with the nature of the landscape through which the trail passes.

B. Plan greenway trail routes carefully. Greenway trails should avoid crossing large natural areas. They should follow, not create, disturbance zones around protected core areas. Overall trail density should be kept as low as possible.
C. Understand trail users. Trail users are a diverse and heterogeneous group, each with unique and important characteristics. For example humans, dogs, and horses may all use a trail, and each has particular needs and impacts.
D. Manage trail use. Greenway trail management is an ongoing process, which needs to employ a full range of management actions including trail closure, limits of use, and trail repair and restoration.
E. Monitor trail impacts over time. Begin with an initial biological inventory, followed by monitoring. Enforce trail closures.
F. Involve users and the public with trail management. Develop a sense of stewardship and engage volunteers in trail planning, implementation and management.

(Adapted from: Hellmund Associates, 1998; Smith and Hellmund, 1993; Flink and Searns, 1993).

Secondly, open land protection promotes many forms of economic activity and investment. Parks and open space attract business and residents to communities, stimulating commercial growth, tax revenues and tourism. In many regions tourism is fast becoming the main economic activity. Open space is now recognized as an integral component of a sustainable economy.

Finally, open land protection provides cost-effective means to safeguard the environment, producing a direct benefit for humans. These beneficial functions include: flood protection, water storage and purification, air cleaning, degradation of organic wastes, and reduction of urban heat island effects. These economic benefits can be attributed to any form of protected land, including greenways.

Building a base of political support through multiple uses. When greenways are integral with urban development, the opportunities and challenges for compatible multiple use come to the forefront. Clearly choices and tradeoffs need to be made to optimise any particular use. As these tradeoffs become more explicit and intentional, new knowledge can be generated through monitoring and continued evaluation and research.

The greenway movement has been criticized for following a parochial "parks and recreation" focus. While this historical orientation produced many notable results and successes in rural areas, it reached its limits in urban areas. When greenways are conceived to provide multiple benefits, they hold the potential to engage multiple political constituencies in their implementation. This has proven to be an effective strategy in successful implementation of greenways in multiple cases across the USA (Erickson and

Louisse 1997, Quayle 1995). In the USA the tradition of planning for land protection is much more developed in remote and isolated, spectacular landscapes, than it was in urban centres and regions, particularly within metropolitan areas.

Once realised and implemented, multipurpose solutions hold a greater potential to endure over time, as demographics, economics, environmental issues and landscape context change. In this respect, it is interesting to compare multipurpose greenways, with greenbelts. The former are inherently multipurpose, the latter tend towards single purpose, i.e. to contain urban expansion around urban areas. The greenbelt concept, because it was based on political boundaries and not on natural features, became vulnerable to land use change, effectively becoming a "bank" into which undeveloped land was held until development pressure demanded its use. In Canada's capital city of Ottawa, a greenbelt was established in 1950 as part of a regional plan. The greenbelt was incrementally compromised as pressure for land use change mounted over time (Taylor et al.1995). In contrast, greenways that support multiple functions, inherently enjoy a broader base of political support, and are therefore more sustainable over time.

In summary, the compatibility of uses in a multi-purpose greenway is dependent on:

1) Social values: The relative importance of the functions supported in the greenway which reflects social values. For example, one community may favor water resource benefits, while another may favor recreational uses. In a democratic society, a greenway is ultimately a social policy and action which reflects prevailing social values.

2) Resources: The physical, biological and cultural resources contained in the greenway which determine its ability to support a specific suite of multiple uses.

3) Inherent compatibility: The sensitivity or compatibility of the greenway use/ purpose with respect to other uses, i.e. nature protection and recreation, versus recreation and cultural landscape protection

Historical Development of Greenways in the USA

A brief historical review of greenways in the USA illustrates an evolutionary process which parallels and reflects innovations in American landscape planning. In the public domain, vast areas of public land were added to the US National Park and US Forest systems over the last two centuries. These actions involved large pristine areas, far from human populations which came under public control. Despite the monumental amounts of land

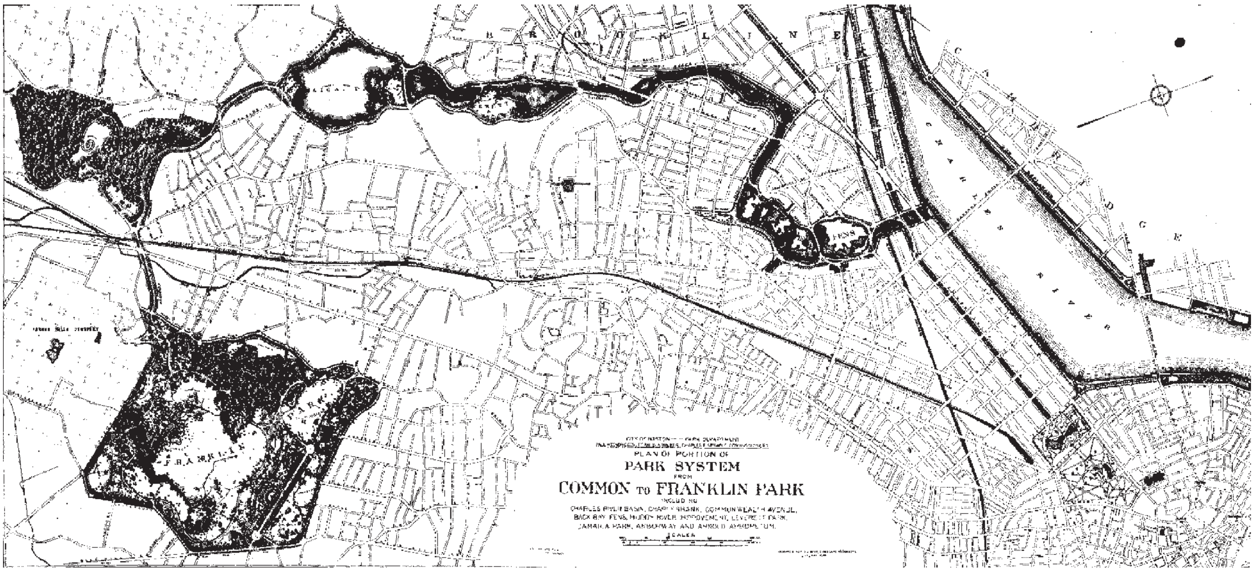

Figure 6.3. Frederick Law Olmsted's "Emerald Necklace" Plan for the Boston Park System, the first greenway in the USA , 1880's. The black structure represents the Emerald Necklace, totally situated within the urban area of Boston

involved, this was a relatively easy task because much of the land was never released from federal control, and much of it is mountainous and arid, thus less suitable for agriculture or urban uses. Greenways are quite different from these national parks for they focus on linear areas, are more often located near population centres, and they are managed for multiple uses. This review articulates the issues, theories and policies that led to the development of greenways and serves as a basis for understanding their present situation and potential for future development.

Most of the literature on greenways points to their evolution from urban design concepts of the 19th century, including boulevards, axes and parkways. Searns (1995) labels these as first generation, or ancestral greenways. The first true greenways originated from the metropolitan open space systems of the late 19th and early 20th century (Fabos 1995, Newton 1971, Zube 1995, Smith and Hellmund 1993). These were "systems" in the sense that they involved a spatially-linked network of mostly linear publicly-owned lands. They were usually based on topographic and hydrological patterns in the landscape. Foremost among these systems was a built plan for the Boston Park System by Frederick Law Olmsted, Sr. (ca. 1880's). the father of landscape architecture in America. His later work involved his sons as partners (Zaitzevsky 1982).

The Olmsted's plan for the Boston Park System, known as the "Emerald Necklace" is regarded as a model of integration of existing protected lands, ecological corridors, and built linear elements (Figure 6.3). The system largely functions today to provide recreation,

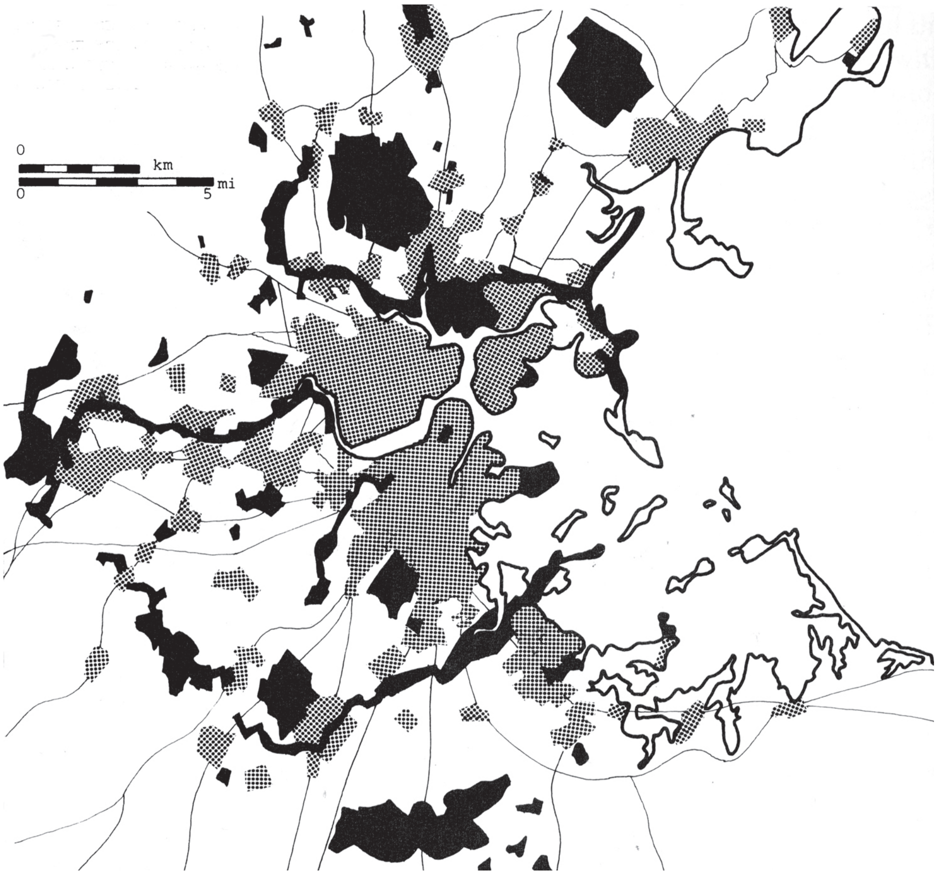

Figure 6.4 Charles Eliot's Metropolitan Boston Park System, circa 1899. Courtesy Fabos, 1985, Legend: black: Metropolitan park system, grey: built-up areas.

transportation, water quality and flood control, scenic amenity, and wildlife habitat. The "necklace" is a fine example of a simple, yet powerful and enduring spatial planning concept. Under Olmsted's hand, several other American cities embraced this concept of linked linear parks including, Washington D.C., Minneapolis, Kansas City, Buffalo, and Cleveland (Fabos et al. 1968).

The next historically significant greenway was the Metropolitan Boston Park System, in the 1890's, planned by Charles Eliot, a protege of Olmsted (Figure 6.4). Eliot's work greatly expanded Olmsted's "emerald necklace", by creating a regional open space system, or greenway, structured by five principal landscape types which closely resemble contemporary greenway elements: ocean fronts, river estuaries, harbour islands, large forests, and small urban squares.

Benton MacKaye (1928) expanded Olmsted and Eliot's urban park system concept in his book *The New Exploration*, in which he advanced, for the first time, the idea of a metropolitan system of protected lands conceived and configured to control urban expansion. Influenced by the earlier work (1898) of Ebenezer Howard in England, using the analogy of river, he identified topographic ridges as "levees" to contain and control the "flow" of metropolitan urban expansion.

The environmental planning movement of the 1960's marks the next significant development towards greenways. Ian McHarg's *Design with Nature* (1969) raised international awareness of the need for an ecological basis for planning and advanced a widely adopted method to accomplish it. McHarg argued that the major landscape planning issue was that of influencing the pattern of distribution of occupied and protected lands, not their absolute or relative areas. The work of Phil Lewis mentioned previously integrated environmental planning through his "Wisconsin Heritage Trail Proposal" (Figure 6.2).

The greenline concept of the 1970's introduced a new idea in land protection and management based on mixed public-private ownership. Greenline parks are mixed mosaics of public and private lands not defined exclusively by public ownership but rather by a "green line" on a map. This idea, based on the national parks of England and Wales, responded to decreased federal funding for land acquisition, and the awareness of the need to protect open space within urban and metropolitan areas (Zube 1995a). The greenline parks were represented by the Adirondack Mountains in New York, the New Jersey Pinelands, and many urban recreational areas within or adjacent to major cities.

As the concept of greenline reserves evolved, its emphasis shifted from large, park-like reserves to linear corridors including historic canals, railroads, and rivers. This was largely due to an emphasis on riparian corridors responding to the unprecedented expenditure made by the federal government to clean America's rivers in the 1960's. The effort brought attention to the problems of water pollution, and then when the rivers were once again clean, their recreational potential was rapidly rediscovered and developed. The wild and scenic rivers act of 1968 provided additional protection for rivers, wetlands and coastal zones, adding further interest to innovative models for the protection of linear landscape features. There was an emphasis on trail-oriented recreation during this period, which Searns (1995) labels the second generation of greenway evolution. Greenline reserves have evolved further into a planning/management entity known as National Historic Corridors (NHC), of which there are currently over 15 in the USA. NHC's are essentially greenways because they are comprised of linear areas, they are spatially integrated and are managed for multiple uses. These third generation greenways (Searns 1995) are truly multi-objective and demand an interdisciplinary planning and design approach.

In the 1980's, the loss of open space and increased need for recreation in urban and metropolitan areas focused attention on greenways. The President's Commission on Americans Outdoors (1987) found strong support for greenways to address the need for additional open space and recreational land and proposed a national system of greenways (see introduction).

Greenways have evolved into a flexible multipurpose model for landscape planning and resource protection. In contrast with the "crown jewels" of the US National Park System (i.e. The Grand Canyon, Yosemite) greenways protect "working" landscapes in cities and regions where people live and work. The strategic nature of greenways suits them well to situations where land use must be spatially-efficient and multiple uses are essential to gain political and economic support. The continuing evolution and adaptation of greenways is discussed in the following section on contemporary trends.

Contemporary Trends

Although USA greenway history can be traced back over one hundred years, it is clear that greenway activity has never been as effective as in the contemporary time. An examination of this recent greenway activity is useful to understand the continuing evolution of greenways, to identify opportunities for applications and future research needs.

To gain a more accurate understanding of the nature, extent and location of greenway planning across the US, a national survey of greenways was conducted by the University of Massachusetts, from 1996-1998. The survey was designed with the primary goal of identifying the nature and extent of greenways and greenway planning, at the state level, across the USA. The survey was conducted with assistance from the American Greenways Program, sponsored by the Conservation Fund (Washington, D.C.). Officials from each state were given a standardized telephone interview followed with a written request for information and responses to specific questions.

The survey found that while 48% of the states supported the concept of greenways, an equal number (48%) were not familiar with greenways at all. Not surprisingly, therefore, only 24 % of the states had an official greenway plan, with 68% indicating that there was no plan. A similar response was obtained regarding the existence of a mapped inventory of greenways: 24% responded yes, 62% no and 14% did not know if such an inventory existed for their territory. The survey also found a trend regarding the spatial distribution of greenway planning across the USA. Greenways were found to be most popular in the east and northeast where the states are small, population density is high, and the percentage of publicly-owned land is low. The results of this survey also indicated that greenways are often initiated to support trail and recreational use, but evolve to support multipurpose planning objectives. Finally, the survey found that greenways are increasingly integrated with comprehensive statewide planning.

The Rails-to-Trails Conservancy (RTC) has been active in greenway and trail creation since the 1980's. In the decade from 1988 to 1998, RTC helped to convert over 10,000 miles of abandoned railroads to greenway trails. Another recent greenways-related activity occurred in1999 when the White House, the US Department of Transportation and the Rails-to-Trails Conservancy established the Millennium Trails Program. The goal of the program is to recognise, promote and stimulate the trail movement in the USA and to reconnect communities with trails. Under this initiative, trails are designated in three categories: National Millennium Trails (12), Millennium Trails (52) and community trails (1,000's). This program will advance trail-based greenways, increase public awareness of all greenways, and most likely will inspire future greenway development.

At the regional level, the most significant greenway planning effort to date is the New England Greenway Plan (Fabos Ryan and Lindhult 1999). The plan coordinates greenway planning for all six New England states with a combined land area of over 42 million acres (ca. 16 million hectares) (Figure 6.5). The plan, prepared in collaboration with the American Society of Landscape Architects, builds on the tradition of Frederick. L. Olmsted Sr., Charles Eliot, and Benton MacKaye who worked extensively in New England. The plan was prepared through a coordinated, decentralized effort which integrated locally with state-

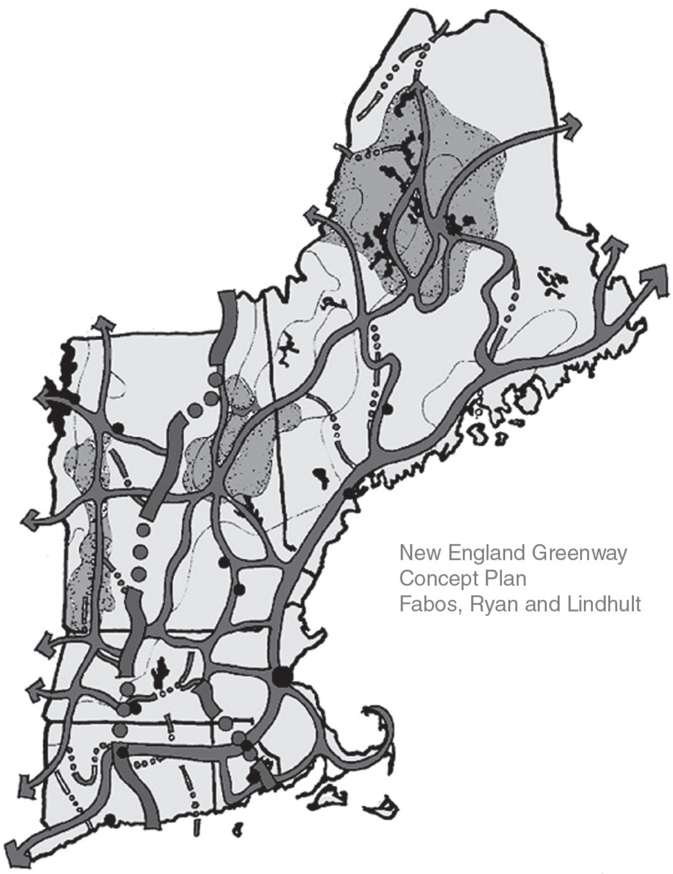

Figure 6.5 New England greenway Vision Plan (Fabos, Lindhult and Ryan 1999)

wide plans. Using GIS, the vision plan integrates single purpose plans for nature protection, recreation and historic and cultural resources. The plan emphasizes linear features, the importance of connectivity, and the imperative for multiple uses.

Conclusions and prognosis

Greenways represent an efficient and strategic method for protecting the most resources with the least amount of land (the hypothesis of co-occurrence). The connectivity inherent in greenways supports numerous biological, physical, and cultural landscape functions that are important for sustainability. Within a spatial network of important and connected lands, greenways are planned and managed to support multiple compatible uses, thus assuring a broader base of political support and increasing the probability that the greenway lands may remain under protection for the future.

Greenways are becoming a popular international movement (Fabos and Ahern 1995). The theory of greenways and greenway planning presented in this paper provides a rational basis for supporting greenways, and identifies future opportunities for application, and needs for research. It is argued that these three ideas provide a rational basis of support, supported by published literature and case studies that transcend political context or geographic location.

Greenways is a strategic planning concept that has evolved over the past century in the USA in response to changing environmental, cultural, political and economic factors. The proliferation of decentralized urban sprawl has motivated interest in alternative planning models and methods. Greenways addresses this need through its strategic approach, its record of successful integration of top-down and bottom-up approaches, and for its emphasis on physical and organizational linkages. Physical linkages offer distinct advantages in terms of movement and transport of materials, species or nutrients. Greenways also provide a social and political network which integrates people with diverse values and perspectives concerning land use and planning. This is perhaps the most significant characteristic of greenways, and distinguishes greenways from other landscape planning concepts.

The continued evolution and implementation of greenways is likely to produce three significant changes in the future:

Greenway planning will change the ways in which local and higher-level planning is coordinated and implemented. A major driver of this change is the emphasis on corridors, and the assumed value of connectivity which together emphasizes the need to link local plans to their larger landscape ad regional context. This coordination will be accomplished, in part, through a new suite of land use controls and design guidelines in lieu of public ownership of land.

Greenways will inspire and motivate a new generation of partnerships and collaborations among individuals and organizations that formerly had some common interests, but with little record of cooperation. (e.g. wildlife habitat and recreation, tourism, water resources). As Zube stated "partnerships are a way of life in greenways" (1995). Formal agreements for planning and technical assistance and for interagency and intergovernmental coordination will become more the norm than the exception.

Finally, greenways will promote an adaptive approach to the dilemma of landscape planning and management. While greenways will continue to apply the best available empirical knowledge and theory from landscape ecology in decision making, this knowledge, with respect to specific places and processes is inherently uncertain and incomplete. At the same time, social, political and environmental changes demand that actions are taken. The adaptive approach to planning and management offers a solution to this dilemma. Planning and management decisions can be re-conceived as experiments, with the potential to add new knowledge as a result of their application. Greenways are well suited to this adaptive approach.

7 Conclusion

Context of Greenway Planning Research

Within the broader field of landscape planning, greenway planning focuses largely on the integration and application of landscape ecology theory and knowledge. This is due to the fact that landscape ecology is an interdisciplinary field including the biological, physical, and social sciences, and the professional disciplines of landscape architecture, forestry, planning and related fields. Landscape ecology developed to address the need for interdisciplinary knowledge about landscape structure and function and for communication of that knowledge for informed planning and decision making. The infusion of new knowledge, theories, and concepts from landscape ecology has had a profound impact on the knowledge base of landscape and greenway planning. This research has reached beyond landscape planning to learn about landscape ecology - specifically what are the key concepts, theories, principles, and how can they be applied in greenway planning and design.

This research asserts that that greenways and ecological networks provide a useful theoretical and spatial framework for comprehensive landscape planning. Much of the research has been conducted at the broad, or landscape scale, and is based on planning – that is on formulating policies and spatial plans to guide land use change and landscape protection. Although focused on planning, the research does have significant implications for design, as the broader landscape structure resulting from planning provides the context in which designed forms and spatial sequences reside. The theoretical basis for planning and design is largely based on landscape ecology. A general consensus is emerging in landscape ecology that a system or networks of connected patches, corridors, and large areas is essential to achieve a sustainable landscape condition, by supporting essential ecological processes. This has enormous significance for landscape architecture and landscape planning. Based on a fundamental understanding of ecological interactions between physical pattern and ecological process, landscape ecology provides the scientific foundation for this work, but is actually only a new point of departure. How useful, or accurate is this scientific information? What do planners and designers need to know about ecology? or about landscape ecology? Cultural and aesthetic issues need to be addressed in a comprehensive landscape planning approach, and scientifically derived knowledge must be complemented with creative insights and design proposals. Landscape ecologists are not planners, and landscape planners are not ecologists, yet the participation and cooperation of both is required to formulate and to implement sustainable landscape plans. Communication between these disciplines is complex and challenging. The will and intention to communicate and collaborate has been present for some time, yet the reality unfortunately shows little of substance achieved in such integration to date. Perhaps the challenge of interpreting sustainability, and manifesting it in real, physical places in the world will inspire the next level of reciprocal collaboration.

The paradox of uncertainty is inherent in the challenge to apply landscape ecology theory to contemporary plans. By definition, ecological systems are place-specific, that is, their structure and function is determined by the specific locus, in its most particular and physical, biological and cultural sense. While place-specific knowledge is often incomplete, planning and design decisions and actions are virtually always made for specific places. Planners and designers operate under an imperative to act. Even more, planners must anticipate, and make preparations for future actions. They plan so that designers and managers can act. If data and knowledge is inherently uncertain for the present, surely it is even more so for the future. Uncertainty is a fundamental paradox in planning, for even while reducing uncertainty is a core purpose of planning, all planning decisions are made in the face of some uncertainty.

To address this paradox of uncertainty, I have advocated and applied the concept of adaptive management to ecologically based landscape planning to complete a "knowledge feedback loop" in which planning and design actions are understood as tools for testing hypotheses, assumptions and for ultimately generating new knowledge. When planning operates within an adaptive paradigm, it explicitly acknowledges uncertainty, makes decisions, and takes actions, which are thereby reconceived as experiments. That is to say these planning "experiments" can follow protocols for experimental design, and if monitored properly for sufficient time, and analyzed critically, they can yield new knowledge. This completes an adaptive "knowledge feedback loop" in which the need to act in the face of uncertainty drives experiments which , in turn, add new knowledge that can reduce uncertainty. Presumably, with this new knowledge more sustainable and designs can be made.

Landscape ecology and landscape planning have been more widely practiced in Europe than in North America. The European tradition is well represented in the literature, and is particularly active in contemporary academia and in professional practice. I have collaborated extensively with European landscape planners in my research. Foremost among many are those at the Wageningen University, where I have maintained a close working relationship with the landscape architects/planners who have helped me to understand and to integrate the Dutch planning theory and applications in several publications. From Klaas Kerkstra I learned of the framework concept and its potential application in greenway planning. Kerkstra also challenged me to address the tension that is inherent in a nature:culture duality, and to ask probing questions about the definition of nature. Rob Jongman, introduced me to ecological network concepts, at a range of scales, and the landscape ecology of rivers. Meto Vroom offered perspectives on the Dutch landscape that helped me to understand its inherent paradox and contradiction, and the role of landscape architects in this complex, and unique post-agricultural, post modern landscape where anything is possible. Michael van Buuren introduced me to the hydrological framework concept and its application in landscape planning. Peter van

Bolhuis showed me the Dutch landscape through the eyes of a designer, artist and historian. The late Nico de Jonge, shattered my illusions of quintessential romantic Dutch town planning and design. He showed me stunning mature "man-made" landscapes that he helped to create a half-century earlier. These individuals, among many others, awakened my landscape perceptions and gave me an informed, and critical perspective on the Dutch landscape, and in turn, on own home landscape in the USA.

During the period of this research, I have also had an extensive involvement with Portugal, including greenway planning in the metropolitan areas of Lisbon, Porto, and Coimbra. Portugal a very different context for planning and design, than The Netherlands, or the USA. The last decade has been a period of intense development of urban infrastructure, supported largely by the European Union. During this period, Portuguese national policies appeared to facilitate this unprecedented urbanization. In this context, greenways was introduced and fell on receptive ears in academia and with planning professionals. Our greenway work in the metropolitan areas of Lisbon (1994), Porto (1997) , and Coimbra (2001) introduced the greenway concept, and its potential to protect strategic corridors where resources are concentrated. The greenways concept is presently spreading widely in Portugal.

Working in the USA and Europe over a period of time reveals key differences and tensions. In Europe, "landscape" is a more complex and integrated concept than in the USA. Nature and culture are interdependent, and largely indistinguishable in Europe. Certain biotic communities, like heathlands, have co-evolved under human influence over centuries – thus confounding the differences between "natural" and "cultural " landscapes. This has led to a contradiction in European environmental attitudes: is wilderness a part of nature creation? Or is wilderness an artifact that cannot (by definition) be created by humans? To further complicate the issue, many European forests are "plantations" monocultures, of intentionally selected species – offering only a subset of the potential ecological, aesthetic and cultural benefits.

In the USA, perceptions of landscape are still inseparable from the historical wilderness myth, and from the belief in unlimited resources to support human needs. Not surprisingly, this shared perception leads to an active disinterest in planning. A notable exception are those regions where explosive contemporary urban development has pushed the landscape over the threshold of sustainability, resulting in ecological crises (e.g. Florida, Southern California).

In Europe and in the USA there is, arguably, an undercurrent of anti-urbanism in greenways and nature development plans. The origins of this attitude can be traced to Medieval and Renaissance conceptions of nature in Europe: alternating between pro-urban views : nature as raw and uncivilized, and the town as an improvement on nature - and anti-urban views "god made the country-man made the town". The ancient pastoral landscape ideal has survived into contemporary culture in Europe and in the US. Under this view, nature is understood as not only more beautiful than human creations (i.e. town) but is also imbued with moral, spiritual, and philosophical values. These deep cultural values underlie contemporary landscape planning, particularly with respect to agriculture. In much of Europe, agriculture is inseparable from landscape heritage and patrimony. Indeed certain species are dependent on agricultural habitats. Ironically, contemporary intensive agriculture is also responsible for much habitat loss and pollution. While landscape ecology provides the tools for understanding the biophysical aspects of nature, and agriculture in the contemporary world, tools for understanding the cultural and aesthetic aspects remain largely absent from contemporary landscape planning. The challenge for sustainability in future landscapes demands that this inherent dilemma between nature:culture be more deeply understood and addressed. Perhaps the greenways strategy will prove to be a useful one to address this issue.

Ironically, I see a convergence in philosophy and attitude towards "landscape" in Europe and the USA. The last half of the 20th Century saw much of urban Europe redeveloped, and much of the rural landscape intensified for agricultural production. Over the same period, landscape ecology evolved, and matured in Europe lending new awareness and understanding of this new "post-modern" landscape. In response to a recent understanding of the ecological consequences of this new landscape condition, and in support of the global paradigm of sustainability, parts of Europe are now deliberately "reintroducing nature" to the landscape according to the best scientific knowledge. Landscape ecology is "put to work" to make new plans for "nature". Because of a decentralized growth pattern in the urbanized regions of the USA, landscapes have reached an advanced stage of fragmentation nearly concurrent with Europe. The driving processes are different in Europe and the USA, but the ecological consequences are similar, excessive nutrients and pollutants flow across the landscape, habitats are fragmented and isolated, and broad scale, slow dynamic processes begin to fail. Landscape ecology provides the descriptive and analytical tools to understand the spatial, and temporal dynamics of these landscapes. Planners and designers provide the prescriptions and strategies. My typology of planning strategies (protective, defensive, offensive, opportunistic) is useful to understand the similarities and difference between these cultures, and points to methods for adopting and adapting other's planning and design strategies in one's own landscape. Greenways is arguably a concept that can find different but appropriate expression in either context.

The research contained in this dissertation contributes to a growing body of academic knowledge to support greenway education, planning, and implementation. Greenways are gaining international popularity annually. The International Greenways Association has recently sponsored two international conferences. The European Greenways

Association is quite active, and is gaining member countries each year. Greenways in the USA have been popular for over a decade. In spite of this impressive popularity, greenways literature has been extremely limited. Chapters and articles included in this dissertation are part of a recent flow of scholarly publications that address greenway theory, planning and implementation. These publications include books, special journal issues, and conference proceedings. In the aggregate, these publications articulate greenway theory, establish an intellectual link with landscape ecology, and offer new procedures and methods to conduct greenway planning in diverse landscape contexts. The chapters included in this dissertation represent an original contribution to this body of literature.

The publications included in this dissertation have benefited from collaborations with students, fellow landscape architects, and scientists. Many of the case studies and case applications included were completed with the participation of landscape architecture students at the University of Massachusetts. The research contained in the chapters was first presented at national and international symposia and conferences on landscape ecology and landscape architecture. These events include: International Association for Landscape Ecology (IALE) World Congress 1995, Toulouse, France; IALE World Congress, Snowmass, Colorado, 1999; International Symposium on Man and Nature, Kunming China, 1999; Environmental Challenges for an Expanding Urban World, Caparica Portugal, 1997; GIS PlaNET, Lisbon Portugal, 1998; and United States – Division of IALE Symposia of 1995, 1996, and 1998, 2000, and 2001. My work has benefited from comments and discussions resulting from these discussions.

Much of this work has been conceived and conducted in an integrated educational and research environment. As such, the findings and methods contained in the work, are explicitly aware of, and inseparable from pedagogy – for university instruction, and for the professional training of planners and landscape architects. The case study and case application methods used have proven to be effective pedagogical approaches. The emphasis on pedagogy in the course of the research has resulted in an effective model for the transfer of knowledge from landscape ecology to landscape architecture and planning. This is achieved through explicit reference to theories and principles from literature and case studies and to criticism and public discussion and debate on theory and its application in a studio teaching setting.

Original Contributions of the Research

Chapter 2 Spatial Concepts, Planning Strategies and Future Scenarios: a Framework Method for Integrating Landscape Ecology and Landscape Planning

This work was published as a chapter in the book*: Landscape Ecological Analysis: Issues and Applications,* edited by Jeffrey Klopatek and Robert Gardner in 1999. The volume is a compilation of invited, peer-reviewed contributions presented at symposia of the U.S. Division of IALE in 1996 and 1997. As stated in the editors' preface:

"The final chapter in this section (Planning Strategies) attacks the problem of sustainable landscape planning. Ahern uses the experience and methods derived from European landscape architects to integrate the disciplines of ecology and planning into landscape ecology. He argues that the landscape scale is the only viable unit for sustainable planning" (Klopatek and Gardner, 1999, p. vii).

This volume, including the Ahern chapter, represent a significant and recent contribution to the contemporary literature of basic and applied landscape ecology.

The chapter includes a through review and analysis of landscape planning theory and methods, articulating an evolution towards a landscape ecologically based approach. The landscape ecological approach is defined, articulated and distinguished from earlier methods. A fundamental distinction is made in terms of the integration of topological and chorological approaches that are characteristic of a landscape ecological approach. The landscape scale is defined and advanced as the appropriate scale at which to engage the challenge for sustainable landscape planning because it is sufficiently broad to include diverse, heterogeneous landscapes, yet manageable and familiar in terms of plan formulation and implementation.

Spatial concepts are introduced in the context of landscape planning. Through spatial concepts rational knowledge is complemented with creative insights, and human knowledge is re-conceived as a potentially positive ecological process, rather than a destructive force to be regulated. Spatial concepts are familiar in Dutch planning, but still a rather radical idea in American landscape planning. The framework concept is defined as a spatial concept that builds on landscape ecological theory, emphasizing the biotic and abiotic value of connectivity, particularly with respect to hydrological networks. The framework concept bears great similarity to greenway planning.

The theory and application of scenarios are systematically reviewed from the perspective of landscape ecology. Scenarios are offered as important tools for linking planning goals with potential future spatial changes. They also feature prominently in the chapter's framework method for landscape ecological planning. This method integrates abiotic, biotic, and cultural goals; spatial concepts, scenarios and adaptive management in an iterative, continuous planning process. The framework method is the principal contribution of this chapter, and one of the main original contributions of this dissertation.

Adaptive management is discussed here as an essential, strategic response to the dilemma of applying landscape ecology in planning. Through adaptive management, landscape ecological plans can be implemented as experiments, which in turn, have the potential to yield new knowledge and understanding.

The final contribution of the chapter is a case application of the framework method to a landscape plan for the town of Orange, Massachusetts. In this plan, abiotic, biotic, and cultural resources are assessed, and spatial concepts are designed and applied in alternative scenarios for the town.

Chapter 3 Greenways as a Planning Strategy

This chapter was originally published as an article in a special "Greenways Issue " of the international journal *Landscape and Urban Planning* (1995). This issue, co-edited by J. Fabos and J. Ahern, included 25 peer-reviewed articles from authors representing five countries in North America and Europe. Because of the magnitude and significance of this work, the journal's publisher, Elsevier, republished the special issue as the book *Greenways: The Beginning of an International Movement* in 1995. The journal issue, and book, arguably represent the most comprehensive, scholarly international investigation of greenways to date.

"Greenways as a Planning Strategy" is an introduction and overview to the main section of the book on greenway planning. The chapter begins with greenways definitions, and presents arguments in support of and opposed to greenways. It continues with a discussion of contemporary ecologically based planning programs and concepts. The chapter argues that while these activities carry differing labels and names, they share fundamental similarities. These similarities are then organized into an original typology for greenway classification. The typology is based on: scale, goals, landscape context, and planning strategies. The planning strategies defined: protective, defensive, offensive, and opportunistic, represent a significant original contribution to American planning theory, significantly informed by the European traditions of planning. The typology is an important contribution to the international scholarship of greenways for it provides a common basis for communication, collaboration, and sharing of research findings and new applications methods.

The greenway typology is then applied to three case applications from the Netherlands and the USA, selected to represent a range of greenway types, and to articulate similarities, differences, and to explore the transferability of knowledge and concepts. The case study approach provides an original examination of diverse approaches to contemporary landscape planning, across a range of scales and landscape contexts. Through this discussion, greenways are argued as a useful strategy for planning, design, and management of sustainable landscapes.

Chapter 4 Greenways as Ecological Networks in Rural Areas.

This chapter was published in the 1994 book *Landscape Planning and Ecological Networks* edited by E. A. Cook and H.N. van Lier. The book belongs to the ISOMUL Series (International Studygroup on the Multiple Use of Land) published by Elsevier. In the forward, the editors state:

> *"The adaptation and application of the spatial concept of ecological networks promise to become a major approach to solve problems of sustainability of our natural resources for future generations" (p. xiv).*

My contribution makes the link explicit between the powerful spatial concept of ecological networks and greenways.

The chapter argues that greenway planning should be integral to a comprehensive landscape planning process, including consideration of: development suitability, open space resources, wildlife habitat protection, and scenic resource management. An original method is proposed for assessment of these resources and for applying the results in a sustainable planning approach. In this larger context, greenways may be seen as the connecting elements in a network which links protected lands. This chapter reviews the relevant literature from landscape ecology and landscape planning, and argues for the use of landscape ecological theories in sustainable landscape planning.

A case application of the greenway approach is made in the "Quabbin Reservation to Mount Wachussett Reservation" study in central Massachusetts, USA. This project was one of the first contemporary test applications of the ecological network/greenway concept in the USA. The application includes an early test of scenarios to explore alternatives: evaluated from the perspective of of target species. The chapter presents a suite of tools for greenway implementation: as a necessary step in realizing the potential of the greenway concept. These tools are also evaluated for their efficacy in implementing each of the two scenarios presented.

Chapter 5 Time Space, Ecology and Design: Landscape Aesthetics in an Ecological Framework in the Netherlands

This paper was selected through a competitive, peer-reviewed selection process to be presented at the symposium "Ecology, Aesthetics, and Design." The symposium was sponsored by the American Society of Landscape Architects (ASLA) Council of Education, in cooperation with the Council of Educators in Landscape Architecture (CELA). The proceedings included seven papers that were selected from thirty five papers submitted to be presented at the symposium. The symposium was conceived to:

> "Öaddress the urgent and complex challenges in developing, restoring and conserving our ecological resourcesÖ" (p. i) .

The Ahern and Kerkstra contribution to this symposium starts from the premise that landscape aesthetics should support and provide visible expression of the concept of sustainability. Recent international agreements on sustainability are perhaps the closest the world has ever come to a consensus on environmental policy, and provide a sound conceptual foundation for developing a new landscape aesthetic. The paper asserts that landscape architecture is uniquely poised to address the challenge of sustainability in the realms of both planning and design, at multiple scales, by advancing a landscape aesthetic and spatial strategy based on a greenway network, or framework of protected lands.

The paper presents a series of recent case applications in planning and design from The Netherlands to support these arguments. Featured among these are the framework concept, based on a durable network of "low-dynamic uses" that support long term ecological patterns and processes. The interstices of the framework, then, are available for the "high dynamic" uses, supporting social and economic needs and resources. The Plan Ooievaar is presented as a case study in which the framework concept has been adopted and implemented at the national level and in a local pilot project for river restoration, the Blauwe Kamer. These theories and applications, well known in The Netherlands, were new ideas to the American audience. The presentation of these ideas offers an interesting and contrasting approach that inspires and challenges conventional planning theory and practice.

The framework concept is presented as a type of greenway. The paper argues that the framework concept provides a context for cultural and aesthetic expression, and that by so doing, supports a broad conception of sustainability. Additional examples from Walcheren, Netherlands are given to support this assertion.

Chapter 6 Greenways in the USA: Theory, Trends and Prospects

This chapter is based on a presentation made at the 1999 World Congress of the International Association for Landscape Ecology (IALE) in Colorado, USA. The chapter has been accepted (June 2001) for publication in the book:
New Paradigms in Landscape Planning: Ecological Networks and Greenways, edited by R.H.G. Jongman and G. Pungetti featuring the papers presented at the IALE greenways symposium.

This paper identifies three fundamental principles that support greenways: 1) The hypothesis of co-occurrence of resources in greenways, 2) The inherent benefits of landscape connectivity, 3) The concept of compatible, or synergistic multiple use in greenways. This paper asserts that these three fundamental greenway principles derive from landscape planning theory; are supported and strengthened by emerging landscape ecology theory; and that their application as greenways supports the contemporary international policy goal of sustainability.

The paper identifies contemporary greenways trends based on an original survey which found that: 1) Greenways are increasingly integrated with comprehensive landscape planning at the state level in the USA, and 2) Greenways are often initiated to provide trail and recreational use, but evolve to support multipurpose/multi-functional planning goals and objectives. A future prognosis for greenways in the USA is offered including an expected shift from locally initiated to regional and interstate greenway planning and implementation, and more explicit integration of multiple uses in greenways.

Evaluation of the Research Propositions

As discussed in the introduction, this dissertation has been structured to address five research propositions. The linkages between the chapters and the propositions were described in Chapter 1, and summarized in Table 1. The sections below, briefly evaluate the extent to which each proposition was supported in the chapters.

Proposition 1. Greenways offer strategic advantages for sustainable landscape planning.

Chapter 2 "Spatial Concepts, Planning Strategies and Future ScenariosÖ" argued that the landscape scale is the most appropriate for sustainable landscape planning because it addresses dynamic spatial processes at the scale at which plans can be made, and discrete action(s) taken. Because greenways exist at the landscape scale, they hold the potential to support sustainable landscape planning.

Chapter 3 “Greenways as a Planning Strategy” defines and discusses many international activities which apply landscape ecology principles and theories towards the goal of sustainable landscape planning. While many of these activities are often not explicitly classified as greenways, when organized according to an original typology they share many of the key characteristics of greenways.

Chapter 4 “ Greenways as Ecological Networks in Rural Areas” links greenways with ecological networks which are presented as important spatial concepts for sustainable planning. Greenways, like ecological networks possess inherent strategic advantages because of spatial characteristics and multi-functional uses.

Chapter 5 “Time Space, Ecology, and DesignÖ” defends the framework concept as an effective strategic approach for sustainable landscape planning, because it offers a spatial solution to the need for both high and low dynamic areas in sustainable landscapes.

Proposition 2. Landscape ecological principles provide new perspectives which are fundamental to greenway planning.

Chapter 2 “Spatial concepts, planning strategies and future scenariosÖ” reviews the development of theory in support of landscape ecological planning. The chapter asserts that the key factor distinguishing landscape ecological planning from earlier methods is the integration of topological and chorological approaches. The latter is particularly related with horizontal landscape processes supported by greenways (hydrological flows, species movements).

Chapter 3 “Greenways as a Planning Strategy” applies theories and principles of landscape ecology to define greenways and to argue for their benefits.

Chapter 4 “Greenways as Ecological Networks in Rural Areas” presents a conception of greenways that is fundamentally linked with landscape ecology theory, particularly island biogeography, as it relates to connectivity to support species movement in fragmented landscapes.

Chapter 6 “Greenways in the USAÖ” argues that connectivity is one of three fundamental theoretical greenway principles, and that the understanding and significance of connectivity in landscapes is attributable to landscape ecology theory.

Proposition 3. Alternative scenarios are particularly effective in greenway planning

Chapter 2 “Spatial Concepts, Planning Strategies and Future ScenariosÖ”presents a comprehensive review of scenario literature and theory. It argues that scenarios are effective in greenway planning because they integrate intuitive and rational thinking, and that they can produce images and spatial concepts that help decision makers understand and remember the logic of the plan.

Chapter 4 “ Greenways as Ecological Networks in Rural Areas” presents an early application of scenarios to landscape ecological planning. Using an indicator species approach, the chapter demonstrates the spatial consequence of alternative scenarios, and then links these alternatives with the most fitting implementation methods and strategies.

Proposition 4. Cultural resource values need to be integrated into landscape ecological planning.

Chapter 2 “Spatial Concepts, Planning Strategies and Future ScenariosÖ” features a framework planning method in which cultural factors are valued equally with biotic and abiotic resources. Cultural resources are then included in the case application in Orange Massachusetts, USA.

Chapter 3 “Greenways as a Planning Strategy” includes cultural factors among the possible goals of greenways in an original greenways typology. One of the case studies included “The Minute Man Historic Park” represents a greenway with cultural/historic resources as its primary goal.

Chapter 5 “Time Space, Ecology, and DesignÖ” argues that greenways and ecological networks provide an essential context for aesthetic and cultural expression. This argument is supported with examples from The Netherlands including the river restoration Plan Ooievaar, the Blauwe Kamer pilot project , and the planting schemes of the Island of Walcheren.

Chapter 6 “Greenways in the USAÖ” discusses the importance of cultural resources in greenway definitions. It counts cultural resources among those which constitute the greenway characteristic of “compatible multiple use”. It traces the historical development of greenways in the USA, which verifies the importance of cultural resources in greenways.

Proposition 5. An adaptive approach is necessary for landscape ecological planning.

Chapter 2 “Spatial Concepts, Planning Strategies and Future ScenariosÖ” features an original framework method for landscape planning. This method explicitly includes an adaptive management approach to complete an iterative and continuous planning process. The adaptive component offers a solution to a fundamental dilemma of landscape planning: the inherent incompleteness of site-specific data to support site-specific plans and decisions.

Chapter 5 “Time Space, Ecology, and DesignÖ” Implicitly addressed the need for an adaptive approach in the discussion of the “high” and “low” dynamic land uses. By providing stability for the low dynamic processes, the high dynamic processes are given freedom for dynamic and adaptive change – in response to environmental, economic, and cultural factors.

Future Research Questions

Greenway planning is a complex and multidimensional activity. It occurs at different scales, for a variety of purposes, across a global range of landscape contexts and applies planning strategies which span a continuum from protective to offensive. This research has identified the key issues and questions with respect to greenway planning, and has explored these through literature review, case study, and case applications. The original publications included in this dissertation individually and collectively have added to the knowledge base of greenway planning. This concluding chapter has reviewed and summarized the primary, original contributions of the research, and evaluated the extent to which the research propositions were addressed and advanced. Yet many questions remain and additional work remains to be pursued as greenway planning becomes more widely practiced internationally. Among these questions are the following which relate closely with the main propositions of this research:

1. The hypothesis of co-occurrence of greenway resources warrants further testing to arrive at conclusive evidence. If and when the hypothesis is proven, it will provide a powerful argument in support of greenways, and could lend more importance to strategic spatial planning within the broader dialogue of sustainability. If the hypothesis is disproved, it would likely point to new spatial solutions in landscape planning, based on some strategic advantage of a spatial concept or theory.

2. Sustainability is a common, but elusive, goal in landscape and greenway planning. Sustainability needs further definition. More widely accepted definitions and indicators of sustainability are needed to support comparative research and international collaboration on planning policy and methods. Despite the difficulty of the term sustainability, and the fact that it is often criticized, it is also the closest the modern world has yet come to a consensus on global environmental issues. This aspect should not be underestimated. Challenges of the definition of sustainability should continue, and will lead to even more robust, and appropriate broad environmental policies. The expression of sustainability in

built form through design will challenge conventional aesthetic norms and may inspire new values. It is likely that greenways could provide an important conceptual link between planning and design.

3. New protocols are needed for post-implementation monitoring of greenway projects to support an adaptive approach to planning. I have argued that uncertainty is a fundamental paradox in planning. I propose an adaptive paradigm as a means to resolve this paradox. There is much research and testing to be done in this area. What are the key indicators to be monitored? For how long? How can the new knowledge contribute to better planning and design theory and practice?

4. Better, more inclusive models for integrating cultural values and resources within landscape ecological planning and design are needed. Cultural conceptions and definitions of nature differ widely over time and space. The false separation of nature and culture is prevalent, but polemic in the USA. Continued debate and discussion is needed to explore new, more holistic conceptions of "nature" which are more informed of the role and place of culture. The issue of integrating cultural values will remain abstract or academic until it produces designed artifacts that can be observed, criticized, and understood in a new context.

5. Scenario planning is a promising approach for greenway planning. Challenges remain to integrate advanced scientific models with creative ideas and spatial concepts. Scenarios may be useful for debate, but are they useful for actual decision making? Research and testing is needed to track the efficacy of the scenario approach through case studies and applications of greenway planning.

Finally, this research raises a larger set of questions that transcend and cut across many of the issues, theories and strategies identified. If the world is engaged in a quest for sustainability, what is the role of ecology, and how does ecology relate with design? What do ecologists need to know about planning and design? and what do designers and planners need to know about ecology? Landscape ecologists might reply: spatial and temporal pattern and scale, dynamics of process, and disturbance processes. Planners and designers might reply: a better understanding of the role of humans' in creating, transforming and restoring landscapes, the value and place of aesthetics (including historical precedent), and perhaps the ultimate cultural construct, economics.

The questions are many and complex. The challenges will grow in number and intensity as most of the world's landscapes continue to intensify and change. Greenways is an idea that promises to contribute to the resolution of some of these questions and challenges. Progress has been made. I hope that my thoughts and ideas can contribute to this quest for sustainability in some useful way.

Glossary

Glossary

Adaptive Management/Adaptive Planning: A management/planning concept that explicitly recognizes the basic paradox relating to implementing ecologically based planning and design: site-specific ecological knowledge is virtually, by definition, incomplete, or not specifically relevant for any given locus: yet social imperatives routinely require that decisions be made and actions taken. Adaptive management/planning addresses this paradox by re-conceiving planning, or management actions, as experiments. When conceived and designed as an experiment, and followed by appropriate monitoring and analysis, every planning/management action taken in the face of incomplete/imperfect knowledge has the potential to contribute new data, knowledge, and understanding which can inform future planning/management. The term "adaptive management" is well-established in the literature of natural resource management. This thesis introduces the concept of adaptive planning as a related and complementary activity that is fundamental to landscape ecological planning. (Peck 1998, Holling 1978).

Case Application: A planning or design exercise, conceived in a research context, to demonstrate and to test theories (e.g. for planning). In case applications, the assumptions and goals are made explicit, and the results are published/disseminated for public comment and discussion. Case applications are generally pedagogical devices more than professional projects.

Case Study: An established research method well suited to complex cases, and contemporary phenomena in real world contexts where the investigator has little control over events. In case studies the "how" and "why" are of interest. Case studies follow explicit methods for research design, data collection, and analysis. (Francis 2001, Yin 1994)

Chorological Landscape Dimension: The description and analysis of horizontal relationships and flows between topological units (e.g. patches, biotopes, ecosystems) in an heterogeneous landscape matrix. Chorological analysis describes dynamic spatial processes and relationships involving movement and flows of energy, species and materials, such as hydrological dynamics, and nutrient flows. It is integral with theories of metapopulation dynamics in fragmented landscapes. The chorological dimension complements the topological dimension which is well-established in landscape planning. This thesis argues that the integration of topological and chorological perspectives is a distinguishing characteristic of landscape ecological planning (Farina 2000, Zonneveld 1995).

Ecological Networks: A contemporary planning concept (popular in Europe) representing a fundamental change in former conservation planning policies oriented towards protecting individual sites and species to a more holistic, broad national or international/continental-scale view. The change resulted from the realization that despite the many protected 'green islands" located across Europe, species diversity was still in decline. The ecological network concept attempts to link the "green islands" into an interconnected network that is planned and managed primarily for the protection of wildlife species and their habitats (Bennett 1999, Nowicki et al. 1996, Arts et al. 1995).

Greenways: Systems or networks of interconnected lands (patches and corridors) that are planned, designed and managed for multiple purposes, including: ecological protection, recreation, and cultural/historic landscape value(s), (Fabos and Ahern 1995, Smith and Hellmund 1993, Little 1990; Presidents' Commission 1987).

Greenway Planning: A subset of landscape planning, focused on the elements that constitute greenways, including: large protected areas, riparian corridors, other corridors, and linkages. Greenway planning is usually imbedded within a comprehensive planning approach which addresses the other concerns/sectors of planning, including: physical, economic, and social. (Fabos and Ahern 1995).

Land Use Planning: "Öthe systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options. Its purpose is to select and put into practice those land uses that will best met the needs of the people while safeguarding resources for the future. The driving force in planning is the need for change, the need for improved management or the need for a quite different pattern of land use dictated by changing circumstances." (FAO 1993).

Landscape: An heterogeneous, kilometers-wide area of ecosystems and landscape elements including human settlements and land uses. Landscapes contain particular combinations of land uses, and landscape elements/features that occur in a repeating pattern (Farina 2000, Zonneveld 1995, Risser 1987, Forman and Godron 1986).

Landscape Ecological Planning: A contemporary approach to landscape planning, based specifically on theory and principles from landscape ecology. Landscape ecological planning integrates topological and chorological perspectives to achieve a dynamic understanding of landscape pattern:process interactions. Landscape ecological planning uses the patch:corridor:matrix spatial model, from landscape ecology and recognizes the inherent benefits of connectivity. Landscape ecological planning addresses the inherent uncertainty of site-specific ecological information through an adaptive approach in which monitoring and analysis are performed to determine if the planning action(s) achieved the intended results (Ahern 1999, Makhzoumi and Pungetti 1999, Hersperger 1994, Langevelde 1994).

Landscape Ecology: The interdisciplinary science of the ecology of heterogeneous landscapes, including the activities and artifacts of humans. (Farina 2000, Forman and Godron 1986, Naveh and Lieberman 1984).

Landscape Planning: A branch of land use planning and of landscape architecture that supports environmental decisions involving: preservation, protection, and development. Landscape planning is based on scientific assessments of critical resource values, hazard issues, ecological compatibility, and development suitability. It is a process to resolve conflicts between land protection, management and land use change and development. It is multipurpose and multi-objective, including consideration and assessment of physical, biological, cultural resources, values and principles for making decisions about the future. It is based on suitability analysis determined by physical, topo-climatic and aesthetic factors. Unlike other forms of planning, landscape planning is approached from the perspective of the resource base, as opposed to economic, market, or political imperatives. (Kiemstedt 1994, Fabos 1985).

Monitoring: An organized set of empirical observations that are organized and or analyzed to: establish baseline conditions, evaluate the effectiveness of implemented plans, or to validate models of environmental processes. Monitoring is essential for adaptive planning/management (Peck 1998, Holling, 1978).

Planning: An action-oriented process which aims to resolve conflicts and decrease uncertainties. Planning requires definition of a problem in terms of: objectives to be achieved; consideration of alternatives; and a context including consideration of environmental, social, economic, and political factors (Fabos and Caswell 1977)

Scenarios (Alternative Futures, Alternative Scenarios): Scenarios provide a planning perspective that is not constrained by the present situation. A future landscape scenario includes a description of the current landscape, a potential future state, and a means of implementation. Scenarios are different from forecasts which attempt to predict the expected future. Rather, scenarios pose, and answer a series of "if:then" questions. The scenario approach is particularly appropriate when there is a great deal of uncertainty concerning the future, or when there is a general dissatisfaction with the present. Two fundamental types of scenarios can be defined: a "forecasted" scenario projects current trends and controls to produce a future landscape condition. A "backcasted" approach, in contrast, is based on an idealized spatial concept - or vision, of what the future could be. Backcasted scenarios are often designed to articulate, and to visualize the spatial consequences of planning goals or assumptions and the steps necessary to realize them (Ahern 1999, Schooenboom 1995, Veenenklaas and Berg 1995).

Spatial Concepts: A spatial concept expresses through words and images an understanding of a planning issue and the actions considered necessary to address the issue. Spatial concepts are related to the proactive, or anticipatory nature of landscape planning, in that they express solutions to bridge the gap between the present and a desired future situation. Spatial concepts can structure the planning process. Translation of knowledge of landscape pattern and process is a key value of landscape ecology to spatial concept development. Spatial concepts often manifest basic assumptions upon which more specific decisions can be based. Spatial concepts are often carefully selected metaphors, for example "Green Heart" or "Stepping Stones" which communicate the essence of the concept clearly, to build consensus, and as a basis for more concrete planning decisions (Ahern 1999, Langevelde 1994, Zonneveld 1991).

Sustainable Landscape: A landscape that meets the needs of the present inhabitants without compromising the ability of future generations to meet their needs. (WCED 1987).

Strategic Landscape Planning: A future oriented, anticipatory, planning approach- in contrast to short-term reactionary planning based on perceived problems or crises. Reactionary planning results in a "tyranny of case-by-case decisions". Strategic planning cannot be achieved by ad hoc preservation or conservation actions. Strategic planning, in contrast, is forward thinking, and is based on actions to maximize opportunities for most efficient use of land, before options are foreclosed by land use change, or urban growth (Bennett 1999, Ahern 1995).

Target Species: A species selected as a goal for a biodiversity plan, or for the biodiversity component of a multipurpose plan. Selection can be based on ethical perspective, policy goal, or data on species presence, or population status. The target species is a common manifestation of biodiversity in planning (Peck 1998).

Topological Landscape Dimension: The description and analysis of homogeneous landscape components or "places". The topological dimension , characteristic of classic ecosystem ecology, focuses on the "vertical" relationships between component factors within a homogeneous place. The factors typically include: climate, surficial hydrology, vegetation, soil, geology, humans and wildlife (Farina 2000, Zonneveld 1995).

Summary

Summary

Greenways are systems and/or networks of protected lands that are managed for multiple uses including: nature protection, biodiversity management, water resources, recreation, and cultural/historic resource protection. Greenway planning is defined here as a strategic action that integrates theories from landscape ecology with theories and methods of landscape planning to focus on the goal of realizing a sustainable "greenway" network of protected lands, managed for compatible multiple purposes. A greenway system or network includes linear corridors and larger areas of protected land that are physically and functionally connected. Greenways are strategic and spatially efficient for protecting and managing land because greenway resources are not randomly distributed but rather are concentrated in corridors.

This thesis argues that greenways originated in the United States of America (USA) but are spreading internationally because the greenway concept is: (1) based in part on scientific knowledge, (2) understandable and image-able to the public, and (3) strategic in realizing multiple goals. Greenways are supported by theories from landscape ecology, particularly those concerning spatial configuration and connectivity. Because Greenways are a relatively new concept in landscape planning, new theory, planning strategies, and planning methods are needed. The application of greenways as a component of sustainable landscape planning requires new approaches which integrate abiotic, biotic, and cultural resources and issues. This thesis includes reviews of international greenway literature, and makes original contributions to this emerging theory, planning strategies, and planning methods. Case studies and case applications in the USA and The Netherlands are used to explain and test the theory, strategies, and methods.

Key concepts in the emerging greenway theory and methods include: alternative future scenarios, and adaptive management/planning. Scenarios are useful in conceiving alternative future landscapes and greenways feature prominently in many scenario studies. Both scientific knowledge and creative concepts are needed to formulate effective greenway scenarios. Greenway planning is often conducted with uncertain or incomplete knowledge. Adaptive planning/ management offers a framework for planning and implementing greenways in an experimental manner that yields new knowledge through application, plan implementation, and monitoring. A framework method for greenways and landscape ecological planning is proposed which integrates these key theories from landscape ecology, spatial concepts and scenarios, and adaptive management. The framework method is applied in several test applications in the USA and discussed in the Dutch context.

Principles from landscape ecology relating to spatial and temporal scales are also important and are understood in a hierarchical framework. The landscape scale is appropriate for

sustainability planning because it is large enough to accommodate heterogeneity and disturbance regimes, yet small enough to survey, assess, plan, design, and manage for specific landscape structure. Operating at the landscape scale planners can hope to understand and manage fundamental pattern and process relationships and dynamics.

Three fundamental principles are posed in support of greenways: 1) The hypothesis of co-occurrence of resources in greenways, 2) The inherent benefits of landscape connectivity, 3) The concept of compatible, or synergistic multiple use in greenways. This paper asserts that these three fundamental greenway principles derive from landscape planning theory; are supported and strengthened by emerging landscape ecology theory; and that their application as greenways supports the contemporary international policy goal of sustainability.

The thesis identifies contemporary greenways trends based on an original survey which found that: 1) Greenways are increasingly integrated with comprehensive landscape planning at the state level in the USA, and 2) Greenways are often initiated to provide trail and recreational use, but evolve to support multipurpose/multi-functional planning goals and objectives. A future prognosis for greenways in the USA is offered including an expected shift from locally initiated to regional and interstate greenway planning and implementation, and more explicit integration of multiple uses in greenways.

This research raises a larger set of questions that transcend and cut across many of the issues, theories and strategies identified. If the world is engaged in a quest for sustainability, what is the role of ecology, and how does ecology relate with design? What do ecologists need to know about planning and design? and what do designers and planners need to know about ecology? Landscape ecologists might reply: spatial and temporal pattern and scale, dynamics of process, and disturbance processes. Planners and designers might reply: a better understanding of the role of humans' in creating, transforming and restoring landscapes, the value and place of aesthetics (including historical precedent), and perhaps the ultimate cultural construct, economics.

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References

Ahern, J., 1991. Planning and Design for an Extensive Open Space System: Linking Landscape Structure to Function. Landscape and Urban Planning. 21: 131-145.

Ahern, J., 1994. Greenways as Ecological Networks in Rural Areas. In: E.A. Cook and H.N. van Lier (Editors). Landscape Planning and Ecological Networks. ISOMUL, Elsevier, Amsterdam: 159-177.

Ahern, J., 1995. Greenways as a Planning Strategy. In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier. Amsterdam: 131-155.

Ahern, J., 1999. Spatial concepts, planning strategies and future scenarios: a framework method for integrating landscape ecology and landscape planning. In: J. Klopatek and R. Gardner (Editors). Landscape Ecological Analysis: Issues and Applications. Springer-Verlag. New York: 175-201.

Ahern, J., and K. Kerkstra, 1994. Time space ecology and design: landscape aesthetics in an ecological framework. In: J. Judson (Editor). Ecology, Aesthetics and Design. American Society of Landscape Architects. San Antonio, Texas: 49-60.

Ahern, J., M. Gross and J. Finn, 1992. GIS Integrates Landscape Ecology and Open Space Planning. GIS World. February: 64-69.

Alexander, C., S. Ishikawa and M. Silverstein, 1977. A Pattern Language. Oxford University Press, New York, 1171 pp.

Allen, A.W., 1983. Habitat Suitability Index Model: Fisher. U.S. Fish and Wildlife Service, U.S. Department of Interior.

Allen, A.W., 1985. Habitat Suitability Index Model: Otter. U.S. Fish and Wildlife Service, U.S. Department of Interior.

Allen, A.W., 1986. Habitat Suitability Index Models: Mink. Habitat Procedures Group. National Ecology Center, U.S. Fish and Wildlife Service. Biological Report 82, Washington DC.

Andrus, Patrick W., 1992. Bulletin #40: Guidelines for Identifying. Evaluating, and Registering Americas Historic Battlefields. U.S. Department of the Interior, Washington, 27 pp.

Arts, G.H.P. et al, 1995. Special Issue on Ecological Networks, LANDSCHAP (The Netherlands Journal for Landscape Ecology). 95-3. pp.111-121.

Bailey, A., 1991. Letter from The Netherlands. The New Yorker, August. 12:52-65.
Ball, E., 1993. Prospect. Landscape Architecture, April: 136.

Bastin, L. and C. Thomas, 1999. The Distribution of plant species in urban vegetation fragments. Landscape Ecology. 14:5, 493-507.

Beardsley, J., 1984. Earthworks and Beyond. Abbeville, New York. 144 pp.

Beier, P., and R.F. Noss, 1998. Do Habitat Corridors Provide Connectivity? Conservation Biology. 12:6, 1241-1252.

Bennet, G., 1991. Towards a European Ecological Network. Institute for European Environmental Policy, Arnhem, Netherlands, 95pp.

Bennett, A.F., 1999. Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation. IUCN, Gland Switzerland and Cambridge, UK, 254 pp.

Bent, A.C., 1992. Life Histories of Northern Woodpeckers. Indiana University Press, Bloomington and Indianapolis, IN, 262 pp.

Berger, J., 1978. Toward an Applied Human Ecology for Landscape Architecture and Regional Planning. Human Ecology, 6:2.

Berger, J., 1987. Guidelines for landscape synthesis: some directions old and new. Landscape and Urban Planning. 14:295-311.

Binford, M. W., and M.J. Buchenau, 1993. Riparian Greenways and Water Resources. in: Ecology of Greenways. D. H. Smith and P.C. Hellmund (Editors). University of Minnesota Press, Minneapolis: 69-104.

Birnbaum, C. A., Editor. 1996. Guidelines for the Treatment of Cultural Landscapes. U.S.D.I National Park Service. Washington DC. 148 pp.

Bischoff, N.T., and R.H.G. Jongman, 1993. Development of Rural Areas in Europe: the Claim for Nature. Netherlands Scientific Council for Government Policy, The Hague. V 79, 206 pp.

Brown, L., 1993. The State of the World. Worldwatch Institute, Washington.

Bruin, D. de, D. Hamhuis, L. van Nieuwenhuijze, W. Overmars, D. Sijmons, and F. Vera, 1987. Ooievaar: De toekomst van het rivierengebied (Stork: The future of the rivers area) Stichting. Gelderse Milieufederatie. Arnhem, Netherlands, 128 pp.

Budd, W.W., P.R. Saunders and P. Coen, 1987. Stream Corridor Management in the Pacific Northwest:1. Determination of Stream Corridor Widths. Environmental Management. 11:587-597.

Burrough, P.A., 1986. Principles of Geographical Information Systems for Land Resources Assessment. Clarendon Press, Oxford, 333 pp.

Buuren, M. van, 1991. A hydrological approach to landscape planning: the framework concept elaborated from a hydrological perspective. Landscape and Urban Planning. 21: 91-107.

Buuren, M. van, and K. Kerkstra, 1993. The framework concept and the hydrological landscape structure: a new perspective in the design of multifunctional landscapes. In: C.C. Vos and P. Opdam (Editors). Landscape Ecology of A Stressed Environment. Chapman & Hall, London: 219-243.

Checkland, P. 1989. Systems Thinking, Systems Practice. John Wiley & Sons, Chichester, 329 pp.

Cronon, W., 1983. Changes in the Land: Indians, Colonists and the Ecology of New England. Hill and Wang, New York, 241 pp.

Daniels, R.E., 1988. The Role of Ecology in Planning: Some Misconceptions. Landscape and Urban Planning. 15, 291-300.

Dawson, K., 1995. A Comprehensive Conservation Strategy for Georgia's Greenways. In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier. Amsterdam: 27-43.

DeGraff, R. 1996. Personal communication. U.S. Fish and Wildlife Service, Amherst, MA. April.

DeGraff, R.M., and D.D. Rudis, 1983. New England Wildlife: Habitat, Natural History, and Distribution. U.S. Department of Agriculture, U.S. Forest Service, TRNE-108. 491 pp.

Department of Landscape Architecture and Regional Planning, 1996. A Foundation for an Open Space and Recreation Plan for Orange, Massachusetts, unpublished report. University of Massachusetts. Amherst. 162 pp.

Donahue, B., 1993. Causes and Consequences of the American Revolution. In: B. J. Gavrin, M. Rasmussen, J.G. Fabos, J. Ahern. A Management Plan to Balance Cultural and Natural Resources: The Minute Man National Historic Park Case Study. Research Bulletin # 744. Massachusetts Agricultural Experiment Station. University of Massachusetts, Amherst, 163-164.

Erickson, D. and A. Louisse, 1997. Greenway Implementation in Metropolitan Regions: A Comparative Case Study of North American Examples. University of Michigan School of Natural Resources and Environment. Ann Arbor, 39 pp.

Fabos, J. and J. Ahern (Editors), 1995. Greenways: the Beginning of an International Movement. Elsevier. Amsterdam, 491 pp.

Fabos, J., 1995. Introduction and Overview: The Greenway Movement, Uses and Potentials of Greenways. In: J. Fabos and J. Ahern (Editors). Greenways the Beginning of an International Movement. Elsevier. Amsterdam: 1-13.

Fabos, J., M. Lindhult and R. Ryan, 1999. The New England Greenway Vision Plan. http://www.umass.edu/greenway/

Fabos, J.G. and S. J. Caswell, 1977. Composite Landscape Assessment: Part II of the Metropolitan Landscape Planning Model (METLAND). Research Bulletin #637, Massachusetts Agricultural Experiment Station, University of Massachusetts, Amherst, 323 pp.

Fabos, J.G., 1985. Land-Use Planning: From Global to Local Challenge. Chapman and Hall, New York, 223 pp.

Fabos, J.G., C. M. Greene, S.A. Joyner, 1978. The Metland Landscape Planning Process: Composite Landscape Assessment, Alternative Plan Formulation, and Plan Evaluation. Massachusetts Agricultural Experiment Station, University of Massachusetts at Amherst, 229 pp.

Fabos, J.G., G.T. Milde and V.M. Weinmayr, 1968. Frederick Law Olmsted, Sr.: Founder of Landscape Architecture in America. University of Massachusetts Press, Amherst, 57-74.

Fabos, J.G., J. Ahern and M. Lindhult. 1993. Blackstone Heritage Greenway Planning and Community Development. Research Bulletin 745. Massachusetts Agricultural Experiment Station, University of Massachusetts, Amherst.

Farina, A., 2000. Landscape Ecology in Action. Kluwer Academic Press, Dordrecht, 317 pp.
Fedorowick, J. M., 1993. A landscape restoration framework for wildlife and agriculture in the rural landscape. Landscape and Urban Planning. 27:7-17.

Flink, C. A. and R. M. Searns, 1993. Greenways: A Guide to Planning, Design and Development. Island Press, Washington, 351 pp.

Florida Greenways Commission, 1994. Creating a statewide greenways system, for people, for wildlife, for Florida. Report to the Governor, Tallahassee.

Food and Agricultural Organization of the United Nations. 1993. Guidelines for Land-Use Planning. FAO, Rome. pp. 1.

Forman, R. T.T. and M. Godron, 1986. Landscape Ecology. John Wiley, New York, 619 pp.

Forman, R.T.T., 1990a. Ecologically sustainable landscapes: the role of spatial configuration. In: I.S. Zonneveld and R.T.T. Forma (Editors).
Changing Landscapes: An Ecological Perspective. Springer-Verlag. New York: 261-278.

Forman, R.T.T., 1990b. The Beginnings of Landscape Ecology in America. In: I.S. Zonneveld and R.T.T. Forman (Editors). Changing Landscapes: An Ecological Perspective. Springer-Verlag. New York: 35-41.

Forman, R.T.T., 1995. Land Mosaics: The Ecology of Landscapes and Regions. Cambridge University Press, Cambridge, 632 pp.

Francis, M., 2001. A Case Study Method for Landscape Architecture, Landscape Architecture Foundation, Washington, DC. Landscape Journal, 20:1, 15-29.

Friedmann, J., 1973. Retracking America: A Theory of Transactive Planning, Anchor Press. Garden City, NY, 289 pp.

Garreau, J., 1991. Edge City: Life on the New Urban Frontier. Doubleday, New York, 546 pp.

Gavrin, B.J., M. Rasmussen, J.G. Fabos and J. Ahern, 1993. A Management Plan to Balance Cultural and Natural Resources: The Minute Man National Historic Park Case Study. Research Bulletin 744, Massachusetts Agricultural Experiment Station, University of Massachusetts, Amherst, 258 pp.

Golley, F.B., and J. Bellot, 1991. Interactions of landscape ecology, planning and design. Landscape and Urban Planning. 21:3-11.

Gottman, J., 1961. Megalopolis: The Urbanized Northeastern Seaboard of the United States. MIT Press, Cambridge, MA, 810 pp.

Groome, D., 1990. Green Corridors: a discussion of a planning concept, Landscape and Urban Planning. 19: 383-387.

Gunderson, L.H., C.S. Holling and S.S. Light (Editors), 1995. Barriers and Bridges to the Renewal of Ecosystems and Institutions. Columbia University Press, New York, 593 pp.

Hamhuis, D., L. van Nieuwenhuijze and D. Sijmons, 1992. Het casco-concept. Ministerie van Landbouw, Natuurbeheer en Visserij. Utrecht, Netherlands, 85 pp.

Harms, B. H., J. P. Knaapen and J. G. Rademakers, 1993. Landscape planning for nature restoration: comparing regional scenarios. In: C. C. Vos and P. Opdam (Editors). Landscape Ecology of a Stressed Environment. Chapman and Hall. London: 197-218.

Harris, L. D., 1981. The Fragmented Forest: Island Biogeography and the Preservation of Biodiversity. University of Chicago Press, Chicago, 211 pp.

Harris, L. D., and P. B. Gallagher, 1989. New Initiatives for Wildlife Conservation: The Need for Movement Corridors In: Gay Mackintosh (ed.), Preserving Communities & Corridors, Defenders of Wildlife, Washington DC: 11-34.

Hay, K. G., 1991. Greenways and Biodiversity. In: W. E. Hudson (Editor), Landscape Linkages and Biodiversity. Island Press, Washington, DC: 162-175.

Hellmund, P. C., 1993. A Method for Ecological Greenway Design. In: D. S. Smith and P. C. Hellmund (Editors). Ecology of Greenways. University of Minnesota Press, Minneapolis: 123-160.

Helmund Associates, 1998. Planning Trails with Wildlife in Mind: A Handbook for Trail Planners, Trails and Wildlife Task Force, Colorado State Parks, 51 pp.

Hersperger, A.M., 1994. Landscape ecology and its potential application to planning. Journal of Planning Literature. 9(l):14-29.

Hess, G., 1994. Conservation Corridors and contagious disease: a cautionary note. Conservation Biology. 8:256-262.

Hirschorn, L., 1980. Scenario writing: a developmental approach. APA Journal. April: 172-183.

Holling, C.S., 1978. Adaptive Environmental Assessment and Management. Wiley International Series on Applied Systems Analysis, Vol. 3. Chichester, UK.

Houck, M. C., 1991. Metropolitan Wildlife Refuge System: A Strategy for Regional Natural Resource Planning. In: L. W. Adams and D. L. Leedy (Editors). Wildlife Conservation in Metropolitan Environments. National Institute for Urban Wildlife, Columbia, MD: 225-230.

Howard E., 1898. Tomorrow: A Peaceful Path to Reform. Swan Sonnenschein, London (2nd edition, 1945). Garden Cities of Tomorrow. Faber and Faber, London.

IUCN, 1992. The Rio Declaration on Environment.

IUCN. 1980. The World Conservation Strategy. IUCN, UNEP, WWF. Gland.

Jonge, J. de, 1994. Provincie Noord Brabant , s'Hertogenbosch. Personal Communication, January.

Jonge, N. de, 1994. Personal Communication, Renkum, Netherlands. March.

Jongman, R.H.G., 1998. The role of rivers in the European Ecological Network. In P. Nienhuis and R. Leuven (Editors). New concepts for river systems. Bakhuys Publishers, Leiden: 53-66.

Kaplan, R., S. Kaplan and R.L. Ryan, 1998. With People in Mind: Design and Management of Everyday Nature. Island Press. Washington, 225 pp.

Kerkstra, K. and P. Vrijlandt, 1990. Landscape Planning for Industrial Agriculture: a proposed framework for rural areas. Landscape and Urban Planning. 18:3-4, 275-287.

Kiemstedt, H., 1994. Landscape Planning: Contents and Procedures. The Federal Minister for Environment, Nature Protection, and Nuclear Safety, Bonn, Germany.

Klopatek, J. and R. Gardner (Editors). Landscape Ecological Analysis: Issues and Applications. Springer-Verlag. New York: 175-201.

LaCour, N. P., 1991. Blackstone River Valley National Heritage Corridor: Planning Framework, Techniques, and Technology for Today and the Future. Proceedings from Selected Educational Sessions of the 1991 ASLA Annual Meeting. American Society of Landscape Architects, Washington: 38-74.

Langevelde, F. van, 1994. Conceptual integration of landscape planning and landscape ecology, with a focus on The Netherlands. In: E.A. Cook and H.N. van Lier (Editors). Landscape Planning for Ecological Networks. Elsevier, Amsterdam: 27-69

Langevelde, F. van, 1999. Habitat connectivity and fragmented nuthatch populations in agricultural landscapes. Doctoral Dissertation. Wageningen Agricultural University, Netherlands, 205 pp.

LARP, 1990. Quabbin to Wachusett Wildlife Corridor and Greenway Study. LA597 Ahern, J. (Editor). University of Massachusetts, Amherst, Massachusetts, Unpublished Studio Report.

Lerner, S. and W. Poole, 1999. The Economic Benefits of Parks and Open Space. The Trust for Public Land, San Francisco, 48 pp.

Lewis, P.H., 1964. Quality Corridors for Wisconsin. Landscape Architecture. January: 31-40.

Lewis, P.H., 1996. Tomorrow by Design: A Regional Design Process for Sustainabilitv. John Wiley and Sons, New York, 258 pp.

Linehan, J., M. Gross and J. Finn, 1995. Greenway Planning: Developing a Landscape Ecological Network Approach. Landscape and Urban Planning. 33:1-3, 179-193.

Little, C. E., 1990. Greenways for America. The Johns Hopkins University Press, Baltimore and London, 4-5.

Lyle, J. T., 1985. Design for Human Ecosystems: landscape, land and natural resources. Van Nostrand Reinhold, New York, 279 pp.

Lyle, J. T., 1991. Can Floating Seeds Make Deep Forms? Landscape Journal. 10:1, 37-47.

Lyle, J.T. and R.D. Quinn, 1991. Ecological Corridors in Urban Southern California. In: L. W. Adams and D. L. Leedy (Editors). Wildlife Conservation in Metropolitan Environments. National Institute for Urban Wildlife. Columbia, MD: 105-116.

Lyle, J.T., 1994. Regenerative Design for Sustainable Development. John Wiley & Sons, New York, 338 pp.

Lynch, Kevin 1985. Good City Form. MIT Press, Cambridge, MA., 514 pp.

Lynch, Kevin. 1972. The Openness of Open Space. in Arts of the Environment. Kepes, Gyorgy, editor. George Braziller, New York: 108-124.

MacArthur, R.H. and Wilson, E.O. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, 203 pp.

Machado, J. .R. and J. Ahern (Editors) 1997. Environmental Challenges in an Expanding Urban World and the Role of Information Technology. Centro NaÁional de Informac„o Geografica. Lisbon, Portugal, 525 pp.

Machado, J. .R., M.T. Andresen, A.T. Rico, J. Ahern and J. Fabos, 1995. Metropolitan Landscape Planning: A Greenway Vision for the Metropolitan Area of Lisbon. Landschap (The Netherlands Journal for Landscape Ecology). 111-121.

Macintosh, Gay, editor. 1989. Preserving Communities and Corridors. Defenders of Wildlife, Washington, 96 pp.

MacKaye, B., 1928. The New Exploration. (reprinted in 1962). University of Illinois Press, Urbana, I, 243 pp.

Makhzoumi, J. and G. Pungetti, 1999. Ecological Landscape Design and Planning. E & FN Spon/Routledge. London. 330 pp.

Malcom, J.L., 1985. The Scene of the Battle, 1775 Historic Grounds Report. Minute Man National Historic Park. U.S. Department of the Interior, Washington.

Mass. Audubon Society, 1988. Rutland Brook Wildlife Sanctuary, Preliminary Ecological Inventory, Conservation Department. Lincoln, Mass.

Mass. Audubon Society, 1989. Wachusett Meadow Wildlife Sanctuary, Ecological Management Plan, Lincoln, Mass.

McClelland, L.F., 1991. Bulletin #30: Guidelines for Evaluating and Documenting Rural Historic Landscapes. U.S. Department of the Interior, Washington.

McHarg, I. L., 1997. Ecology and Design. In: G.F. Thompson and F.R. Steiner (Editors). Ecological Design and Planning. John Wiley and Sons, New York: 321-332.

McHarg, I.L., 1969. Design with Nature. Natural History Press, Garden City, New York, 198 p.

Meeus, J.H.A. and M.J. Vroom, 1986. Critique and Theory in Dutch Landscape Architecture. Landscape and Urban Planning. 13: 277-302.

Melnick, R.Z., 1983. Protecting Rural Cultural Landscapes: Finding Value in the Countryside. Landscape Journal, V.2:2.

Merriam-Webster. 1989. The New Merriam Webster Dictionary. Merriam-Webster, Inc. Springfield, MA, USA. 709.

Naiman, R.J., J.M. Melillo, M.A. Lock, T.E. Ford, S.R. Reice, 1987. Longitudinal patterns of ecosystem processes and community structure in a subarctic river continuum. Ecology. 68: 1139-1156.

Nassauer, J.I., 1992. The appearance of ecological systems as a matter of policy. Landscape Ecology. 6:4, 239-250.

National Park Service, 1992. Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors. Rivers, Trails and Conservation Assistance Office. Third Edition. Washington, DC.

Naveh, Z., and A. Lieberman. 1984. Landscape Ecology: Theory and Application. Springer-Verlag. New York. 356 pp.

Ndubisi, F., 1997. Landscape Ecological Planning. In: G.F. Thompson and F.R. Steiner (Editors). Ecological Design and Planning. John Wiley and Sons, New York: 9-44.

Ndubisi, F., T. Demeo, and N.D. Ditto, 1995. Environmentallv sensitive areas: a template for developing greenway corridors. In: J. Fabos and J. Ahern (Editors). Greenways: The Beginning of an International Movement, Elsevier, Amsterdam: 159-177.

Netherlands Ministry of Agriculture, Nature Management and Fisheries. 1990. Nature Policy Plan of the Netherlands, The Hague, 101 pp.

Netherlands Ministry VROM (Housing, Physical Planning and Environment). 1989. 4th Report on Physical Planning. SDU, The Hague.

Newton, N.T., 1971. Design on the Land. Belknap Press, Cambridge, 714 pp.

Noss, R.F. and L.D. Harris, 1986. Nodes, Networks, and MUMS: Preserving Diversity at all Scales. Environmental Management. 10:3, 299-309.
Noss, R.F., 1993. Wildlife Corridors. In: D.S. Smith and P.C. Hellmund (Editors). Ecology of Greenways. University of Minnesota Press, Minneapolis: 43-68.

Nowicki, P., G. Bennett, D. Middleton, S. Reintjes, R. Walters, 1996. Perspectives on Ecological Networks. European Center for Nature Conservation, Arnhem, 192 pp.

Odum, E.P. ,1969. The Strategy of Ecosystem Development. Science. 164:262- 270.

Olin, L., 1988. Form, Meaning, and Expression in Landscape Architecture. Landscape Journal. 7:2, 149-168.

Oor, D.W., 1992. Education and the Ecological Design Arts. Conservation Biology. 6:2, 162-164.

Opdam, P., 1990. Dispersal in fragmented populations: the key to survival. In: R.G.H. Bunce and D.C. Howard (Editors). Species Dispersal in Agricultural Habitats. Belhaven Press, London: 3-17.

Opdam, Paul, Rob van Apeldoorn, Alex Schotman and Jan Kalkhoven, 1993. Population Responses to Landscape Fragmentation. In: Claire C. Vos and Paul Opdam (eds), Landscape Ecology of a Stressed Environment, Chapman and Hall, London: 147-171.

Pace, F., 1991. The Klamath Corridors: Preserving Biodiversity in the Klamath National Forest. In: W.E. Hudson (Editor), Landscape Linkages and Biodiversity. Island Press. Washington: 105-116.

Peck, S. 1998. Planning for Biodiversity. Island Press, Washington, 221 pp.

Peterjohn, W.T, and D.L. Correll, 1984. Nutrient Dynamics in an Agricultural Watershed: Observations on the Role of a Riparian Forest. Ecology. 65:1466-1475.

Pinay, G., H. Décamps. E. Chauvet and E. Fustec, 1990. Functions of Ecotones in Fluvial Systems. In: R.J. Naiman and H. Décamps (Editors). The Ecology and Management of

Aquatic-Terrestrial Ecotones. Man and the Biosphere Series. Volume 4, UNESCO, Paris; and Parthenon Publishing Group, Carnforth UK: 141-169.

President's Commission on Americans Outdoors. 1987. Report and recommendations. Reprinted as: Americans Outdoors: The legacy, the challenge. US Government Printing Office, Washington, DC, 209 pp.

Provincie Noord Brabant. 1992. Streekplan Noord-Brabant. s'Hertenbosch.

Quayle, M., 1995. Urban Greenways and public ways: realising public ideas in a fragmented world. In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier , Amsterdam: 461-475.

Quinby, P.A., 1988. The Development of Landscape Ecology: A Brief History. Landscape Research. 13:3, 9-11.

Ranney, J.W., 1981. The Importance of Edge in the Structure and Dynamics of Forest Islands. In: R.L. Burgess and D.M. Sharpe (Editors). Forest Island Dynamics in Man-Dominated Landscapes. Springer-Verlag,. NY, 67-96.

Ribeiro, L. F., 1998. The Cultural Landscape and the Uniqueness of Place: A Greenway Heritage Network for Landscape Conservation of Lisbon Metropolitan Area. Doctoral Dissertation, Department of Landscape Architecture and Regional Planning, University of Massachusetts, Amherst, MA, 173.

Risser, P., 1987. Landscape Ecology: State of the Art. In: M. G. Turner (Editor). Landscape Heterogeneity and Disturbance. Springer-Verlag, New York: 3-14.

Ryder, B. 1995. Greenway Planning and Growth Management: Partners in Conservation? In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier. Amsterdam: 417-432.

Saunders, D. and Hobbs R., 1991. Nature conservation 2: the role of corridors. Surrey Beatty and Sons. Chipping Norton, New South Wales, Australia.

Schooenboom, I.J. 1995. Overview and State of the Art of Scenario Studies for the Rural Environment. In: J.F.Th. Schoute, P.A. Finke, F.R. Veenenklaas and H.P. Wolfert (Editors).Scenario Studies for the Rural Environment. Kluwer Academic Publishers, Dordrecht: 15-24.

Schoute, J.F., P.A. Finke, F.R. Veenenklaas, and H.P. Wolfert. 1995. Scenario Studies for the Rural Environment. Kluwer Academic Publishers, Dordrecht, Netherlands, 743 pp.

Schrader, C.C., 1995. Rural Greenway Planning: The Role of Streamland Perception in Landowner Acceptance of Land Management Strategies.
In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier , Amsterdam:
375-390.

Schreiber, K.F. 1988. Connectivity in Landscape Ecology. Proceedings of the 2nd International Seminar of the IALE. Munstersche Geographische Arbeiten 29, Munster: 255 pp.

Schreiber, K.F., 1990. The History of Landscape Ecology in Europe. In:I.S. Zonneveld and R.T.T. Forman (Editors), Changing Landscapes: An Ecological Perspective. Springer-Verlag, New York: 21-33.

Searns, R. M., 1996. The evolution of greenways as an adaptive urban landscape form. In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier , Amsterdam: 65-80.

Sijmons, D., 1990. Regional Planning as a Strategy. Landscape and Urban Planning. 18:3-4, 265-273.

Simberloff D. and Cox, J. 1987. Consequences and Costs of Conservation Corridors. Conservation Biology. 1: 63-71.

Smith, D. S., and P.C. Hellmund, 1993. The Ecology of Greenways. University of Minnesota Press. Minneapolis, 222 pp.

Smith, D.S., 1993. Greenway Case Studies In: D.S. Smith and P.C. Hellmund (Editors), Ecology of Greenways, University of Minnesota Press, Minneapolis: 161-208.

Soulé, M. E., 1991. Land use planning and wildlife maintenance: guidelines for conserving wildlife in an urban landscape. Journal of the American Planning Association. 3:313-323.

Soulé, M.E. and D. Simberloff, 1986. What do genetics and ecology tell us about the design of nature reserves? Biological Conservation. 35: 19-40.

Spirn, A.W., 1988. The Poetics of City and Nature: Towards a New Aesthetic for Urban Design. Landscape Journal. 7:2, 108-126.

Steiner, F. and D. A. Osterman. 1988. Landscape Planning: a working method applied to a case study of soil conservation. Landscape Ecology. 1(4):213-226.

Steiner, F., 1989. Dutch Master. Landscape Architecture. August, 77-79.

Steiner, F., 1991. Landscape Planning: A Method Applied to a Growth Management Example. Environmental Management. 15(4):519-529.

Steiner, F., G. Young and E. Zube, 1988. Ecological Planning: Retrospect and Prospect. Landscape Journal. 7:1, 31-39.

Steinitz, C., 1990. A Framework for Theory Applicable to the Education of Landscape Architects (and Other Environmental Design Professionals). Landscape Journal. 9(2):136-143.

Steinitz, C., with students of the Graduate School of Design, Harvard University, 1994. Alternative Futures for Monroe County, Pennsylvania. Harvard University Graduate School of Design, Cambridge, MA, 88 pp.

Taylor, J., C. Paine and J. FitzGibbon, 1995. From greenbelt to greenways: four Canadian case studies.
In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier , Amsterdam: 47-64.

Telles, G. R., 1975. Da formaÁ„o do solo ‡ socializaÁ„o da paisagem. In Uns comem os figos. Seara Nova, ColecÁ„o Ecologia e Sociedade), Lisboa, pp. 55-149.

Telles, G.R., Coordenador, 1997. Plano Verde De Lisboa. Colibri, Lisboa, 197 pp.

Thayer, R.L. Jr., 1989. The Experience of Sustainable Landscapes. Landscape Journal. 8:2, 101-110.

Turner, M.G., 1989. Landscape Ecology: The Effect of Pattern on Process. Annual Review Ecological Systematics. 20:171-197.

Tzolova, G. 1995. An Experiment in Greenway Analysis and Assessment: The Danube River. In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier. Amsterdam: 283-294.

UNESCO, 1970. Plan for a Long-Term Intergovernmental and Interdisciplinary Programme on Man and the Biosphere. Document 16 C/78, UNESCO, Paris.

USDI, 1992. Draft Guidelines for the Treatment of Historic Landscapes. National Park Service Draft Bulletin, Washington.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell and C.E. Cushing, 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences. 37:130-137.

Veenenklaas, F.R., and L.M. van den Berg, 1995. Scenario Building: art, craft, or just a fashionable whim? In: J.F.Th. Schoute, P.A. Finke, F.R. Veenenklaas, and H.P. Wolfert (Editors).Scenario Studies for the Rural Environment. Kluwer Academic Publishers, Dordrecht: 11-13.

Vos, C. C. and Opdam, P., 1993. Landscape Ecology of a Stressed Environment. Chapman and Hall. London, 310 pp.

Vos, C. C., and J.L.S. Zonneveld, 1993. Patterns and processes in a landscape under stress: the study area. In: C.C. Vos and P. Opdam (Editors). Landscape Ecology of a Stressed Environment. Chapman and Hall. London: 1-27.

Vroom, M. J., 1992. Outdoor Space: Environments Designed by Dutch Landscape Architects in the Period Since 1945. Thoth, Amsterdam, 208 pp.

Vroom, M. J., 1997. Images of Ideal Landscapes in the Netherlands and the Consequences for Design and Planning. In: F. Steiner and G. Thompson (Editors).
Ecology in Design and Planning. Johns Hopkins University Press, Baltimore: 293-320.

Walmsley, A. 1995. Greenways and the Making of Urban Form. In: J. Fabos and J. Ahern (Editors). Greenways: the Beginning of an International Movement. Elsevier. Amsterdam: 81-127.

Walters, C., 1986. Adaptive Management of Renewable Resources, Macmillan, NY.

Wilson, E.O. and Peter F.M., 1988. Biodiversity. National Academic Press, Washington.

World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press, Oxford.

Yin, R.K., 1994. Case Study Research: Design and Methods. Sage Publications, Thousand Oaks, California, 170 pp.

Zaitzevsky, C., 1982. Frederick Law Olmsted and the Boston Park System. Harvard University Press. Cambridge, 262 pp.

Zonneveld, I.S., 1995. Land Ecology. SPB Academic Publishing. Amsterdam, 199 pp.

Zonneveld, W., 1991. Conceptvorming in de Ruimtelijke Planning. Patronen en Processes (Vol. 1) and Encyclopedie van Planconcepten (Vol. 2). Planoloaische Studues 9, Universiteit van Amsterdam. Amsterdam, Netherlands.

Zube, E. H., 1995. Greenways and the U.S. National Park System. In: J. Fabos and J. Ahern. Greenways: the Beginning of an International Movement. Elsevier, Amsterdam: 17-25.

Zube, E. H., 1995a. National Parks and Protected Landscapes Planning: From Islands to Regions. In: M. Yokohari, S. Yujoba and K. Shinozawa (Editors) Ecological Landscape Planning. Process Architecture. Tokyo: 110-116.

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Curriculum Vitae

John F. "Jack" Ahern was born in Cambridge Massachusetts, USA on November 15, 1952. He grew up in the suburbs of Boston, Massachusetts near Route 128, an early high technology m etropolitan beltway that resulted in profound changes in land use and land use patterns – on the spine of the N.E US megalopolis. He was moved by the landscape changes he experienced to study Environmental Design at the University of Massachusetts, graduating with a bachelor's degree in 1974. He earned his Masters of Landscape Architecture at the University of Pennsylvania in 1980, studying with Ian McHarg - the father of ecological planning and design. He then worked in several landscape architecture offices in Philadelphia, including John Rahenkamp and Associates and Wallace Roberts and Todd. In 1986 he became an Assistant Professor at the University of Massachusetts. After earning his promotion to Associate Professor, he spent a sabbatical year (1993-1994) working with Klaas Kerkstra and colleagues at the Department of Physical Planning and Rural Development at Wageningen University. During this time he began his research focus on greenways, publishing several of the articles included in this thesis. He also co-edited a book "Greenways: the Beginning of an International Movement" with Julius Fabos. In 1997 he received a Fulbright Fellowship to research and lecture on landscape ecological planning in Portugal. During this period, with Joao Reis Machado he co-edited the book: "Environmental Challenges in an Expanding Urban World and the Role of Emerging Information Technologies". He continued to research greenways in the context of landscape ecological planning, and has participated actively with the US and International Divisions of the Association for Landscape Ecology (US-IALE, and IALE), serving as US-IALE Chair from 1998-2000. In 1999 he authored the book "A Guide to the Landscape Architecture of Boston" published by the Hubbard Educational Trust, in conjunction with the centennial celebration of the American Society of Landscape Architects (ASLA) in Boston. He is now a Professor of Landscape Architecture and Department Head at the Department of Landscape Architecture and Regional Planning at the University of Massachusetts Amherst. He is a Fellow of the American Society of Landscape Architects. He lives in Pelham, Massachusetts, USA with his wife Linda and three sons: Ryan, Jeffrey, and Sean.