What is green infrastructure? An evaluation of green infrastructure plans from across the United States

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What is green infrastructure?  
An evaluation of green infrastructure plans from across the United States  

By  

Timothy Dennis Youngquist  

A thesis submitted to the graduate faculty  
In partial fulfillment of the requirements for the degree of  
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Program of Study Committee  
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CHAPTER I: INTRODUCTION

“Infrastructure – the substructure or underlying foundation…on which the continuance and growth of a community or state depends.”
- Webster’s New World Dictionary

We humans face an ecological dilemma. Throughout the course of our history, humans have always relied on nature and natural systems. We are dependent on nature to provide us with clean air and water, food, and good health. However, as our society has grown and our technology has developed human activity has had an increasingly negative effect on the critical natural systems that support life on this planet (Randolph 2004). In the last 200 years, human activity has become so widespread that no aspect of nature is left untouched. Nature can no longer freely take its course. Our actions determine what will survive and what will not (Chicago Wilderness Consortium 2004, 25). Practices of resource exploitation and the pollution of our environment have the potential to greatly affect systems that are vital to our sustainable occupation of this planet. Surely, no one wishes to maliciously harm the environment. Surely, this destruction is not inevitable. As humans, we have the potential to live more in balance with natural systems. I believe that green infrastructure represents an approach we can take to do so. With this research, I intend to explore the nature and meaning of green infrastructure, distinguish its guiding principles from previous environmental planning strategies, and determine if the principles of green infrastructure are being applied to planning efforts in the United States.
Purpose of Study

It is the purpose of this study to help define the term green infrastructure within the context of the United States, to distinguish whether or not green infrastructure planning is fundamentally different from previous forms of environmental planning, and to determine if the principles of green infrastructure planning are being applied in the United States. My research is an evaluation of green infrastructure plans activities in ten locations throughout the United States. The locations include Pima County, Arizona; Prince George’s County, Maryland; Chicago, Illinois; Portland, Oregon; Montgomery County, Maryland; the Twin Cities in Minnesota; Saratoga County, New York; Chester County, Pennsylvania; Anne Arundel County, Maryland. These were chosen because they are pioneers in the field of green infrastructure and they all have long and documented histories of environmental protection. All sites are dealing with an increasing population and a high rate of land consumption, which is putting pressure on the natural environment.

An additional goal of this study is to add to the dialogue on the discussion of green infrastructure. This is a very important concept, but it is also very new and not well known by the public. “People do not value what they do not know” (Drobney 1994, 18). Most people have very limited experience with green infrastructure, so they do not understand its significance or the potential it can bring to our cities. This research can be used as an educational tool to inform the common citizen about the importance of green infrastructure planning.

In addition, the final goal of this research is that the results of this study can be used to aid cities in creating their own plans. The indicator criteria can be used as a
checklist for green infrastructure plan creation at the local level. Although all jurisdictions have different needs and there is no blueprint or “one-size-fits-all” method for creating a perfect plan, the literature suggests that there are key components that must be included in a plan in order for it to fulfill the goals of green infrastructure planning.

**Research Questions**

- What is green infrastructure?
- Is green infrastructure fundamentally different from previous environmental planning strategies?
- Are the principles of green infrastructure applied in planning in the United States?

The answers to these research questions were found through the review of relevant literature and by evaluating green infrastructure plans from across the United States. Finding an answer to the question of what green infrastructure is came from an extensive review of books, journals, research articles, magazines, and green infrastructure plans. Determining if there is a fundamental difference between green infrastructure and previous planning strategies was answered by reviewing books, journals, research articles, and “green” plans. By starting at the turn of the 20th century at the roots of planning history, with a primary focus on the last thirty years of planning, the main objectives and conservation tools used were distilled from the different types of environmental planning. Key plan elements and stages were derived from the answers to the first two research questions, which were then used to answer whether or not green infrastructure principles are being applied in the United States. Jurisdictions with green infrastructure plans were
then chosen to determine the answer to this question. Chosen sites have high growth
pressure, valuable natural resources that are in jeopardy and plans that are currently being
implemented. Through the process of plan evaluation, I was able to determine what
green infrastructure planning is in these settings throughout the United States.

Research Problem

One of the problems with green infrastructure planning is whether, in practice, it
is any different from earlier forms of environmental planning. Perhaps it is different in
name alone, and will result in the more of the same: problems that previous planning
strategies failed to address. Numerous studies have linked the degradation and loss of
natural functions not only to haphazard development practices, but also to haphazard
conservation efforts (Beatley, 2000; Noss, 1987). In theory, green infrastructure intends
to create an interconnected network of green spaces. When serving as the basis for
development, loss can be prevented – the loss of species, the loss of ecosystem function,
the loss of the rural aesthetic, and the loss of natural heritage. Uncontrolled growth can
devastate animal habitat and degrade air and water quality. A single development of a
couple of hundred tract houses, or even fifty, can eliminate the rural ambience for miles
around (Little 1990, 31). Green infrastructure planning places much more of an emphasis
on the relationship between the people and the natural environment. Previous forms of
environmental planning have led us to a point where it is necessary to implement new
strategies to benefit not only the rest of the species on the planet, but for humans as well.
The importance of maintaining our natural heritage for future generations cannot be
estimated in dollars. “There is value in the sense of discovery that comes to each new
generation as it learns the essential facts of what came before. If that history includes a
richness of color, shape, and form, so much the better” (Chicago Wilderness Consortium 2004, 15). Planning has the capacity to protect this valuable natural heritage and green infrastructure with its focus on broader, landscape-scale environmental protection could be the strategy that city planners use to do so.

Water problems are a major concern around the globe and urban development and human activity has exacerbated this problem. Cheap water and flagrant misuse of that water have helped to create problems. Urban development produces an increase in impervious surfaces, which in turn has led to an increase in stormwater runoff and its associated pollutants. “Green infrastructure provides an antidote by intercepting rainfall before it reaches sewers. And green infrastructure usually costs less to install and maintain when compared to conventional “gray” forms of water infrastructure that rely on concrete gutters, sewers, and end-of-pipe treatment. This is important in a time of shrinking financial resources and increasing public and regulatory demand for clean water” (Wise 2008, 16). Green infrastructure pilot projects have shown repeatedly that this type of approach has the potential to capture, retain, infiltrate or evapotranspire 90 percent or more of the precipitation from a storm delivering an inch or less of rain. Typical storms produce this amount of precipitation and the majority of pollutants are carried in the first half-inch to one-inch of precipitation (Wise 2008). Traditional planning practices have led to the degraded environment we live with today; without a paradigm shift we may reach a tipping point, which, when passed will result in an environment that is impossible to save.
Importance of the study to the field of planning

Considering the current state of city planning within the United States, the study of green infrastructure is very important for several reasons. “In an expanding human world, competition for use of a finite land base can only intensify” (Shaffer 1981, 134). This is not a problem that is going to go away on its own. In a time of economic uncertainty and shrinking city budgets throughout the United States, this research is very important because it can help cities develop conservation priorities. Connecting local governments with the funding necessary to implement a green infrastructure network can maximize the effectiveness of conservation funding. Additionally, the evaluation criteria outlined later in this thesis can help jurisdictions that are interested in developing their own green infrastructure plans.

Study Design

This thesis is composed of five chapters that consist of information on green infrastructure planning in the United States. My primary research questions were answered through an evaluation of green infrastructure plans that are currently being implemented throughout the United States. A review of literature is used to highlight the key principles of green infrastructure and describe green infrastructure in concept, as well as examine prior research into concepts and practices. The review also distinguishes green infrastructure from previous environmental planning strategies. This is the start of my attempt to answer my second research question: Is green infrastructure planning fundamentally different from previous environmental planning strategies? The history of environmental planning is investigated, highlighting the primary objectives and tools
used by each environmental planning strategy over the last 30 years. The review of literature suggests that there are specific frameworks that can be used to evaluate green infrastructure plans and that there are specific criteria that are necessary within these types of plans. An explanation of the necessary elements of green infrastructure planning as well as the indicator criteria used for plan evaluation is also included. Chapter III addresses my research methodology. I review several plan evaluation studies that have already tested hypotheses either supporting or refuting green infrastructure theory. These prior plan evaluation studies offer models that have been used to address plan elements. The importance and relevance of indicator criteria is justified in this chapter.

Using case studies, Chapter IV illustrates some of the limitations and potential of using the green infrastructure strategy in creating plans. Case studies were chosen from a sample of jurisdictions that have green infrastructure plans. Plans were chosen from across the United States to give a sense of the state of green infrastructure planning in different contexts in this country. Areas that were chosen all have long histories of environmental protection and were among the first to create green infrastructure plans in this country. The findings from the plan evaluations are documented in this chapter. This chapter contains the answer to my most important research question: Are the principles of green infrastructure planning being applied in planning in the United States? My first and second research questions are expanded here as well. Through the analysis of data gathered by the qualitative study, my research has extracted four realities of green infrastructure that should be taken away from this study.

First, as a strategy, green infrastructure is being used to shape plan development in of each of the nine jurisdictions under review. However, decades of conservation
planning have resulted in several plan taxonomies that are no longer easily differentiated. Green infrastructure, greenway, open space, and other types of conservation planning efforts all produce plans that have many similar goals and use similar tools. Thus plans that are produced are often hybrids, using theory from numerous types of environmental planning strategies. It has become increasingly difficult to articulate the differences between different types of environmental plans.

Second, the use, definition, and language of green infrastructure vary between each of the 9 plans studied, but there are common elements within each definition. There has been a trend towards increasing complexity within environmental planning both in its goals and the tools that are used to create and implement plans. By distilling the core components and purposes of conservation plan taxonomies, it is possible to shed light on the advancements that have been made in the field of conservation planning.

Third, green infrastructure does not serve the same purpose as “gray” infrastructure does in traditional city planning. Although some plans referred to the potential of green infrastructure to replace traditional infrastructure in, for example, managing stormwater, most did not. The majority of the plans under review see green infrastructure as a landscape scale conservation strategy. The word “infrastructure” is meant to resonate more strongly than past phrases like “greenways”, “green space”, or “open space.” It is meant to imply something that is necessary for the expansion of the human built environment, but not in the functional way that we use electric lines or sanitary sewers to expand our cities.

Finally, green infrastructure is different and newer than what was occurring in these regions prior to its arrival. Green infrastructure is a much more strategic approach
to conservation planning that combines the methodologies of the previous forms of conservation planning with the goal of planning for broader landscapes and with much more of a focus on ecosystem services.

Chapter V is a summary of conclusions from the discussion, complete with implications, constraints, and recommendations for other American cities and citizens who are interested in green infrastructure. This chapter also touches on opportunities for continued research on the topic, acknowledges the limitations of this study, and includes my final thoughts on the research topic.

Through this research process, I found that green infrastructure is different and newer than previous strategies of environmental planning and that its principles are being beginning to be applied to plans throughout the United States. Green infrastructure represents a new approach to city planning that aims to minimize the impact that human development has on functioning natural systems in urban areas. These systems include the numerous ecological services provided by wetland environments including flood control, and improved water quality; vegetation which controls erosion and stabilizes the soil on steep slopes, habitat, carbon sequestration, oxygen production and natural areas which have aesthetic values and can increase property values. Jurisdictions that have applied green infrastructure realize the multiple ecological, financial, and community objectives green infrastructure serves.

Green infrastructure planning represents a strategic approach to conservation that combines the efforts of previous conservation planning methodologies and practices in the US into a systematic framework that can encompass larger landscapes and broader planning goals (McDonald 2005). As the world’s population increases and the size of
our urban centers grow, a new line of thinking in city planning becomes increasingly necessary.

About 50% of the world’s population and approximately 76% in more developed countries are urban dwellers. Even though there is evidence to suggest that in many ‘advanced’ industrialized countries there has been a reversal in the rural-to-urban shift of populations, virtually all population growth expected between 2000 and 2030 will be concentrated in urban areas of the world (Sandstrom 2002).

This growth has led to severe environmental degradation, including the infiltration of new chemical compounds, heavy metals, and petroleum products into the water supplies of urban areas. Additionally, “The amount of land exploited for roads and buildings has increased at the expense of parks and other green spaces that are already in limited supply, affecting urban biodiversity” (Sandstrom 2002). In the coming decades, as a population we will face significant land degradation, population growth, water shortages, fertile soil erosion, and biodiversity loss as a result of the spread of huge urban areas (Dramstad 1996). Instead of continuing along the path towards this destruction of our urban environment, physical design and the urban built environment should be more in tune with natural processes (Catlin 1997).

Managing our relationship with nature is a big responsibility. How society assumes that responsibility is largely dependent on the values and norms of a society, which have varied throughout human history. “It is important to understand culture and values for two reasons. First, a society’s approach to managing the environment is usually a reflection of its values, culture, and norms. And second, we need to understand and integrate these values in planning and decision making to manage the environment effectively” (Randolph 2004, 7). “The environmental movement has heightened public
value given to these ‘noneconomic’ natural resources. This value stems from both an anthropocentric view based on human enjoyment of these resources, now and in the future, and a perspective that natural ecosystems and the life they support have value for their own sake” (Randolph 2004, 4). Our relationship with the environment and the way we regard it has morphed several times throughout history and it continues changing today.

City planners have always played a role in managing our relationship with nature and in very recent history planners have turned to green infrastructure for this purpose. The concept of “green infrastructure” was developed out of the discipline of ecological planning and uses the basic principles of ecology in a planning framework. Benedict (2007) who is a pioneer in the field of green infrastructure defines the term to include all of the open space, woodlands, wildlife habitat, parks, and other natural areas that sustain clean air, water, and natural resources, and enrich our quality of life. A green infrastructure network can naturally manage storm water, reduce the risk of floods, capture pollution, and improve water quality (Wise 2008, 15). “In cities and other urbanized areas, that network can be extended by means of rain gardens, green roofs, tree plantings, permeable pavement, and other landscape-based drainage features. They restore, protect, and mimic hydrologic functions within the built environment” (Wise 2008, 16). It originated from the idea that linking parks and green space benefit people and that preserving and linking natural areas benefits the entire ecosystem (Benedict 2007). In short, green infrastructure can be considered our city’s “life support system” and if properly planned a green infrastructure network can be a cost-effective, and highly visible way for jurisdictions to manage growth within a framework of land conservation.
CHAPTER II: REVIEW OF RELEVANT LITERATURE

America has developed educational systems, transportation systems, and we even seem to be on the verge of developing a health care system at long last. But comprehensive land-use planning on more than the most elementary level—mainly planning for zoning in towns and cities—seems to be beyond us. ‘It’s my land,’ folks say, as if they were living alone on an island in the middle of the sea, ‘and no one is going to tell me what to do with it.’ As a result, the public values of a regional landscape become obliterated by the cumulative effect of self-interested private decisions.

In order to successfully study green infrastructure, it is vital to understand what is meant by the phrase green infrastructure and where this idea originated. This chapter starts with an exploration into the foundations of green infrastructure that begins at the turn of the 20th century. By examining the important shifts in the way Americans have attempted to protect the natural environment it becomes possible to understand where the principles behind green infrastructure originated. I then move through a brief history of the last 30 years of environmental planning, highlighting the conservation tools and the primary objectives that guided each unique strategy. This portion of the chapter is meant to determine how green infrastructure is fundamentally different from previous environmental planning strategies and thereby answer one of my primary research questions. This portion of the chapter is intended to establish a base definition of the term for my research and answer my first research question.

This chapter concludes with the different stages at which green infrastructure plans can be evaluated. The literature suggests that there is a basic plan framework that is appropriate for plan development in the green infrastructure style of planning (McDonald 2005, Benedict 2007, Sandstrom 2002). This basic framework includes goal
setting, analysis, synthesis, and implementation. This framework is discussed in detail at the end of this chapter.

Foundations of Planning for the Natural Environment

The way that the government conserves and protects environmental land in this country has evolved over time. “Ultimately, how the environment is managed is based on society’s culture and values” (Randolph 2004, 6). A society’s values are manifested in environmental ethics and have their roots deep in human history.

The origins of the environmental movement in the United States were based on conservation of natural resources and occurred in the mid to late 19th century. This historical movement was largely influenced by the work of important authors and environmental thinkers. The next paradigm shift occurred in the mid-20th century and responded to issues of environmental health and protection of commonly held resources. Most recently, the environmental movement has been focused on a much larger landscape scale approach to ecology, and long term protection of natural systems.

The first clear origins of the environmental movement in the United States occurred as a result of several important conservationists and preservationists. Revolutionary conservationists like George Perkins Marsh with his book *Man and Nature* famously stated, “Man is everywhere a disturbing agent. Wherever he plants his foot, the harmonies of nature are turned to discords” (1864). Henry David Thoreau with *Walden* (1937) advocated conserving natural resources, while John Muir with *My First Summer in the Sierra* (1911) and Gifford Pinchot sought to preserve natural resources. During this period in history, numerous organizations were founded, such as the Sierra Club and
the National Wildlife Federation. Government agencies like the National Park Service, the Fish and Wildlife Service, and the Forest Service were formed to set aside nature refuges and to manage forests for wildlife and recreation and National Parks for future generations to enjoy. Their legacy continued in the 20th century with Aldo Leopold who brought environmental issues to a new generation. Leopold introduced the concept of a, “Land ethic, focusing on the fundamental principles of ecology in his seminal work *A Sand County Almanac* (Leopold 1949).

This sounds simple: do we not already sing our love for and obligation to the land of the free and the home of the brave? Yes, but just what and whom do we love? Certainly not the soil, which we are sending helter-skelter downriver. Certainly not the waters, which we assume have no function except to turn turbines, float barges, and carry off sewage. Certainly not the plants, of which we exterminate whole communities without batting an eye. Certainly not the animals, of which we have already extirpated many of the largest and most beautiful species. A land ethic of course cannot prevent the alteration, management, and use of these ‘resources,’ but it does affirm their right to continued existence, and, at least in spots, their continued existence in a natural state (Leopold 1949).

The early 20th century brought with it a greater understanding of many relationships of environmental conditions to human health. Rachel Carson expanded the American consciousness to include ecological health. In her groundbreaking work *Silent Spring* (1962), she criticized the way that we have modified our landscape,

To a large extent, the physical form and the habits of the earth’s vegetation and its animal life have been molded by the environment. Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight. Only within moments of time represented by the present century has one species – man – acquired significant power to alter the nature of his world. During the past quarter century this power has not only increased to one of disturbing magnitude but it has changed in character. The most alarming of all man’s assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials (Carson 1962, 5-6).
Within the field of landscape architecture, Ian McHarg advocated designing urban areas with nature. He believed that by using natural processes as the framework for developing our cities, public and private benefits could be maximized by safeguarding and enhancing land, water, air, and biotic resources (McHarg 1969).

At the national level the United States government implemented policies to protect natural resources. This period spurred the establishment of the Environmental Protection Agency, in addition to lots of environmental protection laws such as the Clean Water Act, the Clean Air Act and the Endangered Species Act (Ferry, 2004; Jurgensmeyer, 1998). Also, environmental watchdog groups like the National Resource Defense Council and the Environmental Defense Fund were formed during this period.

These phases of history set the stage for the most recent and current environmental movement, which is a shift towards an increased understanding of ecology, a growing emphasis on connected systems with linkages and critical hubs and a focus on landscape scale processes. This generation of Americans views protected green space as an investment that is vital to maintaining a high quality of life within cities as well as protecting the environment (Maryland National Capital Park and Planning Commission, 2004). This era has been characterized by a desire to integrate human habitation and use of resources with the long term protection of natural systems. Under this movement, environmental management projects are locally based, have ecosystem or watershed boundaries, and involve collaboration and partnership of stakeholders (Ndubisi 2002; Perlman 2005). This era has also seen an emphasis on ecosystem management among federal agencies – principally the Forest Service, the Fish and Wildlife Service, the Army Corps of Engineers, and the Bureau of Land Management.
The last half century has seen numerous kinds of planning strategies aimed at protecting the environment. Randolph (2004) outlines four primary local conservation planning periods (Table 2.1).

<table>
<thead>
<tr>
<th>Period</th>
<th>Type</th>
<th>Conservation Tools</th>
<th>Primary Objectives</th>
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<td>&lt;1980</td>
<td>Parks and Recreation Planning</td>
<td>Land acquisition; park planning and management</td>
<td>Active Recreation, scenic amenity</td>
</tr>
<tr>
<td>1980s</td>
<td>Open Space Planning</td>
<td>Land acquisition and easement; park planning and management</td>
<td>Active Recreation, scenic amenity, farmland protection, urban forestry</td>
</tr>
<tr>
<td>1990s</td>
<td>Greenways and Open Space Planning</td>
<td>Land acquisition, easement, floodplain zoning, park and greenway planning and management</td>
<td>Active and passive recreation, scenic amenity, farmland protection, urban forestry, urban wildlife</td>
</tr>
<tr>
<td>2000</td>
<td>Green Infrastructure</td>
<td>Land acquisition, easement, floodplain management, Smart Growth Management tools, conservation land development, partnerships with landowners, land trusts</td>
<td>Hubs and links for active and passive recreation, scenic amenity, farmland protection, urban forestry, urban wildlife, regional and state ecological systems, integration of conservation and growth management</td>
</tr>
</tbody>
</table>

He begins prior to 1980 with parks and recreation planning and ends with green infrastructure. His textbook *Environmental Land Use Planning and Management* depicts increasingly complex planning strategies as well as an evolution towards a landscape scale focus. Parks and recreation planning, which occurred prior to 1980 was focused on active recreation and scenic amenity and used land acquisition, park planning and management to achieve those objectives. Open space planning followed during the 1980s, and had the primary objectives of active recreation, scenic amenity, farmland protection, and urban forestry. The tools used by planners included land acquisition and easement, and park planning and management. “In the early days, plans originated out of a specific threat to natural lands, such as the need for recreational trails and parklands,
concern over fragmented habitats or the need to protect precious water resources” (McDonald 2005, 8). The efficiency of acquiring individual parcels of land based on availability and opportunity began to be questioned. Land acquisition was often unrelated either to natural processes or to social need. “Indeed, most of the public funds and semipublic philanthropic efforts devoted to open-space preservation in those days benefited the well-off who lived in estate country. Very little of the newly acquired open-space land appeared in inner city or older suburbs, despite a light sprinkling of vest-pocket parks here and there” (Little 1990, 32).

In the 1990s planning for open spaces and greenways were the most common strategy. Amongst greenways definitions there is a common focus on the concept of linear corridors, which often follow rivers and streams and connect landscapes (Anne Arundel County 2002). The primary objectives of this strategy were to encourage passive and active recreation, provide scenic amenities, protect farmland, urban wildlife, and foster urban forestry. Greenways are often established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or over land along a railroad right-of-way converted to recreational use, a canal, a scenic road, or other route; any natural or landscaped course for pedestrian or bicycle passage; an open space connector linking parks, nature reserves, cultural features, or historic sites with each other and populated areas; or a local strip or linear park designated as a parkway or greenbelt (Florida Department of Environmental Protection, 1998). During the 1990s common planning tools included land acquisition, easement, floodplain zoning, and park and greenway planning and management. “Open space and greenways provide recreation as well as habitat and ecological functions. Ecological protection provides not only wildlife habitat
but also human water supply protection, high-value natural areas, scenic beauty, passive recreation, and scientific education. Mitigation of natural hazards by restricting land use in floodplains, steep slopes, and coastal dunes also provides open space, recreation, and wildlife habitat” (Randolph 2004, 75). Ecological planning and green infrastructure use many of the same planning tools, but also include ecological restoration and an increased focus on social issues.

**Ecological Planning**

Since its inception, ecological planning has focused on finding a way of directing or managing changes in the landscape so that human actions are not as disruptive of natural processes and deals with the wise and sustained use of the landscape in accommodating human needs (Ndubisi, 2002). Ecological planning uses the principles of ecology to guide planning decisions. “Ecology is generally defined as the study of the interactions among organisms and their environment”(Dramstad 1996, 12). Ecology can be thought of as a unified whole that cannot be derived from the summation of its component parts. This means that the achievement of long term ecological integrity depends upon maintaining a comprehensive network of interconnected hubs and corridors. This includes maintaining the integrity of native biota, the size and configuration of the physical environment, the integrity of the physical environment and the context of the landscape. The basic principles of ecology that helped to shape the fundamental ideas of green infrastructure planning are that nature reserves/open spaces can serve many different purposes for humans and animals, planning must proceed based on the best
Ecological planning is characterized as being reactive, proactive, or integrative. It is reactive in the regard that it tries to correct prior environmental damage. It is proactive in that measures are taken explicitly to enhance environmental quality, for example: land use controls to preserve wildlife habitats and wetlands, protect aquifer recharge areas, restrict future floodplain development. It can also be integrative by involving early and substantive consideration of environmental and social factors in the formulation of development plans and projects (Randolph 2004). Out of this came green infrastructure.

**Green Infrastructure**

The concept of green infrastructure was developed out of the discipline of ecological planning. Numerous other strategies within city planning have come and gone - will green infrastructure be just a fleeting fashion or will its full potential be unleashed? Green infrastructure is seen as an approach to conservation planning that combines the efforts of previous planning methodologies and practices in the United States into a systematic framework that that can encompass larger landscapes and broader planning goals (McDonald 2005).

As a phrase, green infrastructure has numerous different definitions in the literature. “Just as gray infrastructure describes the functional support system of urbanized areas, green infrastructure the ‘noun’ refers to nature’s life support system” (McDonald 2005, 8). “Green infrastructure the ‘adjective’ refers to an approach to conservation planning that is landscape-scale, driven by a broad-reaching public process,
and results in an implementation strategy to protect an ecological network of conservation lands” (McDonald 2005, 8).

Where the term green space implies something that is nice to have, green infrastructure refers to something we need. Green space is thought of as isolated parks, where green infrastructure emphasizes interconnected systems (Benedict 2006). Interconnected open space is important for two reasons, “the first is ecological; the second is human” (Erickson 2006). “In current efforts to achieve sustainable urban development, ‘green infrastructure’ has the same dignity as ‘technological infrastructure’ has had in traditional urban planning” (Sandstrom 2002, 3). “Taking a landscape-scale focus for conservation planning is the foundation for green infrastructure planning, a strategic conservation planning approach that builds on conservation planning approaches of recent years. The planning and scientific analysis that has served as a foundation for regional biodiversity networks, often called ‘reserves’ are the roots of the green infrastructure approach” (McDonald 2005, 7).

Researchers from the United Kingdom recently defined green infrastructure as “a network of multifunctional greenspace provided across the defined area. It is set within, and contributes to, a high quality natural and built environment and is required to deliver liveability for existing and new communities” (Kambites 2006). Within the context of the United States, Benedict (2007) defines green infrastructure to include all of the open space, woodlands, wildlife habitat, parks, and other natural areas that sustain clean air, water, and natural resources, and enrich our quality of life. He believes that it originated from the idea that linking parks and green space benefit people and that preserving and
linking natural areas benefits the entire ecosystem (Benedict 2007). In short, green infrastructure can be considered our city’s “life support system.”

McDonald (2005) broadens the definition of green infrastructure. She sees it as the, “interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks, and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to health and quality of life” (McDonald 2005, 6).

For my research, I define green infrastructure as a multi-functional, interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks, and other conservation lands; working farms, ranches and forests; cultural heritage sites, and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and provide benefits to both humans and nature. Benedict, McDonald, and other authors agree there is a common approach to green infrastructure that can lead to the creation of successful plans. A successful plan would be considered one that integrates the guiding principles of green infrastructure.

**Green Infrastructure Plan Evaluation Frameworks**

Not all green infrastructure plans will be identical. However, the literature suggests that there is a basic framework for plan development that is appropriate for the green infrastructure style of planning. McDonald et al, (2005) claims that there are certain elements that differentiate green infrastructure plans from other types of plans and
that these elements can be broken down into four primary steps: goal setting, analysis, synthesis, and implementation. Time and funding constraints will likely prevent most planning efforts from fully addressing all indicators included within these stages of plan development. However, the evaluation criteria chosen for this research can help to distinguish green infrastructure plans from other types of “green” plans.

**Goal Setting**

The initial stage of plan development involves setting plan goals. The development of a green infrastructure plan should be guided by an advisory group or some other type of local leadership. Generally, advisory councils are made up of a wide range of stakeholders, including planners, ecological experts, concerned citizens, among others. Ideally the advisory group should be composed of stakeholders from within the planned area (McDonald 2005, 9). Connectivity is a key element of green infrastructure plans, not only within elements of the green infrastructure plan itself, but the plan should also create connections between local institutions and people (Sandstrom 2002). A diversity of stakeholders helps give the plan a strong base for developing the goals that will guide future planning efforts. A wide range of stakeholders can also help to generate public support for green infrastructure planning. This stage in the planning process is very similar to what is done for other types of environmental plans. “Greenways almost always begin with two key elements: an outstanding natural or cultural feature and committed visionary leadership” (Flink 1993). Setting goals, bringing people together and garnering support for a green infrastructure plan is not easy, therefore visionary
leadership in the form of an advisory committee or a local leader is a critical component in this stage of the planning process.

A wide range of plan goals further distinguishes green infrastructure planning from previous strategies. “Green infrastructure plans must include goals for the protection of ecological functions, as well as protection of working lands, and open space for human benefit. These are factors that have been covered in other plan types, but typically not included all within one plan” (McDonald 2005, 9-10). “It should be noted that not all areas will include all possible conservation objectives, but a plan should still be considered a green infrastructure plan if it incorporates and balances all salient conservation goals for the area” (McDonald 2005, 10).

Goals for green infrastructure plans must be made for the entire landscape within the plan area. It is critical that the plan makers recognize the ecological context of the region they are planning for. Long term ecological integrity depends upon the integrity of native species, the size and configuration of habitats within the landscape, integrity of the physical environment, and the context of the landscape (Perlman 2005). Ecosystems are interconnected, dynamic systems. They do not end and begin where the political lines are drawn on a map. Green infrastructure planning must take into account that an area’s resources are influenced and affected by the resources and population of neighboring regions. “Drawing upon landscape ecology and conservation biology theories and practices within an environmental planning framework can ensure that green infrastructure plans integrate and account for all of these factors” (McDonald 2005, 10).
Analysis

After plan goals have been established, the green infrastructure network must be analyzed. “The goal of a network design is to delineate an interconnected green infrastructure system that incorporates both benefits to nature and to people” (McDonald 2005, 10). Similar to the goal setting stage, the analysis of the green infrastructure network should be based on current theories from ecology and land-use planning. The green infrastructure network should focus on creating meaningful links between habitats and ecosystem functions, understanding biodiversity at the local, landscape, and ecosystem scale, identifying critically valuable habitat areas, and the interaction of all these elements with the features of the built environment (Sandstrom 2002).

The design of the green infrastructure network should be based on the results of a thorough analysis of the plan area to determine the type and range of resources within the region. It is difficult to express the value and benefits of natural systems (deGroot, 2006). McDonald (2005) recommends conducting the analysis around each individual green infrastructure goal, and then compiling that information to define the entire network. The Nature Conservancy uses this approach to conservation planning that incorporates ecoregional and site-level planning (The Nature Conservancy, 2000). The primary difference between these approaches is that The Nature Conservancy is focused almost exclusively on biodiversity conservation. The “top-down”, or government oriented approach of green infrastructure planning, “ensures that landscape scale functions and processes are the foundation of the network design as well as the more local and smaller scale lands that will constitute the larger network” (McDonald 2005, 11).
The design of the network should utilize a hub and corridor framework, with stepping stones to facilitate healthy wildlife habitat. Figure 2.1 provides an illustrated example of the design that this type of framework should seek to replicate. [see Figure 2.1] Hubs are essential features in a green infrastructure network. They are defined as large, ecologically significant natural areas which serve two important purposes. The first purpose is to provide habitat for animal and plant species that cannot thrive in small patches of open space that exist in highly fragmented landscapes. Populations that are small, isolated, or subdivided into small groups because of restricted dispersal can be particularly susceptible to inbreeding and extinction (Falk 2006).

Without genetic variation, the population of a species will deteriorate. Natural corridors that link hubs are intended to link the gene pools of two populations. “The wide movement of wildlife, even plants, along a natural corridor is essential for the survival of some species, especially those fairly high up on the food chain. If confined to a single nature reserve, even a quite large one, species such as fox or owl can become an island population and possibly perish”(Little 1990, 36-7). The gene pools of many remnant native populations have been seriously eroded, so that what persists today is often a small remnant of the original diversity. Small gene pools are more prone to inbreeding, as well as random genetic change from drift. Populations that formerly exchanged genes regularly may have also become genetically isolated by habitat fragmentation (Schwartz 1993; Young 2000). The second purpose of a hub is to provide areas for wildlife to forage and breed (Anne Arundel County 2002).

Another key component of the network is that it should include a broad diversity of land uses. A green infrastructure is intended to protect a wide variety of natural areas
and ecosystems as well as including provisions for the protection of working lands and cultural heritage sites. This distinguishes green infrastructure plans from previous types of environmental planning.

To serve their purposes, hubs should have a high ratio of interior habitat to edge habitat and be structurally diverse, that is containing a variety of microhabitats. [see figure 2.2] They should have the most uniform boundaries possible, since boundaries that are irregular (that is, zigzagging in and out) reduce the ratio of...
interior to edge habitat. In general the larger and more diverse a hub habitat, the greater its ecological value” (Anne Arundel County Department of Recreation and Parks and Office of Planning and Zoning, 2002; Perlman, 2005; Dramstad, 1996). The probability of species extinction decreases as average population or patch size increases (Schoener and Spiller 1987; Hanski 1991). The likelihood of extinction also decreases as the overall number of large patches increase (Simberloff 1976; Hanski and Gyllenberg 1993).

Figure 2.2 – Visual representation of the difference between edge and interior habitat. (Anne Arundel County Department of Recreation and Parks and Office of Planning and Zoning 2002, 28)

The plan should also contain information about the geographical distribution of the green infrastructure network. The network should be easily accessible, with equitable distribution of green spaces throughout the planned area because there is a strong need for nature that is easily accessible to residents of all ages. “No single park, not matter how large and how well designed, would provide the citizens with the beneficial influences of nature” (Little 1990, 11).
Synthesis

The purpose of this stage of plan development is to advance conservation implementation strategies by specifically identifying opportunities for protection efforts. It is critical that this section includes the protection status of green infrastructure network lands. Placing some land under legal protection is critical for the conservation of biodiversity (Moreira-Munoz 2005). Some lands within the green infrastructure network will likely already be under some type of legal protection. The plan should include some type of ranking system in which unprotected lands rank higher than those that are already under legal protection. Unprotected lands should also be ranked according to the resource value of the lands.

The plan makers must also acknowledge the gaps in the network and the plan to fill in those gaps in the future. “Restoring hub and linkage gaps is a crucial component to any green infrastructure plan, as most network designs will contain ‘holes’ in the form of developed or degraded lands” (McDonald 2005, 11). Gaps within the network are acceptable, as long as they are identified and the need for detailed analysis is acknowledged (Randolph 2004). Finally a geographic representation/map of the green infrastructure network should be included to help advance conservation efforts.

Implementation

The final stage of plan development is implementation. One of the most important elements in this section is the establishment of a system for prioritizing protection opportunities, McDonald (2005) refers to this as a “decision-support tool”. “Without this system, the plan serves only as a blueprint of conservation lands – not a
framework for assessing priorities (McDonald 2005, 12). “In order to prioritize sites, the plan requires the identification of an underlying strategy for biodiversity conservation and its application to the ecoregions found within the planning area. The strategy should identify what features or sites one intends to protect, the priority assigned to the protected sites or features, and how sites and methods for conservation should be linked (McKinstry 2007, 882). The plan should result in a land protection strategy that can guide implementation. This helps it to be cost effective. “As choices have to be made between conservation opportunities, local governments can use a decision support tool to ensure that they are making the most of their conservation dollars when weighing competing choices (McDonald 2005, 12). This element of the plan will be more successful if it provides information about the tools available to local governments to conserve land in the green infrastructure network. “This implementation strategy provided within a green infrastructure plan should highlight opportunities for utilizing existing regulatory and non-regulatory land use tools for protecting important network lands” (McDonald 2005, 12). Within most jurisdictions, a large percentage of land is under private ownership. Therefore, private stewardship is necessary to ensure that the entirety of the network is implemented. The plan should address implementation strategies for private landowners complete with funding sources and local government resources that are available to them.

In addition, available sources of funding should be mentioned – without adequate resources there can be no implementation. Most green infrastructure plans are written in a regional context, so therefore it may be difficult to identify specific, parcel-level implementation strategies. However, local governments will greatly benefit from a coordinated strategy that helps them to secure funding for the most critical areas of the
green infrastructure network. In addition to protecting some of the most valuable areas within the network, this type of strategy should help to reduce parochialism between localities who are in competition for the same funds.

**Summary**

This chapter described a working definition for the term green infrastructure. By looking at planning’s recent history, information suggests that ecological planning has increased in complexity over the years, culminating at the current phase of green infrastructure. This exploration determined that green infrastructure planning is in fact fundamentally different and more complex than any strategies for environmental protection which preceded it. A framework for plan evaluation was then established, which will be explored further in the next chapter.
CHAPTER III: METHODOLOGY

“If planning is to have any credibility as a discipline or a profession, evaluation criteria must enable a real judgment of planning effectiveness: good planning must be distinguishable from bad.”

This study employed two-phases of qualitative data gathering. The first phase began with finding communities that have created and implemented green infrastructure plans and then analyzing their content. This phase of research, in addition to the literature review, aided the process of creating evaluation criteria for the green infrastructure plans. For the future of cities and regions, the plan is incredibly important. “The plan remains one of the planner’s primary tools to influence future growth and development” (Baer 1997, 330).

The second phase of research involved an analysis of plan evaluation frameworks. The plan evaluation frameworks came from a review of plan evaluation literature and green infrastructure plans. The two phases were then integrated together to draw final conclusions, discuss limitations and challenges, and finally give recommendations. These two sources of evidence help to strengthen the accuracy of the study. This chapter includes an outline and justification of the particular strategies which were employed to complete the research design as well as the collection and analysis of data used for this study.
Phases of Research

My research was completed with two distinct phases of data gathering. The first phase of research involved identifying communities with green infrastructure plans. Plans were then exhaustively researched to determine their content and thereby gain a greater understanding of the goals of these plans as well as proposed implementation strategies. The second phase of research involved a qualitative analysis of plan frameworks.

Case Selection

The initial phase of research for this project involved searching out cities with green infrastructure plans. From the selection of cities with plans, sites were chosen that met several criteria. One of the most important criteria that had to be met in order for inclusion in the study is a rapid increase in population. I selected areas that have experienced an increase of 10,000 since the year 2000. Rapidly increasing population is considered important in the selection criteria, because it implies an increasing rate of land consumption. Another criteria that had to be met in order for selection was the identification of a clear “pollution problem”. This simply means that the jurisdiction in question is dealing with a specific environmental problem, like loss of viable habitat, decreasing water quality, potential species extinction in the region, or rapid land consumption. Sites were only chosen from within the United States and a graphic representation is available in FIGURE 3.1. The case studies that I chose include, Prince George’s County, Maryland; Chicago, Illinois; Anne Arundel County, Maryland; Saratoga County, New York; Montgomery County, Maryland; Minneapolis, Minnesota; Portland, Oregon; Chester County, Pennsylvania; and Pima County, Arizona.
Several sites were chosen from the State of Maryland. This was done because the State of Maryland has initiated a statewide GreenPrint Program to guide land development, which is one of the first of its kind and the only jurisdictions within this study that have a statewide program. The program was designed with the principles of green infrastructure in mind (Maryland Department of Natural Resources 2003). The program has three primary goals: use computer mapping to identify the most important unprotected lands in the state, connect those lands with corridors, and to save those lands through targeted acquisition and easements (Maryland Department of Natural Resources 2003). Sites chosen from within Maryland are illustrated in Figure 3.2. With the exception of the Maryland cases, I attempted to select sites that would represent a diverse geographic sample from throughout the country.

Figure 3.1 – Map of some of the sites chosen for study
This research is intended to add to a growing body of knowledge related to green infrastructure planning. Researchers in Sweden (Sandstrom 2002) evaluated green infrastructure plans from seven Swedish cities. The goal of their research was to determine whether green plans in Swedish cities were adequately considering the many uses of green infrastructure in urban areas as well as their role in fostering sustainable development (Sandstrom 2002). Using criteria developed by the Swedish National Board of Housing, Building, and Planning they developed 47 indicators relating to recreation, maintenance of biodiversity, city structure, cultural identity, environmental quality, and biological solutions to technical problems. They justify their choices for indicators by claiming that they “provide a comprehensive picture of the importance of green infrastructure and its multi-form role in urban sustainable development” (Sandstrom 2002, 4). If an indicator was fully analyzed within the plan, it would receive a higher score than a plan that failed to mention the indicator. The results of the quantitative analysis were displayed with a table. The main strength of this research is that the diverse array of
indicators acknowledge the multi-functional capacity of green infrastructure. However, by using criteria developed by the Swedish National Board of Housing, Building, and Planning it focuses only on urban areas and fails to capture whether or not the principles of green infrastructure are being applied.

In more recent research, McDonald et al (2005) developed evaluation criteria that were intended to be specifically used to aid planners creating green infrastructure plans. Their criteria is meant to serve as a checklist of “best practices” for developing green infrastructure plans. Although their framework does an excellent job of capturing the principles of green infrastructure the research is not applied to any plans. Also, they fail to include consistency with other planning efforts, identification of parties responsible for implementation and provisions for financing and implementation.

My research builds on the efforts of these and other plan evaluation research efforts. I used the plan evaluation framework laid out by a number of different researchers, from the United States, Europe, and South America to help set the base for my evaluation criteria. I attempt to address the weaknesses of previous research on the topic by adding additional indicators that focus on the multi-functional aspects of green infrastructure. Additional indicators were derived from the review of literature and are focused on green infrastructure principles. Also, the sample size for this research is larger than any of the green infrastructure plan evaluation studies I encountered. The plans were evaluated and the results displayed in a quantitative table, which is available in Appendix B.

These green infrastructure plans are a primary source of data for this project. Booth (1995) defines a primary source as “the materials that you are directly writing
about” (Booth 1995, 69). My main goal for this phase of research was to analyze whether or not the principles of green infrastructure are being included in American green infrastructure plans.

At the core of this research is the assumption that the more a green infrastructure plan adheres to the ideal principles of green infrastructure the more effective it will be in protecting and enhancing the region’s green infrastructure network. Hamin (2006) conducted an evaluation of conservation subdivision plans, employing a select interpretive method when reading the plans, in which she imagined the ideal community, the ideal developers, and the ideal zoning code. Hamin’s analysis demonstrates, at least in one particular case, that conservation subdivision plans fail to fully realize, or fall short, of ideal theorized goals of ecological planning. Divergence between the ideal and the real shift from the lofty goals set forth in identified public purposes of land use regulations and the specificity in the actual regulations. “The goals set forth what a community wants to be, while the regulations set for the minimum the community is willing to accept; the goals exhort while the regulations discipline” (Hamin 2006). Why is there the existence of this gap? In part, it can be blamed on careful lobbying by interest groups to push the bar higher or lower, the reality of human limitations and the difficulty of projecting outcomes from the regulations (Hamin 2006). She found that difference between the ideal and the real are caused in part by a shift from the lofty goals set forth in identified public purposes of land use regulation and the specificity in the actual regulations (Hamin 2006).
Data Analysis

As with the collection of data, the analysis of data used multiple methods as well. Analysis was conducted using a multi-step method created by John Creswell (2003) in his text, *Research Design*. He includes six steps in the data analysis process for research projects, including:

- Step 1: Organize and Prepare Data
- Step 2: Read through all data
- Step 3: Detailed analysis and Coding
- Step 4: Generate categories/themes
- Step 5: Use of narrative to convey findings
- Step 6: Interpretation of data

The first step in the project was to organize all the data that had been collected. This included the plans being evaluated and the typing of notes. This step also included sorting and arranging data into different categories, depending on the source of the material. The next step in the project was to read through all the data that had been gathered. The primary goal of this phase was to help me obtain a general sense of the data that had been collected (Creswell 2003, 191). It was out of the second step that I was able to develop indicator criteria that would accurately reflect an “ideal” green infrastructure plan. The third step in the process was to code the data and begin detailed analysis of the material. This step involved “taking text data or pictures, segmenting sentences (or paragraphs) or images into categories, and labeling those categories with a term” (Creswell 2003, 192). This section of the research process helped me to divide my
data into the four main elements of the plan making process: goal setting, analysis, synthesis, and implementation. This was then followed by step 4, which includes the development of major themes within the data. During this stage of the process I was able to differentiate the ways in which each plan defined green infrastructure. The next step of the process involved relaying plan information in way that would be easy to understand for the reader, which made up most of the background information about each plan. Using a narrative style to tell stories about the foundations of each plan helped me to understand more about the jurisdictions who were writing the plan, as well why they chose green infrastructure to help them manage the relationship between their citizens and their natural environment.

These initial data analysis steps lead to the creation of the final product: a qualitative narrative, which represents the findings. The final step in the process involved interpreting or searching for meaning within the data collected. This phase of research helps answer the question “What were the lessons learned?” (Creswell 2003, 194).

Finally, data was analyzed. Direct content analysis was employed to analyze the green infrastructure plans, where information coding and sorting will start with categories and a theoretical framework derived from current literature on green infrastructure. Content analysis began during the course of my data collection, rather than as a series of procedures conducted at the end of the data collection process. This early involvement and engagement with the data will allowed me to move back and forth between concept development and data collection, which directed subsequent data collection in more meaningful ways. To establish dependability and confirmability, I compiled an audit trail
during the process of my data, field notes, and theoretical notes, and spreadsheets, which were reviewed by my major professor and committee members. Dependability refers to the attempt to account for changing conditions in the subject chosen for study and in the research design, which occurs as a result of an increasingly refined understanding of the situation. Confirmability is another important concept of the research, and essentially asks the question “Could the findings of this study be confirmed by someone else?” (Marshall 2006). Additionally, I consulted members of my committee during the data gathering process. If inconsistencies arise among the various aspects of my audit trail, I will seek to clarify these inconsistencies by additional primary research and/or looking for examples of similar inconsistencies in previously published secondary sources. If the inconsistencies persist and cannot be explained, I will not discuss that aspect of the data in my analysis.

**Plan Evaluation**

“The appropriate criteria to evaluate a plan are implicit in the concept that the plan embodies. Moreover, in reciprocal fashion, the plan’s concept is clarified only by considering the criteria to judge it” (Baer 1997). To capture the principles of green infrastructure, 51 indicators (all available in Appendix B) were developed relating to plan foundations, stakeholder involvement, conservation vision, network design criteria, network suitability, priorities and relationship to plan goals, decision support tool, implementation, funding, conservation strategies, and development opportunities. The plans were evaluated according to each indicator using four evaluation standards (Table 3.1):
The definitions of the evaluation standards are fairly straightforward. Indicator criteria receiving an evaluation of – would receive a numerical score of 0. Plans who completely failed to include an indicator would receive this mark. Indicator criteria that receive a (+) would result in a numerical score of 3. This mark is typical of plans who mentioned the indicator criteria with a sentence or two, but do not go into further depth. The indicator criteria which receive a score of +, or a numerical score of 8 go into deeper detail than those receiving a (+) therefore more in-depth analysis is assigned a higher score. ++ is the highest possible score under this evaluation criteria. Therefore, in order to receive a ++ or a numerical score equivalent to 10 are required to discuss the indicator in detail, and fully analyze the indicator. Full analysis refers to the thoughtful consideration of the indicator. In the Appendix, each of the indicators is explained and the results of the evaluation are presented.

The frameworks used in my research are broken down into four main plan stages:

- Goal Setting
- Analysis
- Synthesis
- Implementation
These criteria can serve not only as a means for evaluating plans, but also as a guiding framework for plan development. The scoring system can be used to provide a comprehensive checklist for green infrastructure plan development efforts. Using the scoring system, plan content was evaluated page by page. Under each plan stage, there are multiple indicators that can be evaluated to determine the extent to which green infrastructure principles were considered while drafting the plan. The plans were evaluated for the presence or absence of the indicator. If the indicator was present, the depth to which it was analyzed was considered. This was completed with thorough note-taking, in which a record was kept of how fully each indicator was analyzed.

Goal Setting

This is the first stage of plan development. “Goal setting or direction setting provides a clear, relevant basis for developing plans and later for decision-making and evaluation” (Kaiser et al, 1995). This element consists of three primary criteria: plan foundations, stakeholder involvement and conservation vision, each with independent indicators for a total of sixteen indicators.

Plan foundations evaluates the basic elements and purposes for plan development. This includes whether or not the plan assesses the green infrastructure network and the threats to it. The creation of connections with other jurisdictions plays an important role in green infrastructure planning and this element is also concerned with the plans level of coordination with other jurisdictions. The stakeholder involvement criteria are focused on the origins of the plan, whether or not the public was adequately involved, if there was a diversity of stakeholders, and the way in which stakeholders were chosen. The Chicago
Wilderness Plan scored the highest on the Plan Foundations category, which can be seen in Appendix A. The score was given because the plan was created with a strong vision to protect urban biodiversity and also in part because of the strong inter-jurisdictional links that the plan created.

Conservation vision looks at the environmental goals that guided the green infrastructure planning efforts. Connectivity of habitat elements plays a key role in this element. Strategic connections of ecosystem components such as parks, preserves, riparian areas, wetlands, and other green spaces should be included. The presence of green passageways between valuable green cores, including connection with the surrounding land to facilitate migration of species should be analyzed. Valuable green cores refers to spaces with native habitats that can act as breeding, foraging, and nesting ground for species. The Montgomery County, Maryland Plan received the highest score under conservation vision. The plan makers considered a wide range of issues relating to conservation, including goals to protect ecological processes, watershed protection, and the connection of strategic ecosystem components.

**Analysis**

This section and its criteria are meant to be an assessment the scientific basis for the green infrastructure network. Criteria includes: network design criteria, and network suitability analysis complete with seventeen independent indicators. Network design criteria includes assessing the experts involved in the design process, the data incorporated in the spatial modeling and the scientific thresholds utilized (McDonald, 2005). The network suitability analysis “evaluates the nature of the network, the incorporation of a range of scales and land uses into the model, and the ability the
replicate the analysis” (McDonald 2005, 14). Analyzing the context of the green infrastructure network is critical, as ecological systems are dynamic and always changing. “As ancient Greek philosopher Heraclitus claimed, ‘You can never step in the same river twice.’ Moreover, rates and directions of change in systems are shaped increasingly by human activities” (Suding 2006, 190). Anne Arundel County’s network suitability analysis used five criteria to assess lands within their potential green infrastructure network. Those criteria included habitat value, size, connections to other land with ecological value, future potential, and linkages to trails systems.

Biodiversity of both plants and animals are the hallmark of any healthy ecosystem. Planning for biodiversity is a large part of the analysis component. Biodiversity should be considered at the landscape level, the ecosystem level, and the species level including rare and endangered species. “Biodiversity is the totality of genes, species, and ecosystems in a region” (Chicago Wilderness Consortium 2004, 6). A high degree of biodiversity is normally an indication of a healthy, sustainable natural community, ecosystem, or region (Thompson 1992). “Around the world, people depend on biodiversity for the very sustenance of life. The living things with which we share the planet provide us with clean water and air, food, clothing, shelter, medicines, and aesthetic enjoyment, and they also embody feelings of shared culture, history, and community. The nations of the world have signed a treaty calling biodiversity the common heritage of humankind and calling on all peoples to be custodians of the biodiversity found in the countries and regions” (Chicago Wilderness Consortium 2004, 6). Also included are a public health element, and equitable distribution of the green infrastructure network, which both address the importance of green infrastructure in the
everyday lives of its citizens. As seen in Appendix A, many of the plans scored highly on the “biodiversity” indicators. The plans from Chicago, Illinois and Pima County, AZ were most clearly centered on the protection of biodiversity. For the Chicago Wilderness Plan the goal was to create an “urban bioreserve” to protect their natural heritage. In the context of Pima County their goal was to use the plan to protect habitat for rare and endangered species.

**Synthesis**

The stage of plan development is intended to move the plan from analysis to implementation. Identification of priorities for implementation, network design model enhancements, and relationship to plan goals are covered by this plan element, complete with five indicators. The protection status of lands in the network should be evaluated during this section of the plan. By identifying protection status of the lands within the network, implementation priorities can be identified. This section also analyzes the appropriateness of implementation provisions documented in the plan as well as the appropriateness of the agency or person responsible for plan implementation. Finally, I also look at the relationship of implementation priorities to plan goals.

**Implementation**

The implementation stage helps achieve established plan goals by integrating plan priorities with implementation tools and funding sources that are available to local governments. The stage has thirteen indicators with the main themes including the decision support tool, implementation tools, conservation funding, conservation strategies, and defining development opportunities. “A good plan will identify the threats to
biodiversity, the most effective tools for addressing those threats, the institutions and funds needed, and the available institutional mechanisms for measuring biodiversity and implementing a plan” (McKinstry 2007, 881).

The decision support tool criteria assess the plans ability to assist implementation. Implementation tools are an assessment of the documentation and assessment of potential planning tools that can be used. Conservation funding assesses the various funding mechanisms documented within the plan. Conservation strategies, “evaluate the plan’s ability to develop a strategic effort that links implementation tools with funding sources to actual lands within the green infrastructure network, and to mandate or recommend additional efforts aimed at restoration and conservation management” (McDonald 2005, 15). Defining development opportunities assesses the plans ability to guide development within the green infrastructure.

**Summary**

This chapter included a discussion of the research design and methodology used to complete the research within this Master’s thesis. The use of multiple approaches of data collection and multiple sources of data help to validate the accuracy of the findings of this research. By reviewing several plan evaluation studies that have already tested hypotheses either supporting or refuting green infrastructure theory, I was able to develop an framework for evaluating green infrastructure plans. These prior plan evaluation studies were then used to determine key plan elements, out of which indicators were developed.
CHAPTER IV: STUDY FINDINGS

“Nature offers us such advantages as no other city could rival…. If we fail to secure these natural features and suffer them to be destroyed, no power on earth can restore them.”
—Horace Cleveland, 1888

Chapter IV serves to advance the conversation about my three primary research questions.

• What is green infrastructure?

• Is green infrastructure fundamentally different from previous environmental planning strategies?

• Are the principles of green infrastructure being applied in planning in the United States?

The findings presented in this chapter are a result of the plan evaluation framework criteria, which were applied to each plan. The information in this chapter tells the story of the green infrastructure plans under study by presenting the data and evidence provided by the evaluation results.

The goal of this evaluation was to gather information about each jurisdiction’s green infrastructure plan and therefore answer my primary research questions. The study findings begin to reveal how green infrastructure is defined and translated into plan-form within the jurisdictions studied by exploring the myriad of variables of the green infrastructure strategy. Through the combination and analysis of these different variables,
a general sense of what green infrastructure is and whether or not its principles are being applied.

The plan framework evaluation is focused on four general stages of the plan.

1. Goal Setting
2. Analysis
3. Synthesis
4. Implementation

Each stage makes up an individual section of this chapter. The indicators within each section that were most often most and least common are the highlight of this chapter. Brief background information will be presented prior to the results of the evaluations.

Background

Basic background information is provided in table 4.1, which is intended to provide, at least in part, the reasoning behind why these jurisdictions chose green infrastructure to guide their future development. Data relating to the motivations behind each plan were derived from exact wording within the plans themselves, as most of the plans referred to a specific “pollution problem” like degraded water quality, or land fragmentation as a result of intense development. Population data helps to highlight the growth trends experienced by each jurisdiction and was taken from United States census data. The ecoregion column provides information about the type of ecosystem upon which human development is occurring. This background information is intended to complement the data presented by the plan evaluations and provide the context within which the plan was created.
<table>
<thead>
<tr>
<th>Location</th>
<th>Population</th>
<th>Growth Since 2000</th>
<th>Development Pressure</th>
<th>Ecoregion (US EPA Level III)</th>
<th>Ecoregion ( US EPA Level I)</th>
<th>Pollution Problem/ Plan Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prince George's County, Maryland</td>
<td>830,000</td>
<td>27,000+</td>
<td>Moderate</td>
<td>Southeastern Plains</td>
<td>Eastern Temperate Forests</td>
<td>Population growth/ development pressure</td>
</tr>
<tr>
<td>Twin Cities, Minnesota</td>
<td>3.1M (Metro)</td>
<td>124,000+</td>
<td>Very High</td>
<td>North Central Hardwood Forest</td>
<td>Eastern Temperate Forests</td>
<td>Population growth/ development pressure</td>
</tr>
<tr>
<td>Chicago, Illinois</td>
<td>9.7M (Metro)</td>
<td>365,000+</td>
<td>Extreme</td>
<td>Central Corn Belt Plains</td>
<td>Eastern Temperate Forests</td>
<td>Loss of habitat/ biodiversity</td>
</tr>
<tr>
<td>Pima County, Arizona</td>
<td>967,000</td>
<td>130,000+</td>
<td>Very High</td>
<td>Sonoran Basin and range</td>
<td>North American Deserts/ Southern Semi-Arid Highlands</td>
<td>Loss of Endangered Species/Rapid population growth</td>
</tr>
<tr>
<td>Portland, Oregon</td>
<td>550,000</td>
<td>21,000+</td>
<td>Moderate</td>
<td>Willamette Valley</td>
<td>Northwestern Forested Mountains</td>
<td>Loss of Endangered Species</td>
</tr>
<tr>
<td>Montgomery County, Maryland</td>
<td>930,000</td>
<td>52,000+</td>
<td>High</td>
<td>Northern Piedmont</td>
<td>Eastern Temperate Forests</td>
<td>Loss of biodiversity/ valuable natural resources</td>
</tr>
<tr>
<td>Chester County, Pennsylvania</td>
<td>486,000</td>
<td>53,000+</td>
<td>High</td>
<td>Northern Piedmont</td>
<td>Eastern Temperate Forests</td>
<td>Land Consumption/ Uncoordinated Growth</td>
</tr>
<tr>
<td>Saratoga County, New York</td>
<td>216,000</td>
<td>15,000+</td>
<td>Moderate</td>
<td>Northeastern Highlands</td>
<td>Northern Forests</td>
<td>Land Consumption/ Uncoordinated Growth</td>
</tr>
<tr>
<td>Anne Arundel County, Maryland</td>
<td>512,000</td>
<td>23,000+</td>
<td>Moderate</td>
<td>Northern Piedmont</td>
<td>Eastern Temperate Forests</td>
<td>Statewide Initiative</td>
</tr>
</tbody>
</table>
Sonoran Desert Conservation Program: Pima County, Arizona

Pima County, Arizona, is located in south-central Arizona, sharing its southern border with Mexico. Pima County has been experiencing a rapid increase in population for the last several decades. “In 2000 and 2001, an average of almost 1,800 new residents moved to Pima County each month” (Benedict 2006, 101). “It has been estimated that each year new construction consumes approximately ten square miles of desert. At the same time, the Sonoran Desert, rich in biodiversity, has been identified by the Nature Conservancy as one of the top eco-regions world-wide, deserving of special conservation attention” (Pima County Board of Supervisors 2006). Pima County chose to use the green infrastructure approach to help protect desert ecosystems and maintain the quality of life in this rapidly growing region of the American Southwest.

The Sonoran Desert Conservation Plan covers an area of 5.9 million acres with residents from a broad diversity of ethnic and cultural backgrounds. The largest metropolitan area included in this plan is Tucson. The planned area lies at the intersection of four ecological regions – the Sonoran and Chihuahuan deserts and the Rocky and Sierra Madre mountains – which makes the area home to a great diversity of wildlife and plants. The lush, undeveloped mountains also provide an important north-south migratory pathway for mammals and birds. “The Sonoran Desert, rich in biodiversity, has been identified by The Nature Conservancy as one of the most sensitive eco-regions worldwide, deserving of special conservation attention” (Benedict 2006, 101; Pima County Board of Supervisors 2006). This spectacular natural background set the stage for the creation of the Sonoran Desert Conservation Plan.
Countywide Green Infrastructure Plan for Prince George’s County, Maryland

Prince George’s County, Maryland is located immediately adjacent to the Washington, D.C. metropolitan area. The County is experiencing development pressure from both the D.C. and Baltimore metropolitan areas. The population of the county is estimated to be 830,000. African Americans make up a majority of the population, composing 67% of the total (United States Census Bureau, 2008).

Prince George’s County has long been at the forefront of environmental protection and has one of the most well known green infrastructure plans. The current trend towards low-impact development has its origin in Prince George’s County. “In 1992, Larry Coffman, then associate director of the Environmental Services Division, created a prototype rain garden in response to concerns about pollution reaching Chesapeake Bay” (Wise 2008, 17).

The County-wide green infrastructure plan is the first comprehensive functional master plan ever developed in the county. “The plan identifies a contiguous network of environmentally sensitive areas throughout the county and sets forth a goal, objectives, policies and strategies to preserve, protect, and enhance these elements by the year 2025. The plan supports the desired development pattern in the General Plan” (Prince George’s County Planning Board, 2005).

Chicago Wilderness: Biodiversity Recovery Plan

“‘Chicago Wilderness’ refers to nature and to the people and institutions that protect it” (Chicago Wilderness Consortium 2004, 5). Chicago Wilderness is 200,000 acres of protected conservation land – some of the largest and best surviving woodlands,
wetlands, and prairies in the Midwest. “Approximately 1,500 native plant species occur in the region, making the Chicago metropolitan area one of the more botanically rich areas, natural or otherwise, in the United States” (Chicago Wilderness Consortium 2004, 6). The term also refers to the much large matrix of public and private lands of many kinds that support nature in the region along with the people who protect and live compatibly with it. Geographically, Chicago Wilderness includes northeastern Illinois, northwestern Indiana, and southeastern Wisconsin. The coalition is composed of local governments, state and federal agencies, centers for research and education, and conservation organizations.

Chicago is one of the largest metropolitan areas in the United States. It is a massive center of economic and cultural wealth generation. While building up its size and wealth some of the natural communities in the area were preserved, but as the metropolitan area continues to expand and grow, its natural resources continue to decline.

**Metropolitan Green Spaces Program – Portland, Oregon**

Portland has long been concerned with the protection of its environment. “In 1969, the Oregon Senate passed a bill requiring cities and counties to engage in comprehensive land-sue planning, laying the foundation for the land use-planning system that was detailed in later legislation. Portland’s urban growth boundary was established in 1979, and the Portland Metropolitan Area Local Government Boundary Commission was given the authority to approve or disapprove both major boundary changes (formation, merger, consolidation, dissolution) and minor boundary changes (annexations and withdrawals) of cities and eight types of special districts (Benedict 2006, 269).
Portland is seen as a very desirable place to live and it is estimated that the region will grow by an average of 70 people per day adding up to a population increase of 465,000 people between 2000 and 2017 (Benedict 2006). “A 1997 study of natural areas showed that 16,000 acres of the natural areas identified in 1989 were lost or substantially changed” (Benedict 2006, 270).

**Montgomery County, Maryland: Legacy Open Space Program**

Montgomery County, Maryland is located directly adjacent to the Washington D.C. metropolitan area. This county has been experiencing development pressure from Washington D.C. for the last several decades. Fortunately, “Montgomery County’s park, natural resource, farmland, and heritage conservation efforts have been a priority of the Montgomery County Planning Board since its inception in 1927” (Montgomery County Plan 2001, 4).

**Anne Arundel County, Maryland: Greenways Master Plan**

Similarly, Anne Arundel County, Maryland is located in close proximity to the metropolitan areas of Washington D.C. and Baltimore, Maryland as well as the Chesapeake Bay. This location has attracted numerous people to live and work within the county. “As a result Anne Arundel County’s population and employment base is growing. The County’s population in 2000 was 489,600, a 62,000 increase from 1990, and is projected to increase to 541,000 by 2020. The number of jobs in the County is also expected to rise, from 292,000 in 2000 to 337,000 by 2020. The County’s rate of growth is faster than that of the State and the Baltimore region. The County’s growth
management policies have been quite successful; between 1987 and 1997, for example, more than 90 percent of the county’s growth occurred in existing and planned sewer service areas” (Anne Arundel County 2002, 9).

“Anne Arundel County was the first county in the state to base its officially adopted greenways plan on the concept of green infrastructure and the results of the statewide green infrastructure assessment. The county adapted many of the procedures developed by the state to accommodate its unique goals and needs” (Benedict 2006, 19). The statewide GreenPrint program was designed with the principles of green infrastructure in mind (Maryland Department of Natural Resources 2003). The program has three primary goals: use computer mapping to identify the most important unprotected lands in the state, connect those lands with corridors, and to save those lands through targeted acquisition and easements (Maryland Department of Natural Resources 2003).

“As a response to decreasing open space in the county, several county planning efforts, including the General Development Plan, recommendations from 12 small area plans, and recommendations from the County Land Preservation and Recreation Plan, proposed the protection of a network of linked conservation lands within the county. These efforts were further supported by the State’s Green Print program and the Maryland Green Infrastructure Assessment effort, which resulted in a statewide green infrastructure network design” (McDonald 2005, 23). “This plan serves as a good example for how the green infrastructure planning approach is permeating other plan taxonomies. While primarily focused on developing a linked network of trails and greenways, the analysis for the network design was based upon ecological criteria and...
assessments. Moreover, the greenways network was designed to enhance and improve upon the existing statewide green infrastructure network at the local level” (McDonald 2005, 24).

**Metro Greenprint: Minneapolis and St. Paul Minnesota**

The Twin Cities metropolitan area in Minnesota also has a long history of environmental protection. The landscape architect Horace Cleveland helped to create the first urban open space network, the Minneapolis-St. Paul metropolitan park system, which was completed in the 1890s. The seven county metropolitan area that houses the Twin Cities is the largest metropolitan area in Minnesota and is located in the south eastern portion of the state [FIGURE 4.1] “Despite the area’s legacy of land protection, rapid growth and development in the 1980s and 1990s converted natural and agricultural lands at an unprecedented rate” (Benedict 2006, 79). The Metro GreenPrint program is designed to help combat land fragmentation and conserve the regions valuable natural resources.
Green Infrastructure Plan for Saratoga County, New York

Saratoga County, New York is located in upstate New York in the Hudson Valley. “Sixty-two percent of the county’s border is bounded by nearly 100 miles of the Hudson and Mohawk rivers. The county covers over 540,000 acres, approximately 20,000 of which is surface water. The elevation in the county changes by over 2,500 feet from the lowest point at the southeast tip of the county in Waterford, to the highest point in the Adirondack Park. Nearly thirty percent of the county is located in the Adirondack Park; three of the county’s twenty-one municipalities fall entirely within the park boundary.” (Behan Planning Associates 2006, 30). “The cultural landscape history and settlement pattern of the region is primarily based on the development of small hamlets within each town. There are over 100 hamlets in the county. These hamlets developed around a variety of natural and cultural elements such as major crossroads, the location of mineral springs and water resources, and the concentration of agricultural or industrial land uses” (Behan Planning Associates 2006, 30).

Landscapes: Managing Change in Chester County, PA

Chester County is one of five Pennsylvania counties that comprise the Philadelphia metropolitan area (the others being Bucks, Montgomery, Philadelphia, and Delaware counties). As such, during the last 25 years, Chester County has been greatly impacted by population growth and sprawling development “In Chester County more land is consumed for each new house and for each new job than in any other county in the Delaware Valley region” (Chester County Planning Commission 1996).
Green Infrastructure Definitions

Green infrastructure has many facets and can be seen from numerous different angles and as such each plan defines green infrastructure in a unique way. Similarly to what was found in the literature review, some plans focused almost solely on conservation of land that has been “undisturbed” by human activity, while others went further to include aspects of ecological restoration and recovery for brownfields and areas which have been long occupied by human development. Many of the plans considered the benefits that green infrastructure could provide for animals, ecosystems and humans. Much of the recent literature coming from Western Europe suggests that green infrastructure should be very multi-functional and placed strong emphasis on social equity issues – that is – using green infrastructure for the benefit of things like “fostering community” and creating an “equitable geographic network” of parks and trails throughout human settlements. A small minority of the plans studied from within the United States considered the “social” facet of green infrastructure. However, there are components that are common to each one. Most focus on a definition of green infrastructure that include some reference to “natural” lands and open space. Prince George’s County defined green infrastructure as “an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas of countywide significance” (Prince George’s County Planning Board of the Maryland National Capital Park and Planning Commission 2005, ii). Saratoga County, New York defines its green infrastructure resources as its lakes, rivers, forests, farmlands, and historic resources. “The plan brings together the county’s most important open space resources, including
natural systems such as streams, wetlands and watersheds; working landscapes such as farms and managed forests; recreational and trail opportunities such as multi-use trails and fishing access; and cultural resources such as scenic and historic corridors” (Saratoga County Board of Supervisors, 2006). The plan refers to four basic interconnected elements of green infrastructure including natural systems, recreation and trails, cultural landscapes, and working landscapes. The Twin Cities plan similarly refers to basic interconnected elements of green infrastructure which include natural areas, open spaces, and greenways (Metropolitan Region: Minnesota Department of Natural Resources 1997, 17). However, some counties do not establish a definition and instead turn their attention to the different types of land within the county that will be protected by the plan. Chester County, Pennsylvania provides a framework for protection and growth strategies within the County. This framework includes four distinct landscape types: natural, rural, urban, and suburban.

DATA ANALYSIS

These plans represent diverse methods for developing green infrastructure plans. The following synopsis describes the plans reviewed and presents the results of the evaluation. The scoring system is then applied to each one of the plans.

Goal Setting

Among the indicators that received the most attention under the goal setting criterion were “was the plan led by a vision, formal plan goals, and strategies for guiding
plan development”, “adequate public engagement”, “goals for open space and associated human benefits”, and “connection of strategic ecosystem components.”

<table>
<thead>
<tr>
<th>GOAL SETTING</th>
<th>Prince George’s County, Maryland</th>
<th>Twin Cities, Minnesota</th>
<th>Chicago, Illinois</th>
<th>Pima County, Arizona</th>
<th>Portland, Oregon</th>
<th>Montgomery County, Maryland</th>
<th>Chester County, PA</th>
<th>Saratoga County, NY</th>
<th>Anne Arundel County, Maryland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was the plan led by a vision, formal plan goals, and strategies for guiding plan development?</td>
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<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Did the planning process include an adequate public engagement process that provided stakeholders with ample opportunities to weigh in on plan development?</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Was plan development led by goal(s) to protect ecological processes and functions?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Did the plan include goals for open space and its associated human benefits?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Did the plan include strategic connection of ecosystem components - parks preserves, riparian areas, wetlands, and other green spaces?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
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</tr>
</tbody>
</table>

Table 4.2 – Indicators most fully analyzed under the Goal Setting criterion

Every plan studied was based on a certain set of goals to help guide the development of the plan. The most commonly occurring goal was in reference to protecting ecologically sensitive lands from being developed. The Anne Arundel County plan has a primary goal of protecting almost 10,000 acres with their green infrastructure plan. Previous land acquisition and protection efforts did not follow a coordinated plan and therefore one of the main goals of the new plan is to create an integrated network of open spaces (Anne Arundel County Department of Recreation and Parks and Office of Planning and Zoning, 2002).
It was the goal of the Pima County Board of Supervisors to protect ecologically sensitive land which would allow them to save endangered species within their planned area. The addition of the cactus ferruginous pygmy owl to the endangered species list in 1997 led the Board to realize that by addressing the problems that led to the owl’s listing in the first place it could be possible to reverse the decline of a host of other vulnerable species (Benedict 2006). The County recruited a volunteer Science Technical Advisory Team, who studied the issued and suggested that by protecting the habitat areas of other rare species, in addition to the owl, would help them to save money by avoiding future endangered species issues. The listing of the pygmy owl was the perfect opportunity to spur comprehensive land use planning, which could help direct new development to appropriate areas, while protecting the natural and cultural resources that enhance the quality of life within the county. The objectives for the plan were to create a conservation plan that was science-based, produce and update to the comprehensive plan, and to obtain federal regulation compliance through the protection of endangered species through a multiple-species conservation plan. Portland shares a common goal with Pima County, to protect endangered species. Green infrastructure began appearing in Portland prior to its implementation in most of the rest of the United States. In large part, green infrastructure was used as a way to fulfill the requirements of the Clean Water Act and the Endangered Species Act.

The goal of the Chicago Wilderness Plan is very much in line with the goals of green infrastructure. Their long term goal is extremely visionary. They seek to “build something big, something that could some day transform this region into the world’s first urban bioreserve, a metropolitan area where people live in harmony with rare and
valuable nature” (Chicago Wilderness Consortium 2004, 6). The city’s efforts reinforce their notion to be the “Greenest City in the Nation” (Wise 2008). They plan to reach that ambitious goal in part with a new stormwater ordinance. Chicago now has about two million square feet of vegetated roof, with another two million planned or under construction. A new stormwater ordinance, requires that the first half inch of runoff be captured, or that there be a 15 percent reduction in impermeable surface, on most development and redevelopment projects (Wise 2008).

The public played a key role in shaping nearly all of the plans within this study. Pima County, Arizona did an exceptional job engaging the public with this project. “From engaging citizens and technical experts to lead the planning process, to securing cooperative agreements with neighboring jurisdictions and with federal agency partners, to enlisting private conservation organizations to assist with the analysis and development of prioritization systems, this effort serves as a model for collaborative conservation planning” (McDonald 2005, 20). They knew that to be successful the plan required the support and approval of citizens. They sought to make broad citizen participation of a top priority, and brought together a diverse group of stakeholders to create a balanced approach to plan making. The Sonoran Desert Conservation Plan that resulted combined traditional growth management and conservation planning into a single comprehensive planning initiative.

Similarly, Portland did a phenomenal job collaborating with government agencies, businesses, and non-profit organizations in their region. They worked “to establish an interconnected system of natural areas, open spaces, trails, and greenways in the four-county Portland, Oregon-Vancouver, Washington metropolitan area” (Benedict 2006,
The program sought to keep the public informed about the project with many public presentation and meetings, and inserts in the local paper, *The Oregonian*. They also scheduled regular park forums to help encourage the sharing or information between conservation groups and the public. The Metro Greenspaces program not only involved a tremendous number of stakeholders – it involved stakeholders from outside its jurisdiction. “An essential element of the Metro Greenspaces program is its cross-jurisdictional approach. The program draws its strength from its focus on interconnectivity – between natural areas, between people, and between programs. The regional approach crosses political boundaries and embraces the principles of landscape ecology that emphasize the interdependency of ecosystems by taking context into account (Benedict 2006, 277).

By contrast, although Anne Arundel’s County Master Plan brought together a good blend of conservation and planning experts, they included only a modest public involvement component. The State of Maryland’s GreenPrint program does not include public participation as a primary goal. It is worth noting that both Prince George’s County and Montgomery County both obtained much more in-depth citizen participation while drafting their plans.

All of the plans in the study realized a key fact: many planning elements that improve environmental quality also improve quality of life and make communities more livable. Portland provides an excellent example. In 2007 the city adopted a Green Streets policy that encourages the implementation of swales, rain gardens, and curbside plants in a variety of locations. This serves several objectives for the city. It helps manage the flow of stormwater and improve water quality while at the same time
increasing the attractiveness of the streetscape which enhances the aesthetic quality of the city.

Within the Goal setting set of indicators those that received the least attention were, “elements of identity and character”, “procedural validity concerning stakeholder involvement”, “working lands protection”, and the “preservation of cultural/historic resources”. Throughout the selection of plans, these indicators were barely present in some plans, while others gave them little more than trivial analysis.

<table>
<thead>
<tr>
<th>GOAL SETTING</th>
<th>Prince George's County, Maryland</th>
<th>Twin Cities, Minnesota</th>
<th>Chicago, Illinois</th>
<th>Pima County, Arizona</th>
<th>Portland, Oregon</th>
<th>Montgomery County, Maryland</th>
<th>Chester County, PA</th>
<th>Saratoga County, NY</th>
<th>Anne Arundel County, Maryland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the plan include elements of identity and character (i.e. characteristic green spaces that citizens recognize as important and unique for their region)?</td>
<td>(+)</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Procedural validity - does the plan cover how stakeholders were chosen to participate in the planning process?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>(+)</td>
<td>++</td>
<td>++</td>
<td>(+)</td>
</tr>
<tr>
<td>Did the plan include goal(s) for working lands protection? (i.e. farming, forestry, ranching)</td>
<td>(+)</td>
<td>(+)</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Did the plan include goal(s) for the preservation of cultural/historic resources?</td>
<td>+</td>
<td>++</td>
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Table 4.3 – Indicators least analyzed under the Goal Setting criterion

Several of the plans within this study do not acknowledge elements of identity and character in their green infrastructure network. They fail to recognize that there are some green spaces that are unique to their jurisdiction and that that uniqueness is important to the citizens.
Many of the plans make reference to the stakeholders involved in their creation. However, the reasons behind why these individuals were chosen to participate are not addressed within these plans. Chester and Saratoga were the only plans that covered this fully.

The protection of working lands, such as farming, forestry, and ranching is an important element of a comprehensive green infrastructure network. Nearly half of the plans fail to mention anything about the importance of protecting productive agricultural land.

Similarly, the protection of cultural and historic resources, according to the literature, have a place in every green infrastructure network. Unfortunately, most of the plans make little or no reference to the preservation of cultural and historic resources within their jurisdiction.

**Analysis**

The largest number of indicators were included in analysis criterion. The indicators that were most commonly occurring within the plans include, “biodiversity – ecosystem level”, “suitability analysis utilized”, and “the final design resulted in an ecologically connected framework”. All of the plans devoted large amount of time analyzing these indicators.
Biodiversity -
Ecosystem level -
Multiple kinds of
ecosystems within
the planned area.

Was a suitability
analysis or similar
land suitability
method (that
incorporated the
network design
criteria) utilized to
calculate and
classify the range of
conservation values
for the study areas?

Did the final
network design (i.e.
results from
suitability analysis)
result in an
ecologically
connected
framework?

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>Prince George's County, Maryland</th>
<th>Twin Cities, Minnesota</th>
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Table 4.4 – Indicators most fully analyzed under the Analysis criterion

The Pima County plan, with its basis in species protection, scored the highest on the indicator criterion pertaining to biodiversity at the ecosystem level, and the presence of rare/unique species. They assembled a list of potentially covered species, along with vegetation maps, and scientists involved with the project identified the critical habitat and connecting corridors that will help them to establish an effective and sustainable biological reserve. Their goal was to meet the federal requirements of the Endangered Species Act, but they went far beyond that. “They wanted to address the problems that led to the owl’s listing in the first place and reverse the decline of a host of other vulnerable species” (Benedict 2006, 101). The county recommended the conservation of biological corridors and critical habitat, mountainous and riparian areas as well as ranches, historic, and cultural sites (Benedict 2006, 106). The County recruited a volunteer Science Technical Advisory Team, who studied the issued and suggested that
by protecting the habitat areas of other rare species, in addition to the owl, would help them to save money by avoiding future endangered species issues. The listing of the pygmy owl was the perfect opportunity to spur comprehensive land use planning, which could help direct new development to appropriate areas, while protecting the natural and cultural resources that enhance the quality of life within the county. The objectives for the plan were to create a conservation plan that was science-based, produce and update to the comprehensive plan, and to obtain federal regulation compliance through the protection of endangered species through a multiple-species conservation plan.

It should be the goal of every green infrastructure plan to create a final product that results in an ecologically connected framework of land. “The Portland Greenspaces system is anchored by hubs that support a variety of plants and animal species. Portland’s Forest Park, for example, encompasses more than 5,000 acres, making it one of the largest natural forested urban parks in the United States. The park contains old-growth trees, a wide variety of plants, and over 100 species of mammals and 100 different types of birds” (Benedict 2006, 274). The Minnesota Department of Natural Resources aided in the creation of an ecologically connected framework in the Twin Cities. This group conducted research and created natural resource and recreation maps which they then used to identify ecologically important areas of habitat and potential corridors to connect them.

The indicators that received the least attention within these plans were, “public health”, “equitable geographic distribution”, “importance of the network in everyday lives of the residents”. Many of these indicators were not mentioned at all in the plan.
Some of the plans called for the creation of recreational trails to be used by humans, but few of them did any more than mention the role that trails can have in promoting healthy lifestyles and the associated benefits that occur as a result of a healthy population. Among the principles of green infrastructure is that the final network should result in an ecologically connected framework. The literature also suggests that this connected framework should also be equitably distributed across the jurisdiction – not catering to a particular race, class, or neighborhood. Only within the Twin Cities plan was this issue fully addressed. Building upon the last two criteria, green infrastructure should play a role in the everyday lives of the residents it serves. Aside from Portland and Saratoga County none of the plans did more than briefly touch on the topic.

Within Portland, the residents are very concerned with the quality of their environment. “In 1992, voters approved a home-rule charter defining Metro’s most
important service to be ‘planning and policy making to preserve and enhance the quality of life and the environment’” (Benedict 2006, 271). Portland’s Metro Greenspaces Program recognizes that their plan can serve to protect the quality of the environment while improving the quality of life of their residents. Their plan calls for the creation of a network of trails, which are primarily for human use. The trial network also supports habitat and migration corridors for native plants and animals, as well as at-risk animals like the salmon.

**Synthesis**

The stage of plan development is designed to help move the plan from the analysis stage of words and paper to the implementation stage of projects and reality. Among the synthesis criterion, the indicators that received the most attention were “final conservation priorities meet plan goals” and “specific implementation priorities identified”.

<table>
<thead>
<tr>
<th>SYNTHEISIS</th>
<th>Prince George's County, Maryland</th>
<th>Twin Cities, Minnesota</th>
<th>Chicago, Illinois</th>
<th>Pima County, Arizona</th>
<th>Portland, Oregon</th>
<th>Montgomery County, Maryland</th>
<th>Chester County, PA</th>
<th>Saratoga County, NY</th>
<th>Anne Arundel County, Maryland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were specific priorities identified in this plan?</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Did the final conservation priorities meet plan goals?</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

Table 4.6 – Indicators most fully analyzed under the Synthesis criterion

As with all types of plans, the priorities identified within the plan should strive to meet the goals laid out at the beginning of the plan. The Pima County plan created through a highly scientific process, an ecologically connected framework of hubs and
corridors. Their focus on an ecologically connected network was necessary to protect their endangered species and obtain all of the necessary federal permits. However, the plan does not have priorities in place to include the protection of valuable cultural and historic resources within the County into the network design.

The indicators that received the least attention under the synthesis criterion were “appropriate provisions for implementation” and “protection status of green infrastructure lands incorporated into the network design”.

<table>
<thead>
<tr>
<th>SYNTHESES</th>
<th>Prince George's County, Maryland</th>
<th>Twin Cities, Minnesota</th>
<th>Chicago, Illinois</th>
<th>Pima County, Arizona</th>
<th>Portland, Oregon</th>
<th>Montgomery County, Maryland</th>
<th>Chester County, PA</th>
<th>Saratoga County, NY</th>
<th>Anne Arundel County, Maryland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are appropriate provisions for implementation identified?</td>
<td>++</td>
<td>(+)</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Was the protection status of green infrastructure network lands identified and incorporated into the model?</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
</tbody>
</table>

Table 4.7 – Indicators least analyzed under the Synthesis criterion

A majority of the plans failed to realize realistic implementation strategies to make the plan a reality. At this point, many of the plans are based more around a vision than reality. For example, the Anne Arundel plan called for the development of individual implementation/management plans for each of the 41 greenway segments (Anne Arundel County Department of Recreation and Parks and Office of Planning and Zoning 2002). As a result the plan was not very specific in developing conservation priorities or a detailed implementation plan.
Several of the plans failed to consider the protection status of lands within their green infrastructure network. This means that lands that are already under partial legal protection may be given a lower priority than those elements of the network that are unprotected and thus most vulnerable to urban development.

**Implementation**

Among the indicators that received the most attention under this criterion were “identification of state, federal, local and private funding opportunities”, and “identification of available land conservation mechanisms and tools”. Without funding the vision of a green infrastructure plan will never be realized. Similarly, without the knowledge of the tools that are available, local governments will never be able to successfully implement the plan.

<table>
<thead>
<tr>
<th>IMPLEMENTATION</th>
<th>Prince George's County, Maryland</th>
<th>Twin Cities, Minnesota</th>
<th>Chicago, Illinois</th>
<th>Pima County, Arizona</th>
<th>Portland, Oregon</th>
<th>Montgomery County, Maryland</th>
<th>Chester County, PA</th>
<th>Saratoga County, NY</th>
<th>Anne Arundel County, Maryland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the plan identify federal, state, local and/or private conservation funding opportunities?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Does the plan identify available mechanisms and tools for land protection (i.e. acquisition, easement, TDR, other)?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>(+)</td>
</tr>
</tbody>
</table>

Table 4.8 – Indicators most fully analyzed under the Implementation criterion

The Twin Cities plan is made up of numerous local units of government and citizens. As such, in order to effectively implement the plan, private residents and local governments will be required to assist. The plan brings together funding sources and
provides an easy to understand table with all of the tools available to local governments, while at the same time identifying the natural resources that are in the greatest need of protection. The goal of the plan is to gain local support by empowering communities to protect the natural features that are important to them. At a metro-wide scale, a large number of participating individual projects will result in a comprehensive ecological network. A healthy environment, which is the end result of this strategy, benefits all metro residents.

The Metro Greenspaces plan does an excellent job of identifying funding sources for plan implementation. This portion of the plan was a success, in part because the political will to make it happen existed. The Greenways and Natural Areas Collaborative, which was created by the State of Minnesota legislature helped secure funding for the plan. In 1998 Minnesota Legislature appropriated 4.34 million to the MN-DNR Metro Region…The state pledged to work with local units of government and nongovernmental organizations to accomplish the goals identified by the Collaborative” (Benedict 2006, 79).

Among the criteria that received the least attention were, “methodology for developing the decision support tool documented”, “identification of specific implementation strategies for private landowners”, and “making better use of existing infrastructure by encouraging compact growth”.

Table 4.9 – Indicators least analyzed under the Implementation criterion

The Anne Arundel plan contained a brief discussion about the analysis conducted to create the green infrastructure network. The methodology for analysis and the specific metrics used to measure components of the green infrastructure network were not included. The process used to design the green infrastructure was very vague and made it difficult to understand how the planning board developed their decision-support tool.

The Twin Cities plan is one of the few that places a large emphasis on the importance of collaborating with private landowners to implement their plan. The city is working closely with home owners to install rain gardens throughout the city. This collaboration helps the city to keep its costs lower, because after installation, the homeowners are responsible for the maintenance of any rain gardens on their property.

Portland also recognizes the importance of involving private landowners to implement their plan. In 1996 the city began advocating downspout disconnection, to remove many private residences from the cities sewer system. “Homeowners have two options for disconnecting from the city’s combined sewer system so that stormwater can flow over appropriate vegetated sites. The city will pay homeowners who disconnected
their own downspouts, or city crews will disconnect them for free” (Wise 2008, 18).
“Downspout disconnection is one of several actions eligible for residential utility fee
discounts under Portland’s Clean River Rewards Incentive system. By disconnecting
nearly 60,000 downspouts, the city diverted 1.5 billion gallons annually from combined
sewers” (Wise 2008, 18).

As a strategy, green infrastructure is not intended to eliminate development, but
rather guide it to areas where it is appropriate. Most plans failed to acknowledge this
element. However, the Pima County officials realized they could save money by
redirecting growth to areas where infrastructure is already established. This has helped
them sell the idea to their community. It also helps them achieve their goals of fostering
responsible growth and preserving ecologically sensitive areas.

**Study Summary**

Through the analysis of data gathered by the qualitative study, my research has
extracted four realities of green infrastructure that should be taken away from this study.
First, as a strategy, green infrastructure is being used to shape plan development in of
each of the nine jurisdictions under review. Green infrastructure is a complex strategy
that takes different forms in each jurisdiction in which it is implemented. Decades of
conservation planning have resulted in several plan taxonomies that are no longer easily
differentiated. Green infrastructure, greenway, open space, and other types of
conservation planning efforts all produce plans that have many similar goals and use
similar tools. Thus plans that are produced are often hybrids, using theory from
numerous types of environmental planning strategies. It has become increasingly
difficult to articulate the differences between different types of environmental plans.

Second, the use, definition, and language of green infrastructure vary between
each of the 9 plans studied, but there are common elements within each definition.
Similarly to what was found in the literature review, some plans defined green
infrastructure to be the land that has been “undisturbed” by human activity, neglecting the
prospect of restoration for natural spaces within the built environment. Chicago, Portland,
Saratoga County, and Montgomery County chose to include working lands within their
definition of green infrastructure. Many of the plans considered the benefits that green
infrastructure could provide for animals, ecosystems and humans. However, only a small
minority of the plans studied from within the United States considered the “social” facet
of green infrastructure. Saratoga County was the only plan that contained a strong public
health element in its definition of green infrastructure. Similarly, the Twin Cities was the
only plan to firmly declare that investment to the green infrastructure should be
geographically equitable throughout the city. Most of the plans focus on a definition of
green infrastructure that include some reference to “natural” lands and undeveloped open
space. Prince George’s County defined green infrastructure as “an interconnected
network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas of
countywide significance” (Prince George’s County Planning Board of the Maryland
defines its green infrastructure resources as its lakes, rivers, forests, farmlands, and
historic resources. “The plan brings together the county’s most important open space
resources, including natural systems such as streams, wetlands and watersheds; working
landscapes such as farms and managed forests; recreational and trail opportunities such as multi-use trails and fishing access; and cultural resources such as scenic and historic corridors” (Saratoga County Board of Supervisors, 2006). The plan refers to four basic interconnected elements of green infrastructure including natural systems, recreation and trails, cultural landscapes, and working landscapes. The Twin Cities plan similarly refers to basic interconnected elements of green infrastructure which include natural areas, open spaces, and greenways (Metropolitan Region: Minnesota Department of Natural Resources 1997, 17). However, some counties do not establish a definition and instead turn their attention to the different types of land within the county that will be protected by the plan. Chester County, Pennsylvania provides a framework for protection and growth strategies within the County. This framework includes four distinct landscape types: natural, rural, urban, and suburban.

There has been a trend towards increasing complexity within environmental planning both in its goals and the tools that are used to create and implement plans. By distilling the core components and purposes of conservation plan taxonomies, it is possible to shed light on the advancements that have been made in the field of conservation planning.

Third, green infrastructure does not serve the same purpose as “gray” infrastructure does in traditional city planning. Although some plans referred to the potential of green infrastructure to replace traditional infrastructure in, for example, managing stormwater, most did not. The majority of the plans under review see green infrastructure as a landscape scale conservation strategy. The word “infrastructure” is meant to resonate more strongly than past phrases like “greenways”, “green space”, or
“open space.” It is meant to imply something that is necessary for the expansion of the human built environment, but not in the functional way that we use electric lines or sanitary sewers to expand our cities.

Finally, green infrastructure is different and new than what was occurring in these regions prior to its arrival. Green infrastructure is a much more strategic approach to conservation planning that combines the methodologies of the previous forms of conservation planning with the goal of planning for broader landscapes and with much more of a focus on ecological functions and processes.

Table 4.9 displays the overall results of the thesis research. The plans from Chicago, Illinois; Portland, Oregon; and Saratoga County achieved the highest overall scores. By contrast, Anne Arundel County; Chester County; and the Twin Cities scored the lowest. Chicago, Portland, and Saratoga consistently scored highly across all of the indicators, specifically in the foundations of the plan and the goal setting section. Chester, Anne Arundel, and the Twin Cities did not have an adequate understanding of ways to take their paper and pencil plan and synthesize it with real-world implementation strategies, which badly hurt their overall scores.

<table>
<thead>
<tr>
<th>Overall Results</th>
<th>Prince George’s County Maryland</th>
<th>Twin Cities, Minnesota</th>
<th>Chicago, Illinois</th>
<th>Pima County, Arizona</th>
<th>Portland, Oregon</th>
<th>Montgomery County, Maryland</th>
<th>Chester County, Pennsylvania</th>
<th>Saratoga County, New York</th>
<th>Anne Arundel County, Maryland</th>
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</thead>
<tbody>
<tr>
<td>Goal Setting</td>
<td>131</td>
<td>145</td>
<td>152</td>
<td>150</td>
<td>147</td>
<td>147</td>
<td>128</td>
<td>151</td>
<td>103</td>
</tr>
<tr>
<td>Analysis</td>
<td>153</td>
<td>149</td>
<td>157</td>
<td>147</td>
<td>162</td>
<td>146</td>
<td>128</td>
<td>152</td>
<td>136</td>
</tr>
<tr>
<td>Synthesis</td>
<td>48</td>
<td>37</td>
<td>46</td>
<td>44</td>
<td>48</td>
<td>50</td>
<td>44</td>
<td>50</td>
<td>41</td>
</tr>
<tr>
<td>Implementation</td>
<td>112</td>
<td>99</td>
<td>120</td>
<td>120</td>
<td>126</td>
<td>115</td>
<td>88</td>
<td>120</td>
<td>91</td>
</tr>
<tr>
<td>Total Score</td>
<td>444</td>
<td>430</td>
<td>475</td>
<td>461</td>
<td>483</td>
<td>458</td>
<td>388</td>
<td>473</td>
<td>371</td>
</tr>
<tr>
<td>Percentage</td>
<td>87%</td>
<td>84%</td>
<td>93%</td>
<td>90%</td>
<td>95%</td>
<td>90%</td>
<td>76%</td>
<td>93%</td>
<td>73%</td>
</tr>
</tbody>
</table>

Table 4.9 – Overall results from thesis research
CHAPTER V: CONCLUSIONS AND RECOMMENDATIONS

New strategies to protect the natural world are commonplace throughout the history of environmental planning. This research worked to classify the most recent strategy, green infrastructure, by reviewing 9 plans from across the United States. This chapter provides my conclusions about green infrastructure planning activities as well as recommendations to ensure that the full potential of the green infrastructure strategy is realized.

The purpose of this research was to define green infrastructure, investigate how its guiding principles differ from previous planning strategies, and determine if the principles of green infrastructure are being applied to plans in the United States. This was accomplished with an evaluation of plans and a review of relevant literature on the topic. The guiding principles of green infrastructure were derived from the data gathered from the literature review and the evaluation of plans. This research is also intended to educate members of the general public who are interested in natural resource conservation. It was not the purpose of this research to answer all questions related to green infrastructure, but rather to add dialogue to the discussion of an exciting new strategy in environmental planning. The final intent of this research is to aid communities who are interested in creating their own green infrastructure plans. The list of indicators used for this research can function as a template with the key elements that should be included in an effective plan. Although there is no blueprint for a successful green infrastructure plan, this list of indicators can serve as a starting point for plan development.
The conclusions presented in this chapter were developed as a result of the analysis of the qualitative research conducted within this study. All research was conducted within the bounds of my three primary research questions, which were presented in Chapter I:

1. What is green infrastructure?
2. Is green infrastructure fundamentally different from previous environmental planning strategies?
3. Are the principles of green infrastructure being applied in planning in the United States?

This chapter also touches on opportunities for continued research on the topic, acknowledges the limitations of this study, and includes my final thoughts on green infrastructure.

Through the analysis of data gathered by the qualitative study, my research has extracted four realities of green infrastructure that should be taken away from this study.

First, green infrastructure theory of some sort or another is being included in the plans of each of the nine jurisdictions under review. Some indicators were included and thoroughly analyzed in every plan. For example, each plan was built around goals to protect and improve ecosystem processes and functions and to create strategic connections between ecosystem components, both of which are basic principles of green infrastructure. All of the plans created a network design that resulted in an ecologically connected framework. Within previous environmental planning strategies, this was not as much of a focal point as it is today. In order to make the vision of the green
infrastructure plan a reality, the plans help to connect local governments to the funding and tools necessary to bring green infrastructure into their communities.

However, decades of conservation planning have resulted in several plan taxonomies that are no longer easily differentiated. It has become increasingly difficult to articulate the differences between greenway, open space, green infrastructure and other types of conservation plans as planning efforts have evolved and now produce plans that look more like hybrids.

In some cases there were indicator criteria that are a part of green infrastructure planning, but they were notably absent from many of the plans. The protection of working lands and cultural resources is an important function that can be served through the comprehensive nature of a green infrastructure plan, but many of the plans failed to include these elements. In other areas of the plans, issues of equity and public health were either barely mentioned, or not included at all. And although much of the land within a green infrastructure network will be under private ownership, most of the plans do not include any specific implementation strategies for private landowners. These issues will be discussed further in the implications section of the chapter.

Second, the use, definition, and language of green infrastructure varies between each of the 9 plans studied. There is a need for a common language within conservation planning. By distilling the core components and purposes of conservation plan taxonomies, it is possible to shed light on the advancements that have been made in the field of conservation planning.

Third, the use of the word “infrastructure” within green infrastructure is not used in the same way that the traditional “infrastructure” is used. Although some plans
referred to the potential of green infrastructure to replace traditional infrastructure in, for example, managing stormwater, most did not. The majority of the plans under review see green infrastructure as a landscape scale conservation strategy. The word “infrastructure” is meant to resonate more strongly than past phrases like “greenways”, “green space”, or “open space.” It is meant to imply something that is necessary for the expansion of the human built environment, but not in the functional way that we use electric lines or sanitary sewers to expand our cities.

Finally, green infrastructure is different and new than what was occurring in these regions prior to its arrival. Green infrastructure is a much more strategic approach to conservation planning that combines the methodologies of the previous forms of conservation planning, with the goal of planning for broader landscapes and with more holistic planning goals. Green infrastructure has been influenced by advancements in ecological sciences and land use planning practices that have been evolving over the last 150 years. Green infrastructure owes a great deal to advancements of numerous disciplines, including landscape architecture, ecology, and planning, among others. Green infrastructure is different from previous environmental planning strategies due to its focus on linking the planning process and plan goals to scientific analysis in order to create a linked network design composed of ecological hubs and corridors which serves as a blueprint for future land conservation and development efforts.
Implications

What does any of this really mean? Green infrastructure plans seek to create an environment in which man and nature can more reasonably coexist. Scientists studying ecology have determined that all things in nature are connected and therefore the intricate interdependences of all living things dictate that natural resource conservation efforts need to be focused on the landscape scale or ecosystem level. As with all things, this is much easier said than done. The magnitude, level of complexity, and numerous competing interests make landscape scale conservation efforts very difficult. Even with a successful plan in place, green infrastructure projects can take years to move from words on paper to real-life projects, as the Portland experience has shown.

As for the principles of green infrastructure, many were included and well analyzed within these plans. Does this mean that the indicators that were heavily analyzed are more important? Does this mean that the indicators that were not analyzed are not important? As a planning strategy, green infrastructure represents an excellent opportunity to conserve land and protect natural resources at a landscape scale. Is this approach the pinnacle of environmental planning? If the full list of indicators within this research are used as a checklist during plan creation, then it certainly has a chance of becoming the best way to protect ecosystem processes and functions, while guiding human development in a responsible manner.

Recommendations

These recommendations are intended to act as goals for future green infrastructure planning efforts to achieve. This research has produced three major recommendations in
an effort to aid the creation of future green infrastructure plans: importance of private
citizens in the creation and implementation of a green infrastructure network, the
importance of scientific analysis and data collection when drafting plans and the
importance of plan flexibility.

**Importance of Citizens**

The first recommendation of this research is that citizen participation and
involvement is vital to green infrastructure planning. Much of the land within a green
infrastructure network will be under private ownership. Without the acceptance of green
infrastructure practices by land owners, a green infrastructure network will never be
ecologically connected or comprehensive. For all communities interested in creating a
green infrastructure plan, I recommend improving public education related to green
infrastructure within their region. This should be done at all levels of the community. By
starting early and implementing green infrastructure education in elementary school
curriculum, the importance of ecologically connected networks can be developed over a
lifetime. There should also be specific strategies to target private landowners within the
region. Information should be readily available and easily accessible to anyone wishing
to learn more.

**Importance of Scientific Analysis**

Without a thorough analysis of all ecosystem components within a region prior to
plan creation, there are likely to be many oversights. The analysis and data collection
phase of the planning process should strive to involve numerous experts in the fields of land conservation and ecological sciences.

**Importance of Plan Flexibility**

An incredibly important lesson I learn with this research is that as with the ecological systems it is designed to protect, green infrastructure must be dynamic and ever evolving with modern trends and movements. Plans should be sufficiently flexible to allow for the inclusion of new data and changes within existing systems.

**Limitations of this research**

Plan evaluation can take several forms. This research is focused strictly on the plans themselves and not on the outcomes since plan implementation. By focusing on the plans, my research was able to stay much narrower and more focused. Often, reality is only loosely linked to the plans created by city planners and there can be millions of reasons why plan outcomes could result in something other than what the plan intended. However, I do acknowledge the limitation of strictly researching the green infrastructure plans and literature. Future research could examine the plans that were under study in this research and evaluate the outcomes of plan implementation.

**Opportunities for further research**

I would love to see additional research done on this topic and I believe that there is much left to be discovered on the topic. Here future research could move from the
words and paper of the plans to talking with key stakeholders on the ground who were responsible for the implementation of these plans. This type of work would allow researchers to begin drawing connections between plan quality and plan implementation. I think that it would be fascinating to see whether or not plans who score the highest on the criteria within this research are actually more successful in the implementation stage.

**Final thoughts**

This paper was intended to add to the body of knowledge related to green infrastructure and ecological planning. It was not intended to be the definitive answer to any questions or to result in the end of green infrastructure theory. Rather, this research is mean to inspire additional research with the field of green infrastructure as well as inspiring local government players within the field of city planning. While this study has begun to answer questions pertaining to use of green infrastructure within American communities, there are many more questions to be answered.

These green infrastructure plans are, in large part a vision of a better world. They are an elegant attempt to publicly ask, “What if?” The reader should be attracted into the exercise, lifted to the prospect envisioned, convinced as to its possibility (or that of one like it), and provided just enough ‘realism’ to convince the natural skeptic in us all to at least momentarily suspend disbelief (Baer 1997).

The next time you find yourself outdoors – look around - take the time to appreciate what is there. I then challenge you to uplift yourself to a vision of something more – how could your life be improved by the addition of a comprehensive green
infrastructure network within your community? Envision your neighborhood parks alive with the sounds of songbirds. Imagine your streets lined with attractive vegetation. Consider what would happen if the surface waters in your region were clean enough to swim in and drink from. I ask you to think about the steps that must be taken to make that vision a reality and to find out what you can do to help.
Appendix A: Anne Arundel County Plan Evaluation
Anne Arundel County, Maryland

Goal Setting

Plan Foundations

Were the planning area’s comprehensive green infrastructure components and threats to those components documented?

“Future growth in Anne Arundel County threatens the loss of ecologically valuable land including unspoiled, high-quality landscapes and open space.” P3

The scattered pattern of modern development tends to consume large amounts of land and fragments landscapes. Fragmentation has adverse ecological effects but also has negative effects on the quality of life through the loss of landscape character and scenic beauty, loss of open spaces for people to enjoy, loss of recreational opportunities, and reduced air and water quality.” P3

The network covers approximately 71,700 acres, equivalent to 27 percent of Anne Arundel County's total land area. Greenways are distributed in all parts of the County. Approximately 36,900 acres, or 51 percent of the proposed network, are currently protected as one or more of the following: state, federal, county and City of Annapolis owned lands; agricultural and environmental easements; private conservation lands; and land that is in the County’s Open Space zoning district. The network is divided into 41 greenway segments each of which has been given a name, generally based on streams (see Figure 5). For purposes of implementation and management some of these segments could be combined and the Plan does group the 41 segments into 13 geographic groups.

Did the plan call for coordination with adjacent areas regarding efforts that extended beyond jurisdictional boundaries?

“The Plan takes a primarily ecological approach to defining greenways, but also includes in the proposed greenways network countywide multi-use trails including the East Coast Greenway and the American Discovery Trail.” P4

“Develop a countywide greenways master plan and integrate it into regional greenway planning efforts.” p18

Lots of talk about county-wide and nation wide trail systems

“The greenways network in Anne Arundel County connects to natural greenways in Baltimore City, and Baltimore, Calvert, Howard, and Prince George’s Counties” p31

Two case studies – starting on page 62 that detail past collaborative efforts
Was the plan led by a vision, formal plan goals, and strategies for guiding plan development?

“Create an interconnected network of greenways in Anne Arundel County that protects ecologically valuable lands for present and future generations and provides open space, recreational, and transportation benefits and opportunities for people.” P3

Goals

- Enhance the beauty of the County’s landscape by reducing the fragmenting effects of development and preserving valuable open space;
- Provide adequate habitat to support healthy populations of a diversity of naturally occurring plant and animal species;
- Help guide the location of development so that negative effects on ecologically valuable lands are minimized;
- Link communities to a countywide network of open space;
- Provide off-road transportation opportunities;
- Increase recreational opportunities;
- Improve water and air quality;
- Improve the economy by maintaining and increasing property values and by attracting visitors;
- Encourage the ethic of stewardship of the land in the County; and
- Help achieve the recommendations of county, regional and state plans and programs including Anne Arundel County’s General Development Plan, Land Preservation and Recreation Plan, and Small Area Plans, the Chesapeake 2000 Agreement, and Maryland’s Greenprint program.

Stakeholder Involvement

Did a leadership forum or advisory committee provide leadership and generate momentum for the planning effort?

“The State of Maryland’s green infrastructure initiative; a statewide effort by the Maryland Department of Natural Resources (DNR) to identify and protect large, contiguous blocks of ecologically significant natural areas (hubs) and to link them with natural corridors” p3

“Anne Arundel County’s General Development Plan and the recommendations from 12 completed “Small Area” land use and community plans for different parts of the County that included recommendations for greenways and additional bicycle and walking opportunities” p4

“Anne Arundel County’s land preservation and recreation planning program, especially the recommendations of the current Land Preservation and Recreation Plan” p4
“An Anne Arundel County Technical Advisory Committee including the Department of Recreation and Parks, Office of Planning and Zoning and other resource-related agencies, and assisted by a team of consultants prepared this Plan between Spring 2001 and Spring 2002. Public involvement in the Plan included three informational newsletters sent to community associations and other interested groups, organizations and individuals, public meetings in October 2001 and in Spring 2002, and several meetings with interested groups. The project website included a questionnaire responses to which also provided input for the Technical Advisory Committee.” P11

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Did the leadership forum/advisory committee include a diversity of professional disciplines and represent multiple sectors?

“the Department of Recreation and Parks, Office of Planning and Zoning and other resource-related agencies, and assisted by a team of consultants prepared this Plan” P11

++

Did the planning process include an adequate public engagement process that provided stakeholders with ample opportunities to weigh in on plan development?

“Public involvement in the Plan included three informational newsletters sent to community associations and other interested groups, organizations and individuals, public meetings in October 2001 and in Spring 2002, and several meetings with interested groups. The project website included a questionnaire responses to which also provided input for the Technical Advisory Committee.” P11

+

Did the plan include elements of identity and character (i.e.characteristic green spaces that citizens recognize as important and unique for their region)?

-

Procedural validity - does the plan cover how stakeholders were chosen to participate in the planning process?

Just mentions who participated - local experts, the public and consulting groups but does not discuss why or how they were chosen

(+)

Conservation Vision

Was plan development led by goal(s) to protect ecological processes and functions?

“Improve water and air quality” p3
• Enhance the beauty of the County’s landscape by reducing the fragmenting effects of
development and preserving valuable open space;
• Provide adequate habitat to support healthy populations of a diversity of
naturally occurring plant and animal species;
• Help guide the location of development so that negative effects on ecologically
valuable lands are minimized;
• Improve water and air quality;
• Encourage the ethic of stewardship of the land in the County

++

Did the plan include goal(s) for working lands protection? (i.e. farming, forestry, ranching)
-

Did the plan include goal(s) for watershed protection?
    Improve water and air quality; p4
(+)

Did the plan include goals for open space and its associated human benefits?
  “Enhance the beauty of the County’s landscape by reducing the fragmenting
effects of
development and preserving valuable open space”
• Link communities to a countywide network of open space;
• Provide off-road transportation opportunities;
• Increase recreational opportunities;
• Improve the economy by maintaining and increasing property values and by
attracting visitors;
• Encourage the ethic of stewardship of the land in the County; p10
(+)

Did the plan include goal(s) for the preservation of cultural/historic resources?
-

Did the plan include strategic connection of ecosystem components - parks preserves,
riparian areas, wetlands, and other green spaces?
  “The scattered pattern of modern development tends to consume large amounts of
land and fragments landscapes. Fragmentation has adverse ecological effects but
also has negative effects on the quality of life through the loss of landscape
color and scenic beauty, loss of open spaces for people to enjoy, loss of
recreational opportunities, and reduced air and water quality. The most effective
way to prevent these negative effects in a developed area such as Anne Arundel
County is to create an interconnected network of protected open space corridors or greenways.” P3

The network covers approximately 71,700 acres, equivalent to 27 percent of Anne Arundel County’s total land area. Greenways are distributed in all parts of the County.” p4

“The greenways network identifies approximately 100 “critical connections”; areas where if a connection cannot be made, a greenway segment will be incomplete and be unable to serve its functions in the network. The largest category of critical connections is where greenways cross roads.” p

Did the plan include the presence of greenways between habitats including connection with the surrounding land to facilitate migration of species? Lots of mention of greenways

“Corridors are individual units of a greenways network that link hubs together. Corridors serve as “natural highways” providing cover for animals moving from one hub to another. Wildlife corridors have long been considered an effective means of linking isolated “islands” of wildlife habitat that have been fragmented by development, agriculture, or other forms of land use or management that restrict or exclude usage by species that may be sensitive to human encroachment.” P21

“Corridors are not generally large enough to provide high quality habitat for sensitive species, but do provide mobile species valuable opportunities to travel between feeding, nesting, mating, and nursery habitats on a daily or seasonal cycle depending on the particular needs of each species. Since many species must travel some distance to avoid exhausting food and cover resources available to them, corridors provide an opportunity for species to safely fulfill a basic requirement for survival with a minimum of conflict with humans” p23

“Size of corridors has historically been thought to be the driving factor in corridor usage by wildlife. Small areas tend to lack the microhabitat and structural diversity that larger habitat units provide. Although the importance of maintaining large stands of forest is well documented, recent research has shown that the heterogeneity, or variety, of the habitat contained within a corridor is also an important factor in determining its usage by wildlife.” P23

Did the plan include the protection of valuable green cores with native habitats that can act as breeding ground for species?

“Provide adequate habitat to support healthy populations of a diversity of naturally occurring plant and animal species” p3
“Hubs are essential features in a greenways network. Hubs are large, ecologically significant natural areas that serve two important purposes:
• They provide habitat for animal and plant species that cannot thrive in small “patches” of open space, that is in highly fragmented landscapes. Without such areas a number of species will not be able to live in Anne Arundel County; and
• They serve as “home ranges” for wildlife, providing sufficient forage, reproductive habitat, and cover to meet all the needs of the species. They are typically large enough to help fulfill many of the requirements of species that forage over large areas and heterogeneous enough to satisfy the unique habitat requirements of species that are specialized to particular environmental niches.” P21

“To serve their purposes, hubs should have a high ratio of interior habitat to edge habitat and be structurally diverse, that is containing a variety of microhabitats. They should have the most uniform boundaries possible, since boundaries that are irregular (that is, zigzagging in and out) reduce the ratio of interior to edge habitat. In general the larger and more diverse a hub habitat, the greater its ecological value.” P21

++

Analysis

Network Design Criteria
Variation of landscapes in the surrounding countryside
“Anne Arundel County’s land cover is a mosaic of forest, shrub, agricultural, and developed areas.” P9
+

Importance of preserving rare/endangered habitats and species
“Know the biology of the target species. While crossings should be designed to maximize the amount of species that could potentially use them, some crossings will be designed to benefit particular species especially where threatened or endangered species are concerned.”

This is a mention of endangered species, but doesn’t talk about their importance (+)

Biodiversity - Ecosystem level - Multiple kinds of ecosystems within the planned area
“Large, structurally diverse habitat areas (that is containing a variety of habitats such as mixed forest types with an understory together with meadow, uplands and wetlands), are more useful than large or small areas with uniform habitat;” p27
++
Biodiversity - Species Level - Presence of a great variety of native species

They use “Indicator species” to help them determine habitat requirements and design the network. However, the indicator species were chosen because “They occur or are likely to occur within the county” p23

(+)

Fragmentation and Edge Effects - Effects of subdividing a continuous habitat into smaller entities, which increases the amount of ecotones and number of species and impact on local climate

“Many studies have demonstrated the adverse ecological effects of forest fragmentation in the landscape. As forest areas are divided and isolated by roads and development, interior habitat decreases, human disturbance increases, opportunistic edge animal species replace interior species, and populations of many animals become too small to persist. Fragmentation also has negative effects on the quality of life through the loss of landscape character and scenic beauty, the loss of open spaces for people to enjoy, loss of recreational opportunities, and reduced air and water quality.” P9

“To serve their purposes, hubs should have a high ratio of interior habitat to edge habitat and be structurally diverse, that is containing a variety of microhabitats. They should have the most uniform boundaries possible, since boundaries that are irregular (that is, zigzagging in and out) reduce the ratio of interior to edge habitat. In general the larger and more diverse a hub habitat, the greater its ecological value.” P21

++)

Were ecologists and other natural areas specialists involved in producing the network design criteria and weighting systems?

This plan involved members of the National Park service, parks and rec people, and a bunch of environmental consultants

++)

Prior to development, identify ecologically rich, critical hubs

“Maryland’s green infrastructure identifies hubs and corridors throughout the state (see Figure 1 in Chapter 1). The average size of a hub statewide is around 2,200 acres, although some hubs are as small as 100 acres. Figure 4 shows Maryland’s Green Infrastructure in Anne Arundel County. The acreage in hubs totals approximately 88,000 acres, although this includes acreage in hubs that are partially in Anne Arundel County and partially in other counties. The hubs range in size from over 18,000 acres (Patuxent Wildlife Refuge and Jug Bay) to some that are as small as 130 acres. In developing a more detailed local analysis (at a smaller scale) for the Greenways Master Plan than
the state used, this Plan reviewed the hubs the state had identified and identifies other potential hubs that have significance at the county level.” P21

This was done by the statewide Greenspaces initiative

++

Was the plan based on a wide spectrum of data, where feasible?
“Greenways were identified by analyzing different mapped information, studies, databases, and aerial photographs of Anne Arundel County to identify areas currently meeting the criteria or areas where greenways could, potentially, be created in the future.” P4
Much of the network was based from data complied by the State of Maryland

++

Network Suitability Analysis

Was a suitability analysis or similar land suitability method (that incorporated the network design criteria) utilized to calculate and classify the range of conservation values for the study areas?
“The County used five criteria in assessing land as potential greenways: habitat value; size; connections to other land with ecological value; future potential, that is the potential to create greenways where they do not currently exist; and national and countywide trails.” P4

++

Did the final network design (i.e. results from suitability analysis) result in an ecologically connected framework?
The maps within the plan illustrate an ecologically connected network
Proposed Greenways map – page 4
Green infrastructure in and around Anne Arundel County Map – p14
Existing and proposed trails and greenways map – p19
Green infrastructure network map p22
Proposed greenways and regional trails map – p32
Protected and proposed greenways map –p35
Proposed greenways and critical connections - P38
Green infrastructure and proposed greenways map -p40

++

Did the final network design incorporate a diversity of land uses? (i.e. working lands, open space, parklands, habitat)
No mention of working lands within this plan
Habitat in the form of hubs
Greenways and corridors for wildlife movement and recreation
Little mention of parkland within urban areas
Were gaps in the network identified?

It does not appear possible to make a natural greenway corridor between the greenways east of I-97 north of the Severn River (e.g., Marley Creek, Magothy-Main Creek, Downs Park, and Arnold) and the other greenways in the County, because of development in the Route 2 and I-97 corridors. The major rivers that indent the shoreline in this part of the County (Stony Creek, Magothy River and the Severn River) also make it difficult to connect these greenways, except by water.”

All the stuff about critical connections

Did the plan include a clear and coherent graphic representation of the final network design?

- Proposed Greenways map – page 4
- Green infrastructure in and around Anne Arundel County Map – p14
- Existing and proposed trails and greenways map – p19
- Green infrastructure network map p22
- Proposed greenways and regional trails map – p32
- Protected and proposed greenways map – p35
- Proposed greenways and critical connections - P38
- Green infrastructure and proposed greenways map – p40

Does the plan contain an understanding of how population growth will impact green infrastructure?

“Anne Arundel County enjoys a very attractive location on the Chesapeake Bay close to Washington and Baltimore. This location continues to attract many people to live and work and enjoy the high quality of life that is available in the County. Future growth in Anne Arundel County threatens the loss of ecologically valuable land including unspoiled, high-quality landscapes and open space. The scattered pattern of modern development tends to consume large amounts of land and fragments landscapes. Fragmentation has adverse ecological effects but also has negative effects on the quality of life through the loss of landscape character and scenic beauty, loss of open spaces for people to enjoy, loss of recreational opportunities, and reduced air and water quality. P3

Does the plan contain a public health element (i.e. recognition that green infrastructure promotes healthy habits and improves quality of life)?
“Increase recreational opportunities” p3
“The GDP also includes recommendations geared towards improving the planning, development, and management of pedestrian and bicycle facilities in the County. In a parallel effort to this Greenways Master Plan, the County is preparing a Pedestrian and Bicycle Master Transportation Plan.” P18

Does the plan provide for equitable geographical distribution of the green infrastructure network in all districts?
“Greenways are distributed in all parts of the County” p4
“Public access to greenways has multiple benefits not the least of which is educational; encouraging an ethic of stewardship of the land” p41

Did the plan recognize the importance of the green infrastructure network in the everyday lives of the residents? (i.e. walking, exercising, social interaction)

Mention of biking and recreation
“There are cases where public access could impact a greenway’s ecological functions by, for example, dissuading or interfering with use by wildlife, or by damaging sensitive resources. This should be considered in implementation/management plans. Examples where public use should probably not be encouraged unless protection measures are in place include the bog complexes in the Lake Shore-Bodkin Park greenway, and locations where a greenway corridor is very narrow; and Where there is public access the type of recreational accommodations will vary. Some greenways might have trails with the type of surface depending on the level of use. A greenway with light use might have a dirt or mulch trail. Major recreational greenways like the B&A trail will be paved.” P42

Synthesis

Network Design Model Enhancements
Was the protection status of green infrastructure network lands identified and incorporated into the model?
“Approximately 36,900 acres, or 51 percent of the proposed network, are currently protected as one or more of the following: state, federal, county and City of Annapolis owned lands; agricultural and environmental easements; private conservation lands; and land that is in the County’s Open Space zoning district” p4

P33 – very in depth table of the greenways network and the percentage in acres of the land that is protected in each area of the county
Identifying Priorities
Were specific priorities identified in this plan?
“In order to set priorities for future implementation activities, the following table identifies six greenway segments (in alphabetical order) that are recommended for immediate preparation of implementation/management plans” p53
Table 5 – Priority Greenways

Are appropriate provisions for implementation identified?
“The greenways network identifies approximately 100 “critical connections” (see Figure 7). Critical connections are areas where if a connection cannot be made, the segment will be incomplete and be unable to serve its functions of facilitating wildlife movement.” P37
P 43, p51
“a large portion of the greenways network will remain privately owned and managed. Large portions of the protected lands in the County are in fact privately owned, though zoned Open Space. Protection and enhancement measures will be needed within all the hubs in the County to ensure they maintain and enhance their hub functions” p53

Was the agency/person responsible for implementation identified?
“Anne Arundel County currently lacks a central organizational structure focused on implementing the greenways network, therefore new organizational structures or realignments of existing structures will be needed to both create and manage this network. To address this need, this Plan envisions three organizational levels: a County program staffed by a Greenways Program Manager; strong involvement from the public including local land trusts, greenway advocates, conservation and recreation organizations, and an appointed Greenways Advocacy Committee” p47

Relationship to Plan Goals
Did the final conservation priorities meet plan goals?

Ecological and recreational links
Large population in vicinity. Large number of ecologically sensitive bogs. Several critical connections. Good model for other segments.
Part of highly valued South River watershed. Large population in Vicinity
Extensive recommendations for public access. Good model for other segments.

Implementation
Decision Support Tool
Did the plan include a decision-support tool (i.e. mechanism for quantitatively ranking conservation opportunities based on the network design and other important factors)?

“Based on the habitat requirements of selected locally occurring native bird, mammal, and amphibian species, a “hub” is defined in the Plan as an ecologically significant natural area of at least 250 acres with a high ratio of interior versus edge habitat. A corridor is a natural area at least 200 feet wide. Under the criteria, hubs and corridors must connect and “dead end” corridors are not included in the network unless the dead end is a large enough to serve as a hub (i.e. at least 250 acres).” P4

“The County used five criteria in assessing land as potential greenways: habitat value; size; connections to other land with ecological value; future potential, that is the potential to create greenways where they do not currently exist; and national and countywide trails. Based on the habitat requirements of selected locally occurring native bird, mammal, and amphibian species, a “hub” is defined in the Plan as an ecologically significant natural area of at least 250 acres with a high ratio of interior versus edge habitat. A corridor is a natural area at least 200 feet wide. Under the criteria, hubs and corridors must connect and “dead end” corridors are not included in the network unless the dead end is a large enough to serve as a hub (i.e. at least 250 acres).” P4

“For the Greenways Master Plan, the County selected locally occurring native bird, mammal, and amphibian species and incorporated their habitat requirements into the selection of criteria for ecological greenways.” P23

++

Can the decision-support tool help guide local and site-level implementation efforts?
Coupled with the state data, this gives the county an excellent starting point for their green infrastructure network

++

Is the plan sufficiently flexible to allow for the incorporation of new data as it becomes available?
“The proposed greenway network is conceptual, meaning that the boundaries for each greenway should be reviewed and will likely be refined based on detailed implementation and management plans that are recommended for each greenway.” P36

(+)

Was the methodology for developing the decision-support tool documented?
Much of their methodology was just a replication of what the state did
Implementation Tools
Does the plan identify available mechanisms and tools for land protection (i.e. acquisition, easement, TDR, other)?

Develop greenway implementation/management plans throughout the County

(+) 

Conservation Funding
Does the plan identify federal, state, local and/or private conservation funding opportunities?

“Create an Anne Arundel County greenways fund from a range of sources. The fund would be used to acquire properties and easements; match monies from other sources; and build infrastructure including trails and wildlife crossings” p6

“Create an Advanced Land Protection Revolving Fund to enable the County to act quickly to protect land when unforeseen opportunities arise; and
Make maximum use of related federal, state, and local programs to increase funding for greenways.” P6

Starting on page 58 there is a detailed plan for finding funding sources for this plan

+++ 

Conservation Strategies
Does the plan outline specific implementation strategies?

“Develop detailed greenway implementation/management plans for individual greenways. The Plan’s appendix contains detailed case studies of two greenways in the network illustrating different approaches to preparing these plans” p6

P 50
Very little mention of specific strategies

(+) 

Does the plan outline specific implementation strategies for private landowners?

Does a lot of talking about land trusts, and their responsibility to purchase land

P49
Talks about educating landowners and providing them with technical assistance
Incentives for landowners p56

+ 

Does the combination of all identified implementation strategies encompass a diversity of land uses?

Habitat
Parks and open space
Recreational areas
Defining Development Opportunities
Did the plan discuss opportunities for development within the context of the green infrastructure network?

-  

Were implementation strategies coordinated with state or local growth management efforts?
  Yes – Maryland Greenspaces program

++

Does the plan help determine where to direct new growth?
  “Help guide the location of development so that negative effects on ecologically valuable lands are minimized” p3
  “This Plan does not recommend that no development at all occur within the proposed greenways. If because of development the entire area within a greenway could not be protected, this Plan recommends that the County, through proactive planning and protection measures and through the development approval process, seek to protect that portion of the developable land that is needed to preserve the “integrity” i.e., the wholeness and continuity of the greenway. In the case of a corridor, for example, this would mean, typically, protecting at least a 200-foot wide corridor connecting to other greenways.” P36

++

Does the plan make better use of existing infrastructure by encouraging compact growth?
-
Appendix B: Plan Evaluation Results
<table>
<thead>
<tr>
<th>Goal Setting</th>
<th>Prince George's County, Maryland</th>
<th>Twin Cities, Minnesota</th>
<th>Chicago, Illinois</th>
<th>Pima County, Arizona</th>
<th>Portland, Oregon</th>
<th>Montgomery County, Maryland</th>
<th>Chester County, PA</th>
<th>Saratoga County, NY</th>
<th>Anne Arundel County, Maryland</th>
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<tr>
<td><strong>Plan Foundations</strong></td>
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<td>Were the planning area’s comprehensive green infrastructure components and threats to those components documented?</td>
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<td>Did the plan call for coordination with adjacent areas regarding efforts that extended beyond jurisdictional boundaries?</td>
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<tr>
<td>Was the plan led by a vision, formal plan goals, and strategies for guiding plan development?</td>
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<td><strong>Stakeholder Involvement</strong></td>
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<td>Did a leadership forum or advisory committee provide leadership and generate momentum for the planning effort?</td>
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<td>Did the planning process include an adequate public engagement process that provided stakeholders with ample opportunities to weigh in on plan development?</td>
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<td>Procedural validity - does the plan cover how stakeholders were chosen to participate in the planning process?</td>
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<td>Was plan development led by goal(s) to protect ecological processes and functions?</td>
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<tr>
<td>Did the plan include goal(s) for the preservation of cultural/historic resources?</td>
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<td>82%</td>
<td>91%</td>
<td>95%</td>
<td>94%</td>
<td>92%</td>
<td>92%</td>
<td>80%</td>
<td>94%</td>
<td>64%</td>
</tr>
</tbody>
</table>

**Scale**

- The indicator was not mentioned in the plan - 0
- It was mentioned but not discussed (+) 3
- It was mentioned but briefly discussed + 8
- It was fully analyzed ++ 10

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<thead>
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<th>Chester County, PA</th>
<th>Saratoga County, NY</th>
<th>Anne Arundel County, Maryland</th>
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<tbody>
<tr>
<td>Network Design Criteria</td>
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<tr>
<td>Variation of landscapes in the surrounding countryside</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Importance of preserving rare/endangered habitats and species</td>
<td>+</td>
<td>++</td>
<td>++</td>
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<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>(+)</td>
</tr>
<tr>
<td>Biodiversity - Ecosystem level - Multiple kinds of ecosystems within the planned area</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
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</tr>
<tr>
<td>Biodiversity - Species Level - Presence of a great variety of native species</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>(+)</td>
<td>++</td>
<td>(+)</td>
</tr>
<tr>
<td>Fragmentation and Edge Effects - Effects of subdividing a continuous habitat into smaller entities, which increases the amount of ecotones and number of species and impact on local climate</td>
<td>+</td>
<td>(+)</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>(+)</td>
<td>+</td>
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<tr>
<td>Were ecologists and other natural areas specialists involved in producing the network design criteria and weighting systems?</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<td>++</td>
<td>++</td>
<td>-</td>
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<tr>
<td>Prior to development, identify ecologically rich, critical hubs</td>
<td>++</td>
<td>+</td>
<td>++</td>
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<td>++</td>
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<tr>
<td>Was the plan based on a wide spectrum of data, where feasible?</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
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<td><strong>Network Suitability Analysis</strong></td>
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<td>71</td>
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<td>Was a suitability analysis or similar land suitability method (that incorporated the network design criteria) utilized to calculate and classify the range of conservation values for the study areas?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Did the final network design (i.e. results from suitability analysis) result in an ecologically connected framework?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Did the final network design incorporate a diversity of land uses? (i.e. working lands, open space, parklands, habitat)</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
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<tr>
<td>Were gaps in the network identified?</td>
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<td>++</td>
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<tr>
<td>Did the plan include a clear and coherent graphic representation of the final network design?</td>
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<td>++</td>
<td>+</td>
<td>++</td>
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<td>+</td>
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<tr>
<td>Does the plan contain an understanding of how population growth will impact green infrastructure?</td>
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<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
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<tr>
<td>Does the plan contain a public health element (i.e. recognition that green infrastructure promotes healthy habits and improves quality of life)?</td>
<td>+</td>
<td>+</td>
<td>(+)</td>
<td>(+)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Does the plan provide for equitable geographical distribution of the green infrastructure network in all districts?</td>
<td>(+)</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>(+)</td>
<td>(+)</td>
<td>-</td>
<td>(+)</td>
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<tr>
<td>Did the plan recognize the importance of the green infrastructure network in the everyday lives of the residents? (i.e. walking, exercising, social interaction)</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>(+)</td>
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<tr>
<td>It was fully analyzed</td>
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### Synthesis

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<th>Network Design Model Enhancements</th>
<th>Prince George's County, Maryland</th>
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<th>Chicago, Illinois</th>
<th>Pima County, Arizona</th>
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<th>Montgomery County, Maryland</th>
<th>Chester County, PA</th>
<th>Saratoga County, NY</th>
<th>Anne Arundel County, Maryland</th>
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<tbody>
<tr>
<td>Was the protection status of green infrastructure network lands identified and incorporated into the model?</td>
<td>++</td>
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<td>Were specific priorities identified in this plan?</td>
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<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<td>Are appropriate provisions for implementation identified?</td>
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<td>++</td>
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<tr>
<td>Was the agency/person responsible for implementation identified?</td>
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<td>+</td>
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<td>++</td>
<td>++</td>
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<td>Implementation</td>
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<td>Implementation Tools</td>
<td>Conservation Funding</td>
<td>Conservation Strategies</td>
<td>Defining Development Opportunities</td>
<td></td>
<td></td>
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<td>Chicago, Illinois</td>
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<td>Montgomery County, Maryland</td>
<td>Chester County, PA</td>
<td>Saratoga County, NY</td>
<td>Anne Arundel County, Maryland</td>
</tr>
<tr>
<td>Did the plan include a decision-support tool (i.e. mechanism for quantitatively ranking conservation opportunities based on the network design and other important factors)</td>
<td>+</td>
<td>3</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>0</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Can the decision-support tool help guide local and site-level implementation efforts?</td>
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<td>++</td>
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<tr>
<td>Is the plan sufficiently flexible to allow for the incorporation of new data as it becomes available?</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
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<tr>
<td>Was the methodology for developing the decision-support tool documented?</td>
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<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
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<tr>
<td>Does the plan identify available mechanisms and tools for land protection (i.e. acquisition, easement, TDR, other)?</td>
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<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>3</td>
</tr>
<tr>
<td>Does the plan identify federal, state, local and/or private conservation funding opportunities?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Does the plan outline specific implementation strategies?</td>
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<td>++</td>
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<tr>
<td>Does the plan outline specific implementation strategies for private landowners?</td>
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<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
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<tr>
<td>Does the combination of all identified implementation strategies encompass a diversity of land uses?</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<td>Defining Development Opportunities</td>
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<td>Did the plan discuss opportunities for development within the context of the green infrastructure network?</td>
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<td>++</td>
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<td>Were implementation strategies coordinated with state or local growth management efforts?</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
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<tr>
<td>Does the plan help determine where to direct new growth?</td>
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<td>+</td>
<td>+</td>
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<td>++</td>
<td>++</td>
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<tr>
<td>Does the plan make better use of existing infrastructure by encouraging compact growth?</td>
<td>++</td>
<td>+</td>
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### Overall Results

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<th>Portland, Oregon</th>
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Works Cited


Anne Arundel County Department of Recreation and Parks and Office of Planning and Zoning. 2002. “Anne Arundel County greenways master plan.”


Florida Department of Environmental Protection. 1998. “Connecting Florida’s communities with greenways and trails.”


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Prince George’s County Planning Board of the Maryland National Capital Park and Planning Commission. 2005. *Countywide green infrastructure plan for Prince George’s County*.


