Honors Thesis
Ecological Considerations in Greenway Design

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Introduction

Greenway:

1. A linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridge line, or overland along a railroad right-of-way converted to recreational use, a canal, a scenic road, or other route.
2. Any natural or landscaped course for pedestrian or bicycle passage.
3. An open space connector linking parks, nature reserves, cultural features, or historic sites with each other and with populated areas.
4. Locally, certain strip or linear parks designated as a parkway or greenbelt (Little, 1990).

In 1990, Charles Little defined greenways in the above manner. Throughout the years, the definition would take on numerous variations. However, despite the variations, greenways have always been capable of being classified into five categories: urban riverside greenways, recreational greenways, ecologically significant natural corridors, scenic and historic routes, and comprehensive greenway systems or networks. Ecologically significant natural corridors occur most often along streams and rivers, and occasionally ridge lines, and provide an area for wildlife migration, nature study, and hiking (Little, 1990).

These ecologically significant natural corridors have become the focus of much attention as urbanization continues to threaten much of the existing wildlife habitat. Multiple states, including the state of Maryland, have created plans to develop networks of greenways throughout the nation. Wicomico County, in which Salisbury State University is located, has recently begun to develop a system of greenways throughout the county. As a county which holds many significant ecological habitats, it is desirable that the creation of greenways is pursued in the most environmentally sound manner possible. Numerous examples of greenways with ecological designs have been completed in recent years and could serve as a means of comparison and provide a wealth of suggestions for the design processes to be used by Wicomico County.

The History of Greenways

On October 3, 1865, Frederick Law Olmsted presented, and had accepted by the trustees of the College of California, a design plan for the college grounds which proposed a scenic drive and trails and proposed a link between the campus and a nearby park. With the inclusion of these elements, which are now considered to be characteristic of greenways, Olmsted's plan has become the noted origin for the creation of greenways (Little, 1990).

Approximately one hundred years later, in 1969, Ian McHarg's book, Design with Nature, described a means by which to take into account ecological factors in the design of greenways. McHarg's method consists of creating maps of an area detailing various characteristics, such as wetland locations or areas of steep slope, in color . The numerous maps are then overlaid and those areas suitable for development are the original clear material; in contrast, those areas to be protected are layers of color (Little, 1990).

Despite these early beginnings for greenways, the idea did not become well known until the release of "The Report of the President's Commission on Americans Outdoors" in 1987. The report defined greenways as "corridors of private and public recreation lands and waters that provide people with open spaces close to where they live and that link the rural and urban spaces in the American landscape" (Lusk, 1994). Also within this report, a trust fund to be used for the acquisition of open space and for the preparation of greenway plans was provided for (Didato, 1990). "Trails for All Americans," the report which followed, created a specific goal for these greenways by calling for a network of trails throughout the United States within fifteen minutes of every American's home or work place (Lusk, 1994).

In working towards the goal in "Trails for All Americans," the state of Maryland's prior governor, William Donald Schaefer appointed the Maryland Greenways Commission, in 1990, to create the nation's first statewide system of linked open space corridors (Schardt, 1993). Over nine hundred miles of protected greenway corridors exist within the state of Maryland, and an additional twelve hundred miles are under consideration for their use as possible greenways (The Maryland Greenways Commission, 1996). Congressman Wayne Gilchrest, R-MD, currently leads an effort to create a continuous wildlife corridor from New Jersey to Virginia (Wilson, 1999).

Funding for greenway projects throughout the nation comes from a variety of sources including community participation, foundation sponsorship, and state and national programs. In an article published in the *Journal of the American Planning Association,* it is stated that the Crooked Creek Community Council of Indianapolis, Indiana, was able to raise $300,000 from residents within the greenway corridors. The financial support gained was evidence of the willingness of residents to support greenway projects when the surrounding environment is perceived to be threatened (Lindsey, 1999). However, despite outstanding community contributions, the greatest source of funding for greenways comes from the federal Transportation Efficiency Act of the Twenty-First Century (Greenways Incorporated, 1999). Through this act, grants are awarded to projects which enhance bike and pedestrian travel (Flink, 1993) Preceding this act was the Intermodal Surface Transportation Efficiency Act, which was passed in 1991 (Greenways Incorporated, 1999).

As with funding, management of greenways comes from a variety of sources, also including private foundations, local, regional, or state park agencies, or federal agencies. Examples of federal agencies providing management are the National Park Service, USDA

Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Army Corps of Engineers, and various others (Moore, 1998).

The Benefits of Greenways

Benefits of greenways include their use for recreation, transportation, education, environmental protection, and floodplain management. In addition, they may be used to promote economic growth through the increased ecotourism and increased property values which they create (Greenways Incorporated, 1999).

With the increasing loss of community open spaces as a result of continued development, the demand for recreational areas has increased significantly. Adding to this demand is an increasing interest in such activities as rollerblading and biking (Greenways Incorporated, 1999). According to Phyllis Cangemi of Whole Access, "Greenways with trails are one of the cheapest forms of recreation" (Grove, 1990). And, recreation provides benefits of its own, including improved health and fitness, relaxation, family togetherness, and increased awareness of nature (Moore, 1998).

A second benefit of greenways is that of creating an alternative means of transportation. According to Greenways Incorporated, "Two-thirds of all the trips we make are for a distance of five miles or less." Thus, with properly designed systems of trails, people can walk or bicycle safely from work or school to home or from home to parks and shopping areas. In so doing, air pollution is reduced, congestion is reduced, and mobility for those unable to drive increases (Moore, 1998).

Educational opportunities are a third benefit resulting from the creation of greenways.

Greenways provide access to and linkage of natural, cultural, and historical sites (Bueno, 1995). Several communities have already incorporated educational themes into the development of their greenways. For instance, the Swift Creek Recycled Greenway in Cary, North Carolina, features their use of recycled waste by-products, the Stones River Greenway in Murfreesboro, Tennessee, emphasizes Civil War history, and the Boulder Greenway System in Boulder, Colorado, possesses outdoor classrooms for school systems to use (Greenways Incorporated, 1999). Within the State of Maryland, the C&O Canal provides displays about historic sites along the path describing the past and the ways in which life differed during those time periods under consideration (The Maryland Greenways Commission, 2000).

Economic benefits are the fourth type of benefit which greenways can provide. Ed McMahon, director of the American Greenway Program at The Conservation Fund, stated that, "Studies demonstrate that linear parks can increase nearby property values, which can in turn increase local tax revenues" (Guglielmino, 1997). One survey showed that property along a trail in Seattle, Washington sold for an average of six percent more than comparable property elsewhere in the region (Didato, 1990). Residents near to greenways spend money on products and services which allow for use of the greenways leading to increases in employment opportunities and increases in sales-tax revenue (Guglielmino, 1997). Greenways which attract tourists from out of town lead to added revenues for hotels, restaurants, campgrounds, and other similar locales. For example, the Northern Central Rail Trail in Maryland supports 264 jobs statewide and produces $3.38 million in annual revenues (Greenways Incorporated, 1999).

The final benefit resulting from the creation of greenways is environmental protection.

Air quality, water quality, floodplain management, and biological diversity can all be improved with properly designed greenways.

Air quality: Tree cover and alternative routes of transportation serve to improve air quality through the reduction of carbon dioxide, carbon monoxide, and other toxic pollutants in the atmosphere (Roanoke Valley Greenways, 1999).

Water quality: As a buffer, greenways improve water quality by providing additional filtering - trapping pollutants from urban runoff (Greenways Incorporated, 1999). Furthermore, the buffers also aide in preventing excess nutrients from entering streams and rivers. Excess nutrients in water have been correlated with algal blooms which prevent sunlight from reaching aquatic vegetation eventually leading to a reduction in the dissolved oxygen levels needed by the fish of the streams (The Maryland Greenways Commission, 2000).

Floodplain management: By protecting flood prone areas from development, greenways have become an effective strategy in reducing the negative impacts of flooding, such as reducing the billions of American dollars spent each year in property losses (Greenways Incorporated, 1999). A healthy riparian plant community provides storage and gradual distribution of flood waters to the surrounding waterways. Additionally, it slows the velocity of the runoff, reducing erosion (Flink, 1993).

Biological diversity: Biological diversity has been used to describe flora and fauna and the ecological functions they perform and the genetic diversity they contain (Baschak, 1995). Agreed upon by many ecologists to be the most severe threat to such diversity, habitat fragmentation has four major effects. First, the loss of species that require a substantial amount of habitat for breeding occurs. Secondly, a loss of large mammal species, such as the bear or large cats, occurs because the long distances which they travel for feeding and breeding cannot be made without severe threats to their lives. For example, a single Florida panther requires at least a 50,000 acre range for its survival. However, a range of this size rarely exists due to habitat fragmentation. Thirdly, certain species, such as the raccoon and the deer, become dependent on human aide eventually leading to overpopulation of the species and eventual degradation of habitat. Finally, inbreeding results from habitat fragmentation leading to decreased genetic diversity and, in some instances, extinction (Little, 1990). Greenways which serve as ecological corridors provide habitat, as well as providing a link for the movement of especially mobile animals such as butterflies and birds (Ball, 1990). By allowing the movement of animals, greenways contribute to increased genetic diversity as separated populations are given the opportunity to come together (Little, 1989). Furthermore, greenways designed as a well-vegetated corridor improve climate conditions by providing shaded areas, wind protection, and cooling through evaporation. Such improvements provide better habitat for wildlife by alleviating them from extreme climatic conditions (Baschak, 1995).

Considerations in Greenway Design

In order for the goal of an interconnected system of beneficial greenways to become a reality, the planning must be approached in a systematic manner. There is both a general approach to the planning of greenways, as well as a more specific approach which takes into consideration the intended goal of the greenway. Greenways Incorporated, a business located in Cary, North Carolina, is an environmental planning and landscape architectural firm specializing in the planning and design of greenways (Greenways Incorporated, 2000).

Greenways Incorporated begins any development project by identifying the area under consideration - the corridor of study. In so doing, certain features are identified which allow for successful planning. Such features include, a large enough corridor to allow for flexibility in planning, both in width and in length, and a definite point of origin and a definite point of destination. Maps of the designated area, which allow for the identification of topographic features, can then be obtained from the United States Geologic Survey or any number of sources (Flink, 1993).

The first major stage of planning involves the evaluation of the physical, cultural, political, and socioeconomic characteristics of the corridor. Portions of this evaluation focus on land ownership, environmental needs, access and transportation, socioeconomic analysis, historic and cultural resources, community recreation, and management and operations. The assessment which is used by Greenways Incorporated meets the basic requirements of local, state, and federal agencies (Flink, 1993).

An important step in the process of collecting the data about these features is that of recording the information in a useful manner. One technique for accomplishing this is the use of overlay mapping, the technique which was developed by Ian McHarg. By mapping each of the features looked at, the landscape can be looked at as a complete whole, as a single feature, or the parts currently in question can be looked at in the desired combinations. Access to geographic information systems can aide greatly in this process. An additional technique for recording the data gathered includes field notes, which can be handwritten or typed with the use of a laptop. A voice recorder could also be used to capture thoughts while in the field. Finally, photographs are of importance in visually documenting the landscape (Flink, 1993).

The second stage in the greenway planning process is that of creating a concept plan. To do this, the goals for the project, including environmental goals, and the differing options, such as location, route, and development, should be included. The concept plan, which incorporates these elements, can then be created, setting specific tasks to be accomplished in fulfilling the plan. The presentation of this plan can be in the form of graphics or in the form of a written description. In some instances, both are used (Flink, 1993).

The greenway planning process comes to a completion with the formation of the final master plan. Emphasizing the primary objectives decided upon in the previous stages, the master plan is the document which details the future development of the greenway. Of importance for inclusion in the final master plan are the final location, measures which will be taken to protect the greenway, conditions of accessibility, management plans, and estimated costs (Flink, 1993).

Ecological Considerations in Greenway Design

When one is creating a greenway as a wildlife corridor, the general process is the same as that above with the majority of the changes being in the defining of the corridor and in the questions asked within the inventory. First, the corridor is defined with consideration for its interconnectedness with the surrounding ecosystems. Secondly, an environmental assessment of the corridor of study should be conducted to inventory the natural features and attributes of the land, to determine whether the land in question is capable of supporting the proposed plans and to determine if any permits will be needed in the development process. Features of the corridor of study which are looked at include: vegetation, geology, soils, hydrology, topography, wildlife, and microclimate (Flink, 1993).

Aerial photographs serve to identify the patterns of vegetative growth, while field surveys serve to identify the individual plant species, both their type and their number, found within the area. Both native and invasive species should be noted. Animal species must also be identified, taking note of the migratory routes and the breeding grounds of the animals. For both plant and animal species, rarity, distribution and specific needs should be recorded, as should effects that may result from human encroachment. Additionally, rocks and land form type should be identified and used to answer whether or not the land is capable of supporting the desired uses. Soil type and composition influence suitability of the site as well. The identification of such things as drainage patterns, watersheds, and wetlands allow for the evaluation of the potential of the area for flooding. Stream bank erosion should also be considered in the planning stages, as should the slope of the land or the topography, both longitudinally and across the corridor. The final feature to be examined should be the microclimate, including wind patterns, sun exposure, rainfall amounts, and local temperature. Within this examination, one must extend their observations to determine the effects the introduction of a greenway will have on such features. Following this inventory, ecological goals for the corridor can be defined, as can the management programs needed to meet these goals. Educational and interpretive programs which aid these goals can also be created. For instance, maintaining a greenway for use by migrating songbirds provides an environmental goal towards which planning can be aimed (Flink, 1993).

In order to minimize human-wildlife conflicts, paths and facilities should be located away from the interior and the sensitive habitats of the area. These areas, as well as nonsensitive areas, are vulnerable to compacted soil, trampled vegetation, and soil erosion with overuse. If there is a need for a path to cross a sensitive area, the path should be narrow and natural permeable materials should be used. The natural vegetation surrounding the path should be maintained with the use of pesticides and other chemical applications avoided. A plan should be in existence for the removal of non-native species which invade the corridor. Additionally, manipulation of vegetation to provide all necessary habitat types for the species may be needed. Over time, continuous checks should be conducted which examine the health and the changes in the corridor, with maintenance work done as needed (Flink, 1993).

When a wildlife corridor follows a river, guidelines to be followed include creating the corridor so that it is continuous along both sides of the river and so that it includes the floodplain, tributaries, and associated forests and wetlands of the river. As with other corridors, vegetation in the surrounding area should be as natural as possible. When beginning the planning of riparian greenways, a study should be undertaken to determine the sediment and nutrient flow of the area. Possible supplements to the natural sediment trapping of the area include the creation of retention basins or vegetated berms, and possible supplements to the natural nutrient filtering includes a tree harvesting regime to maximize nutrient uptake by the newly growing plants. Further limits which should be imposed restrict the numbers of people, cars, and grazing animals near the water, restrict the use of toxic chemicals in the greenway, and restrict the fill operations in the area. Continued maintenance of the area includes reviewing mowing practices, monitoring water quality to determine the presence of pollution, conducting stream restoration projects, and considering carefully the effects which new development will have on the condition of the stream (Smith, 1993).

Ecological Recommendations

Creating greenways as corridors: Corridors are sections of land, generally longer than they are wide, following railroads, canals, roads, utility lines, rivers, or ridges. Additionally, corridors can follow the natural migration path of a particular species. By following these features, a corridor becomes a unified whole serving to fulfill any number of roles, including movement of humans and wildlife, drainage of water, filtering of water supplies, and providing food, shelter, and mates for wildlife. When corridors connect parcels of fragmented land, they combat declining genetic diversity in species which have become geographically separated (Flink, 1993). Additional advantages and disadvantages for the creation of wildlife corridors are listed in Table 1. Many of the disadvantages of corridors could be avoided by enlarging the width of the corridor or by applying ecologically sound zoning regulations (Linehan, 1995).

Edges: The edge of a corridor is defined by the points where the corridor meets adjacent landscape. At these edges, a transition zone occurs because soil type, vegetation type, sunlight, and shade conditions change. Corridors also have edges when they come into contact with human activity, which oftentimes creates deleterious conditions for wildlife (Flink, 1993). Edge effects can have influences 200 to 600 meters into the forest, thus corridors narrower than 1200 meters will often not obtain a true interior habitat. Very wide corridors are also not beneficial as they may result in the animal species wandering randomly, leading to lengthened travel time and increased exposure to predators, both of which increase mortality rates (Bueno, 1995). Because of the high ratio of edge to interior habitat within corridors, careful planning is needed to allow the corridor to be used as a greenway which allows human use. Solutions include buffering and removing trails from sensitive habitats. However, edges can also act as buffers themselves. According to experts, greenways which serve to protect wildlife need a one-to-one ratio of interior habitat to edge habitat to provide the needed buffering functions and the needed interior habitat. Planners must realize that greenways which are a majority of edge habitat will do little to enhance the survival of wildlife (Flink, 1993).

Table 1
Pros and cons of wildlife corridors (adapted form Linehan, 1995)

Potential advantages	*Potential disadvantages*
1. Increased immigration which could	1. Increased immigration which could
A. Increase or maintain species richness and diversity	A. Facilitate the spread of diseases, pests, etc.
B. Increase population sizes of particular species	B. Decrease the level of genetic variation between populations (outbreeding depression)
C. Decrease probability of extinction	2. Facilitate spread of fire and other contagious catastrophes
D. Permit species reestablishment	3. Increase exposure to hunters, poachers, and predators
E. Prevent inbreeding depression/ maintain genetic diversity	4. Many not function for species not specifically studied
2. Increased foraging area for wide ranging species	5. Cost and conflicts with conventional conservation direction of preserving endangered species
3. Provide escape cover for movement between patches	
4. Increase accessibility to a mix of habitats	
5. Provide alternative refuge from large disturbances	
6. Provide greenbelts to:	
A. Limit urban growth	
B. Abate pollution	
C. Provide recreational opportunities	
D. Enhance and protect scenery	
E. Improve land values	

<u>Indicator species selection</u>: When selecting a species to be used as an indicator species, factors to take into consideration when first beginning the process are the natural species associations, the habitat needs of a large number of species, the species which need the largest range (thus including animals with smaller ranges), and the rarity of the species under

consideration. The indicator species which is then selected should represent the effects which fragmentation has on the other species within the area, as well as buffering the effects of fragmentation on other species through its protection. In one case study, two species were selected in order to represent two differing habitat needs within the same geographical area (Linehan, 1995).

Trail surface materials: When selecting a trail surface material, features to consider include availability of the selected material, the cost to purchase and install the trail, the maintenance which will be required, and capability to support the expected users. Two categories of surface materials which are often used are soft materials (which includes earth, grass, hardwood bark, and wood decking) and hard surface materials (which includes stone, rock, asphalt, brick, and concrete). Of these two, soft materials (excluding wood decking) are the least expensive to install and are the most compatible with the natural environment. However, soft surfaces require more maintenance if they receive heavy use. A comparison of trail surface materials is shown in Table 2 (Flink, 1993).

Fencing: Fencing within a greenway serves a number of different functions including separation of properties, control of accessibility, abatement of noise and wind, and decoration. The type of fencing material used should be consistent with the surroundings; for example, a picket fence would not be an appropriate boundary indicator in an open range. In a number of situations, the appropriate fencing option can be plant material, which can serve to meet all of the functions listed above. Oftentimes, using plants in this manner is less expensive than using fences or walls. Table 3 describes a number of plant types suitable for fencing uses, as well as attributes, size, and climate descriptions (Flink, 1993).

Recreational access: Many issues arise in regards to recreational access to greenways. Questions such as liability, safety, vandalism, and overuse need to be addressed early on in the development stages. Indeed, trail design and management can alleviate a number of these issues, if not all of them. Designing a trail which is unpaved, merely a 'woodland path,' will help determine its level of use. Oftentimes, trail such as these are unattractive to youths, nonlocals, or others who contribute the most to the worries listed above (Little, 1990).

Water recreation: When waterways are included in greenway design plans, the carrying capacity of the area must be considered. Through examining similar waterways and through listening to public opinion, general estimates in regards to use can be made. Other means for gauging use and setting limits are based on measured amounts of damage to the corridor or by an equation, the Wisconsin Formula, which assumes two parties per mile to be an acceptable level of use (Flink, 1993).

Motor vehicle access: When designing greenways and access to them, planners should look into the use of previously existing, adjacent parking lots. For example, agreements with nearby churches who only use their parking lots on certain days may be arranged. However, if such arrangements cannot be made, parking lots should be planned in such a way as to encourage those using the greenway to utilize the most environmentally considerate means to arrive there, including providing access to public transportation at a nearby, safe, convenient

Table 2
Advantages and disadvantages of trail surface materials (adapted from Flink, 1993)

Surface Material	*Advantages*	*Disadvantages*
Native soil	Natural material, lowest cost, low matintenance, can be altered for future improvements	Dusty and dirty, ruts under heavy use, not an all-weather surface, limited use
Soil cement	Uses natural materials, supports more usage than native soils, smoother surface, low cost	Surface wears unevenly, not a stable all-weather surface, costly, erodes, difficult to achieve correct mix.
Graded aggregate stone (washed stone, gravel)	Hard surface supports heavy use, moderate costs, natural material, accommodates multiple use	Angular stones can be sharp, continuous maintenance required, uneven surface, erosion, ruts
Granular stone (limestone, cinders)	Soft but firm surface, natural material, moderate costs, smooth surface, accommodates multiple use	Surface can wash away, ruts, erodes, constant maintenance to keep smooth surface, replenish stone—long-term expense, not for steep slopes
Shredded wood fiber	Soft, spongy surface—good for walking, moderate cost, natural material	Decomposes under high temperature, moisture, and sunlight, requires replenishment—long-term expense
Wood (boardwalks, bridge decking)	Pliable surface—excellent for multi-use; natural material blends with native landscape, spans streams, ecologically sensitive areas, and soft soils; only surface that places trail user above surrounding grade	High installation cost, easy to damage and vandalize, expensive to maintain, deteriorates with exposure to sun, wind, and water, susceptible to fire damage. Can be slippery when wet
Asphalt concrete	Hard surface, supports most types of use, all weather, does not erode, accommodates most users simultaneously, low maintenance	High installation cost, costly to repair, not a natural surface, leaches toxic chemicals, freeze and thaw can crack surface, access of heavy construction vehicles
Concrete	Hardest surface, easy to form to site conditions, supports multiple use, lowest maintenance, resists freezing and thawing the best, can be colored, all weather	Joints result in bumpy surface, high installation cost, costly to repair, not a natural looking surface, access of construction vehicles
Recycled materials	Good use of trash, surface can vary depending on materials, good life expectancy	High purchase and installation cost, aesthetics

Table 3
Plant materials that provide effective fencing and screening (adapted from Flink, 1993)

Plant Type	*Attributes*	*Growth Habit*	*Climate*
Evergreen			
Arborvitae	Formal shape, soft foliage	Fast, up to 15 ft	Full sun
Barberry	Weedy, thorny foliage	Medium, up to 6 ft	Partial sun
Boxwood	Formal shape, soft foliage	Slow, up to 3 ft	Partial shade
Euonymous	Loose form, glossy foliage	Medium, up to 12 ft	Partial sun
Eleagnus	Weedy, soft foliage	Fast, up to 15 ft	Full sun
Fire thorn	Weedy, thorny foliage	Fast, up to 12 ft	Full sun
Camellia	Formal, glossy foliage	Slow, up to 12 ft	Partial shade
Cotoneaster	Loose form, soft foliage	Medium, up to 12 ft	Partial sun
Cypress	Formal shape, soft foliage	Fast, up to 15 ft	Full sun
Hemlock	Loose form, soft foliage	Medium, up to 15 ft	Partial sun
Holly	Formal, spiny glossy foliage	Medium, up to 15 ft	Partial sun
Honeysuckle	Weedy, soft foliage	Fast, up to 4 ft	Full sun
Mahonia	Formal, glossy foliage	Slow, up to 3 ft	Partial shade
Oleander	Formal, soft foliage	Fast, up to 12 ft	Full sun
Osmanthus	Formal, glossy foliage	Medium, up to 15 ft	Partial sun
Pittosporum	Formal, glossy foliage	Medium, up to 12 ft	Partial sun
Privet	Weedy, soft foliage	Fast, up to 15 ft	Full sun
Laurel	Formal, glossy foliage	Fast, up to 15 ft	Full sun
Yew	Formal, soft foliage	Medium, up to 15 ft	Partial sun
Deciduous			
Buckthorn	Formal, soft foliage	Medium, up to 15 ft	Partial sun
Mock orange	Weedy, stiff thick foliage	Fast, up to 8 ft	Full sun
Forsythia	Weedy, soft foliage	Fast, up to 8 ft	Full sun
Fuchsia	Weedy, soft foliage	Medium, up to 6 ft	Partial sun
Hawthorne	Loose, thorny branching	Medium, up to 5 ft	Partial sun
Quince	Weedy, thick foliage	Fast, up to 6 ft	Full sun
Rose	Weedy, thorny branches	Fast, up to 6 ft	Partial sun

spot. Furthermore, the parking lot itself should be environmentally sensitive. Automobile access and parking lots should be placed as far away from ecologically sensitive areas, most typically on the exterior edge of the facility, and close to already existing highways and roads. The minimum number of parking spaces should be provided to encourage the use of carpooling. Furthermore, natural surfaces should be used instead of paved surfaces as a means to slow traffic within the parking lot. Finally, signs and other forms of literature should be provided detailing the alternative forms of transportation available, as well as providing information about energy-efficient automobiles (Flink, 1993).

Access roads should also be planned with environmental sensitivity in mind. Pavement for these roads should also be a natural substance or a porous material, such as concrete paver, gravel, or porous asphalt pavement, to allow for the absorption of rainfall. A vegetated shoulder and a natural drainage system should be provided to discourage a concrete curb and gutter system (Flink, 1993).

The general methods detailed above can be modified slightly to fit the needs of each specific design project which is being worked on. Below are three case studies which examine the methods used in designing greenways with ecological considerations. Each follows to some degree the general method laid out above; however, each also incorporates additional factors.

Case Study Number One: South Florida

The steady decline in the ecologically significant areas within urban landscapes in South Florida has been attributed to agricultural and urban development within the region (Bueno, 1995). Urban development has tended to isolate and separate natural areas into small patches and corridors. Those larger patches which do remain are adversely impacted by effects from their urban surroundings. Urbanization has also resulted in the separation of functioning ecosystems from their supporting structures. The natural areas which do persist are often over utilized by recreational users because they have been set aside for use as cultural or natural parks. Furthermore, the parks, designed for human use, fail to take into account the needs of the native species (Baschak, 1995). Thus, the number of species which are threatened continues to increase, despite the protection provided through the Endangered Species Act. In order to resolve problems such as these, ecologists proposed the creation of wildlife corridors which would link isolated patches of habitat throughout Southern Florida (Bueno, 1995).

Four types of corridors have been recognized in current literature: line corridors, strip corridors, stream corridors, and corridor networks. Line corridors and strip corridors differ only in their widths. For example, line and strip corridors for birds differ by a width of twelve meters. The general recommendation for the width of a line corridor is nine meters; while a width between 61 meters and 91.5 meters was recommended for strip corridors, thus allowing for the most diversity and the most interior species. In contrast, a width between 12 meters and 30.5 meters contains less diversity and more edge species. It is recommended that wildlife habitats along stream corridors extend an additional 27.4 meters beyond the bank for upland areas. Thirty meters of vegetation along a stream has been deemed adequate to sustain diversity, decrease temperature, increase food supply in the stream, and control erosion, sedimentation, and pollution entering the stream. Corridor networks consist of links (which are the corridors), nodes (which are the intersections of links), and loops (which are closed sequences of nodes and links).

Three characteristics of the networks which are of importance in design planning are: (1) intersections that are of importance in maintaining species diversity, (2) reticulate pattern which provides the loops facilitating species movement, and (3) mesh size which is important in determining the area each species will require for their needed functions (Bueno, 1995).

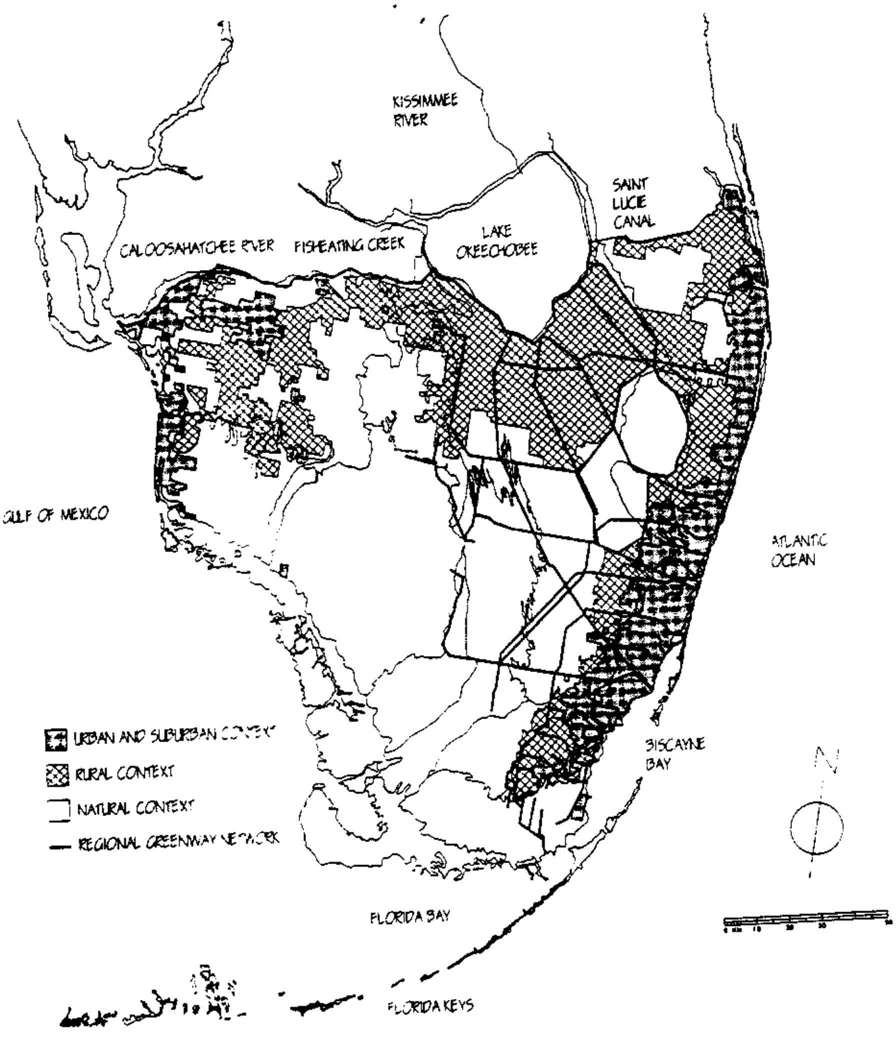


Figure 1: Map of proposed south Florida regional greenway network (adapted from Bueno, 1995)

The first step taken in planning a greenway system throughout South Florida was to consider the impact the proposed greenways would have upon the area landscapes. A vegetation map, satellite images, and a map of the regional drainage canal and flood control levee systems were all used within this process. Through the use of the overlay technique, the relative locations of the greenways to urban and suburban areas, rural areas, and natural areas could be seen. Secondly, the areas composing the corridors were classified as to their ecological types. The effects of line, strip, and stream corridors within these areas was then considered. Finally, ecological principles of corridor network connectivity were examined (Text Box 1) (Bueno, 1995).

Text Box 1: Greenway Connectivity Equations

Greenway network connectivity was calculated by first counting the nodes and the links found within each landscape region and then determining the gamma index and the alpha index. The higher the gamma index of greenway network connectivity (γ), the better linked the nodes of the network are. By use of the equation,

$$\gamma = \text{actual number of links/ maximum number of links} = L/L_{max} = L/\ 3\ (V\text{-}2),$$

where L is the number of links, L_{max} is the maximum possible number of links, and V is the number of nodes, the gamma index could be found. In order to find the alpha index of greenway network connectivity (α), the equation which is used is:

$$\alpha = \text{actual number of loops/ maximum number of loops} = K/\ K_{ma} = L\text{-}V\text{+}1/\ 2V\text{-}5,$$

where K is the number of loops, K_{ma} is the maximum possible number of loops, L is the number of links, and V is the number of nodes. The alpha index ranges from zero, where there are no network loops, to one, which is the maximum number of network loops. Thus, the higher the alpha index, the better the network circuitry is (Bueno, 1995).

Case Study Number Two: Saskatoon, Canada

The following study was done in the South Saskatchewan River Valley in Saskatoon, Canada, an urban river greenway in a prairie environment. An assessment and inventory of the existing resources was the first step which was taken, including a mapping of the landscape elements. Also included in this step were the identification of an area as a patch or as a corridor and the identification of the scale of the area. Three scales used were: (1) a community or single habitat with uniform vegetation (site scale), (2) a series of habitats or communities (local scale), or (3) a large geographic region (regional scale) (Baschak, 1995).

The second step in the development process was the designing of the greenway's spatial structure, including connections to species-rich areas, corridor to urban context relationships, and network structure and content. In the designing process, species-rich areas were connected using corridors at all scales in order to facilitate the movement of species. Due to edge effects, the surrounding urban context is of great importance in relieving the effects of competition with edge species. Several means are then available to link the above characteristics to the overall network structure and content. For instance, riparian corridors are used as a backbone linking varying sizes of habitat patches. Furthermore, it.has been suggested that each corridor should have one or more multiple-use-modules (MUM). A MUM is a well-protected habitat patch of sufficient size to support the interior species of the area. Surrounding the well-protected core are concentric circles providing varying protection from external influences, with the circle closest to the core providing the most protection and protecting against such negative human influences as mowing and excessive trampling of the soil (Baschak, 1995).

The third step which was taken in this design was the assessment process. Many differing means by which to complete the assessment have been described within current literature. For the area along the Saskatchewan River Valley, two assessment processes were used. First, a landscape element rating was used to evaluate the quality of the landscape elements. These elements are assessed according to the following criteria: plant species diversity, degree of naturalness, species rarity, plant community structure, landscape category, and sensitivity to disturbance (Table 4). Each element is rated from one to three and the combined rating, with a maximum of eighteen, is used to determine overall ecological value. Secondly, a network assessment is used to measure the links in the landscape. Landscape element size and shape, connection to species-rich areas, degree of edge, and habitat structure are the criteria used in evaluation (Table 5). Once again, a scale of one to three is used, with a maximum combined rating of nine (landscape element size and shape is excluded) determining suitability. Tables four and five provide descriptions of the criteria needed for each level of score in all categories (Baschak, 1995).

Case Study Number Three: Central Massachusetts

A region of approximately 140,000 hectares within Central Massachusetts consists of two differing landscape types – a forested region, with both hard and softwoods, and a region of human development with some areas of fragmented forest remaining. Within this area, the development of wildlife corridors has been undertaken. The major steps which were followed for this particular region are as follows: (1) land cover assessment, (2) wildlife assessment, (3)

Table 4

Landscape element rating: score descriptions for criteria (adapted from Baschak, 1995)

I. *Plant species diversity*
1. Small number of species present
2. High species diversity
3. Outstanding diversity for particular habitat type(s)

II. *Degree of naturalness*
1. Natural areas are being progressively destroyed
2. Some natural areas are preserved
3. Pristine natural areas are evident

III. *Species rarity (plant or animal)*
1. Species characteristic of region
2. Site supporting good populations or local rarity or local endangered species
3. Site supporting good/limited populations of natural rarity or site supporting good population of regional rarity or many species at limits of distribution

IV. *Plant community structure (structural differentiation)*
1. Plant community structure not evident
2. Good stratification of vegetation types in plant communities
3. Near-natural plant community structure in both horizontal and vertical patterns of vegetation

V. *Landscape category*
1. Agricultural or artificial landscapes. Human interference continuing.
2. Semi-natural landscape with native flora and fauna present. Human interference has altered the vegetation pattern from the original, but still high scientific interest. Very little of moderate human interference.

VI. *Sensitivity to disturbance*
1. Very little buffer to protect from surrounding human activities or very little threat of increase of surrounding human activities.
2. Some protection from surrounding human activities or possible threat if human activities increase
3. Adequate buffer zone of large site which can withstand human activities or in need of immediate protection. Main feature of site threatened by encroachment of human activity

Table 5

Network assessment: each landscape element is assessed for its present status and potential for providing links according to the four criteria listed (adapted from Baschak, 1995)

I. *Size and shape*

Optimal size and configuration of existing or recreated patches and corridors for an urban environment needs further study before an assessment can be made

II. *Connections to species-rich areas*
1. Completely isolated from species-rich areas
2. Limited connection to species-rich areas
3. High connectivity for species movement

III. *Degree of edge*
1. Vegetation dominated with edge species
2. Some evidence of interior species
3. Optimal ratio of interior species to edge

IV. *Habitat structure*
1. No evidence of a unified arrangement of habitat areas with non-existent buffer
2. Some assemblance of habitat areas with limited buffer
3. Optimal arrangement of remnant habitat patches and corridors with sufficient buffer

habitat assessment, (4) node analysis, (5) connectivity analysis, (6) network generation, and (7) evaluation (Linehan, 1995).

The land cover assessment included differentiating the area into habitat types and then further distinguishing these areas based upon vegetation, hydrology, and other such characteristics. All information gathered was incorporated into a geographic information system. Following the land cover assessment, a wildlife assessment served to identify the species of the region and the category from the land cover assessment into which they best fit.
From such information, a species can be selected which will serve as an indicator of the local diversity. A habitat assessment incorporates knowledge about the area of land available, as well as the availability of resources from the land. If either of these components is lacking, the land can be considered unsuitable for habitat use (Linehan, 1995).

The purpose of the node analysis step within the design process was to determine the significance of each of the nodes, which are defined as nonlinear elements that can be considered to be a place or an event. Within a wildlife corridor, nodes most often refer to patches, habitats, protected areas, or corridor intersections. Within a greenway, nodes can refer to any of the above sites, as well as historic buildings, farms, recreation areas, overlooks, and bodies of water. Within the Massachusetts area under consideration, those areas designated as nodes based on the wildlife corridor conception were than evaluated based on size, shape, and habitat value (Text Box 2). In general, the greater the size, the closer the distance, and the less degree of "friction" between the nodes under consideration, the greater the level of interaction between them (Linehan, 1995).

Text Box 2: Greenway Connectivity Equation

To determine network connectivity, the number of distinct networks within the area, the number of links within an area, and the number of nodes within the network were considered. The connectivity analysis makes use of the equation:

$$G_{ab} = (N_a \times N_b) / (D_{ab})^2 ,$$

where G_{ab} is the interaction between nodes a and b, N_a is node weight of node a, N_b is node weight of node b, and D_{ab} is distance between the centers of nodes a and b, to determine the interaction between a pair of nodes (Linehan, 1995).

From the collection of the above information, a model is then generated which connects the nodes. Of primary consideration in generating the network pattern is the 'cost to user' and the 'cost to builder.' To minimize the cost to the user, the network is designed with all points directly connected, thus reducing the costs generated in movement between separated points. A branched network, or a minimum spanning tree (MST), minimizes the cost to the builder. Two common forms of MSTs are the 'Paul Revere' and the 'Steiner point' types. In the Paul Revere network, each node is visited only once and no additional segments extend from the corridor. The Steiner point network has each node as the endpoint of a pathway leading in towards a common corridor. As corridors become more complex, they take on the form of closed loops. Complexity ranges from the 'traveling salesman' type, in which the nodes are connected by a circular path, to the 'least cost to user' network in which additional linkages between non-adjacent nodes form a network of paths within the center of the already existing circuit. The networks which result can then be assessed for their levels of connectivity by use of the gamma and beta indices described in Text Box 1 (Linehan, 1995).

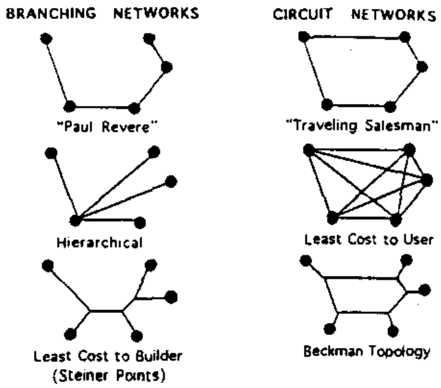


Figure 2: Examples of common network typologies (adapted from Linehan, 1995)

Based upon the above case studies, it can clearly be seen that, although other criteria, such as economic and cultural factors, should be included in greenway design, biodiversity protection should be the backbone of the greenway design. Supporting such an argument is evidence that the needs of wildlife are less flexible than the means by which to satisfy cultural and recreational needs. However, problems do exist. For instance, a wildlife corridor which serves as a means of movement and as habitat for many species, may serve as a barrier for another species. Additionally, the opportunity to view the protected wildlife is an invitation for excess recreational use. Thus, when developing a greenway, a compromise must be met between fulfilling the needs of wildlife while providing humans with the benefits which they desire (Linehan, 1995).

The Maryland Greenways Commission

Founded in March of 1990 by an Executive Order of then Governor William Donald Schaefer, the Maryland Greenways Commission has taken on the task of creating a statewide system of greenways protecting and connecting important natural corridors (The Maryland

Greenways Commission, 1996). Composed of members from both the public and the private sector, the twenty-eight member staff, working in conjunction with the Department of Natural Resources and the Maryland Office of Planning, has undertaken numerous land conservation initiatives in each region of the state (The Maryland Greenways Commission, 2000). The Commission also works closely with regional governments, citizen groups, land trusts, businesses, and private organizations seeking their assistance in protecting natural corridors (The Maryland Greenways Commission, 1996). In order to bring the idea of greenways to these organizations, the Commission has held workshops, seminars, and presentations with the above groups. Additionally, the Commission has published The Maryland Greenways Atlas depicting the existing, planned, and potential greenways in each of the counties of the state (The Maryland Greenways Commission, 2000).

Within The Maryland Greenways Atlas, one can also find the numerous differing programs, funds, and easements the Maryland Greenways Commission uses in order to obtain land for designation as greenways. Program Open Space (POS) is funded by the state's real estate transfer tax, which places one-half of one percent of the purchase price of a home or land into a special fund. The 2,800 projects within Maryland which have been funded through POS are guaranteed to exist into the future as lands bought and improved with these funds can only be used as public open space or recreational areas (The Maryland Greenways Commission, 1996). Maryland's Program Open Space currently uses seventy-five percent of the land it purchases for the creation of greenways (Grove, 1990). The Transportation Enhancement Program, funded by the Maryland Department of Transportation, provides for the acquisition of land to be used as pedestrian and bicycle paths. As a counterpart to the federal Wilderness Preservation System, the Maryland Wildlands Preservation System consists of all property under the management of the Maryland Department of Natural Resources which was designated as wildlands by the Maryland General Assembly. All of these areas serve to create a number of the ecological and recreational benefits which greenways have been noted to provide. As of 1996, twenty-four separate wildlands have been designated on over 37,000 acres in state parks, forests, and wildlife management areas (The Maryland Greenways Commission, 1996).

Companies contribute to the implementation of greenway plans through the creation of mitigation sites which result when a company undertaking a project with negative impacts on the surrounding environment provides land, wetlands, reforestation, or another similar benefit in order to be allowed to carry on their project. Ordinances and land use programs work with developers informing them of potential greenways planning. Armed with such information, the developer can then work with the current plan, incorporating a required amount of open space within their plans (The Maryland Greenways Commission, 1996).

Private property owners can participate in the contribution of land to projects in a number of ways as well. For example, conservation easements can be sold or donated to a land trust. With such a designation, the landowner, who maintains private ownership, agrees to development restrictions in return for tax benefits. Similarly, agricultural preservation easements allow farmers to sell development rights to their land to the Agricultural Land Preservation Foundation. Management agreements with private property owners secure the protection of an area without reducing the rights of the owner (The Maryland Greenways Commission, 1996).

Currently, the Maryland Greenways Commission is striving to form connections between the numerous small parcels of land they have obtained throughout the state. Regional and interstate greenways, such as the Patuxent Regional Greenway and the Potomac River Greenway, are requiring the cooperative efforts of individuals from differing groups at local, state, and federal levels to form a unified corridor. In addition to the more cohesive greenways within the state, the Maryland Greenways Commission has also worked to improve portions of long distance and national trails which pass through the state. Two such trails which are beginning to be worked on are the East Coast Greenway and the American Discovery Trail (The Maryland Greenways Commission, 1996).

The Patuxent Regional Greenway

The Patuxent Regional Greenway, which passes through seven Maryland counties, is a partially established greenway which has the potential to connect to the Patapsco Regional Greenway located elsewhere within the state. Additionally, the Patuxent Regional Greenway could serve as a greenway link between Baltimore and Washington, D.C. (The Maryland Greenways Commission, 1996).

Of the 15,000 acres which the Department of Natural Resources owns and uses for this greenway, which follows the Patuxent River, Anne Arundel County possesses almost 1,000 acres. Through its protected lands, such as the Patuxent Wildlife Research Refuge, the Oxbow Nature Area, Jug Bay Wetlands Sanctuary, and Globe Com Wildlife Management Area, this portion of the greenway forms an important wildlife corridor. Anne Arundel County also uses the greenway to meet some of the county's recreational and educational needs. In Calvert

County, the Patuxent River Wildlife Natural Resource Management Areas total over 1,700 acres. A protected buffer along these areas may be established in order to aide water quality protection efforts. Two publicly owned, undeveloped parcels of land within Charles County form this county's contribution to the greenway. Thirty miles of land, forming the border between Howard County and its neighboring counties, extend the Patuxent Regional Greenway further. The final three counties through which the greenway extends are Montgomery County, Prince George's County (Figure 1), and St. Mary's County. The primary purpose of the greenway in Montgomery County is for water quality protection, although trails do extend through some portions. Prince George's County uses its portion of the greenway for nature study and for outdoor recreation. However, in this highly developed county, the Patuxent Regional Greenway has also been used to enhance water quality, accomplished by use of the development regulations which direct further growth away from the protected greenway area. A final use of the corridor in these three counties is found at the mouth of the Patuxent River in St. Mary's County. Here, the Patuxent Naval Air Station sets aside a tract of land for use as a wildlife habitat (The Maryland Greenways Commission, 1996). Table 6 provides greater detail about the land areas along the Patuxent River and the greenway functions which are fulfilled.

Despite the numerous functions which it fulfills, the Patuxent Regional Greenway is considered to be primarily an ecological greenway because the river corridor contains such a rich riparian environment. The vegetated buffer along the Patuxent River's banks provides water quality protection and habitat for numerous species of plants and animals (Gutierrez, 2000). As such a vital area, the land surrounding the Patuxent River began to be conserved at an early date.

Table 6
Patuxent Greenway Functions (adapted from Tritaik, 2000)

Function	*Description and Examples*
Aquatic Resources / Habitat	Trout streams require extensive shade to maintain essential cool temperatures in warm weather. All freshwater species rely on consistent water flow levels made possible only by infiltration of stormwater and its slow release into streams. One example is the Patuxent River State Park's trout stream protection effort.
Connectors	Corridors for wildlife movement between adjacent properties or habitat areas is an important function of the Patuxent Greenway. Other forms of connectors including rails-to-trails, bikeways, equestrian trails, scenic driving tours, etc. can also be developed in the Patuxent Greenway network.
Education	Greenways provide opportunities to learn about the environment and nature. The Chespax program at Kings Landing and Anne Arundel County's Jug Bay Nature Center are examples.
Land Resources / Habitat	Forests, wetlands, geologic and historic resources and the rural character of the Patuxent can all be protected through greenway compatible efforts. The Patuxent Wildlife Research Center's 1100 acres of undisturbed bottomland hardwood forest is one.
Open Space	In areas of significant urban and dense suburban development, the provision of public open space can significantly improve the local quality of life. The river-side park areas in the City of Laurel is an example of Patuxent-area success. In areas of extensive private lands, open space for hunting and other outdoor pursuits allows local people to recreate close to home. DNR's Bowen Wildlife Management Area is one example.
Recreation	The conservation emphasis of the Patuxent Greenway provides an excellent opportunity for passive recreation. Some examples are the many public trails and the Critical Area Driving Tour.
Scenic Vistas	Numerous lowland scenic areas along the River are greenway candidates like the Thomas Johnson Bridge and peninsulas jutting into the river. An example of an upland scenic vista is the privately-owned Annapolis Rock in Howard County where the City of Annapolis could be seen 40 miles away.
Sensitive Areas	Floodplains, steep slopes, prime agricultural soils, and aquifer recharge areas can be protected within the greenway.
Water Supply	Protecting lands in the watershed of surface water supplies is an important mechanism to protect drinking water quality. The major Patuxent examples are the Rocky Gorge and Triadelphia Reservoirs and the Fort Meade water intake vicinity.

In the first half of this century, more focused conservation management led to the preservation of sizable amounts of undeveloped land. In more recent years, land protection specifically for conservation purposes and for wildlife protection has begun and forms the basis for the regional greenway (Tritaik, 2000).

In 1991, the purpose for the planning of the Patuxent Regional Greenway was stated to be to "promote a watershed-wide vision to conserve and protect a continuous network of lands featuring natural resources, open space and public access in selected areas." The plan developed proposed an overall framework to attain the above vision as well as more general goals and objectives. Furthermore, the Patuxent Natural Resource Management Area Master Plan was created to provide further details in regards to the management and operation of the land acquired for the greenway (Tritaik, 2000).

The first goal listed within the 1991 plan was the establishment and maintenance of a greenway network of protected lands to preserve and protect the Patuxent River watershed. A strip of land up and down both sides of the river, land alongside significant tributaries of the Patuxent River, forest lands linking the waterways, and other areas of environmental or open space significance were all considered as lands to be obtained. A second objective listed beneath this goal was the protection of sensitive living resources. To accomplish this objective, the Maryland Greenways Commission recommended that "large blocks of contiguous natural habitat should be provided to ensure that not all protected area is edge habitat." The final objectives of this goal called for the conservation of the rural and scenic qualities of the land (Tritaik, 2000).

The second goal found within the 1991 plan was that of providing open space for recreational needs consistent with resource conservation needs. Specific objectives to obtain in reaching this goal include: promoting a trail network, promoting scenic routes, enhancing waterway access, and promoting greenway destinations (Tritaik, 2000). In order to maintain protection of this ecologically sensitive area, public access is restricted to designated public sites where scenic trails do not compromise conservation goals (Gutierrez, 2000). Additionally, when possible, previously existing trails were used and new trails were created along the edges of habitat instead of intersecting through such parcels. Waterway access points were also limited to sites which avoided sensitive habitats (Tritaik, 2000).

Wicomico County Greenways

Much of the land throughout Wicomico County is protected by the critical area and tidal wetland regulations. Currently, Wicomico County has begun to establish a network of greenways throughout the county which will connect towns to the natural areas which these regulations protect. Three potential, two partially established, and two existing greenways currently form this network (Figure 2) (The Maryland Greenways Commission, 1996).

The 1999 Wicomico County Land Preservation and Recreation Plan has documented the following as the guiding principles for the county's greenway design: (1) establish greenways along natural areas such as streams, wetlands, flood plains, and edges of water bodies; (2) establish greenways along ridges which offer attractive views; (3) establish greenways along manmade corridors, such as utility right-of-ways; (4) establish greenways along highway right-of-ways; (5) establish greenways which incorporate parks, schools, and plazas, as well as currently existing pathways, bike routes, trails, and sidewalks; (6) establish greenways which serve as buffer areas between differing types of land use; (7) establish greenways which are of interest for users; and (8) establish greenways so as to minimize the need for road crossings.

Also, in the 1999 plan, the establishment of the Wicomico County Greenways Commission was proposed. Formed in September of that year, the commission is headed by Aaron Levinthal, Green Ways Coordinator, and consists of twelve additional members (Levinthal, 2000). Together, these members of the private and public sectors of the community are working to implement a general plan already in place for greenway development (Wicomico County, 1999). Through his position, Aaron Levinthal coordinates the work of the Greenways Commission with the existing resources within Wicomico County. Furthermore, he works closely with the environmental and historical groups when the county acquires new properties. By inquiring about the environmental aspects of the area, as well as the historical significance of the sites, Levinthal assesses the newly acquired lands to determine their incorporation into the greenway planning process. Oftentimes, Levinthal completes forms such as the Maryland Historical Trust Site Form at this stage. Additionally, Aaron Levinthal also researches sites on his own, and informs the Greenways Commission about the suitability of these sites for inclusion in plans (Levinthal, 2000).

The beginning step, which the Wicomico County Greenways Commission has accomplished, was to create a list of objectives for the greenway system. One of the objectives which was agreed upon was the formation of a database of local flora, fauna and historical sites which could be combined with any existing database to provide information to government agencies, local interest groups, and private trusts. The creation of a county greenways map through use of a geographic information system was a second objective to be met. A third objective was to identify the ecological hubs within the county and to develop ecological and recreational corridors which linked these hubs to nearby towns. The final objective to be accomplished before the implementation of the greenway plans will be the development of a master plan which details supporting facilities, funding, and documents needed for the plan's approval. Of importance is that this plan incorporates the information discovered while fulfilling all of the other objectives (Levinthal, 2000).

On February 23, 2000, several members of the Wicomico County Greenways Commission met to discuss the current status of their work. The objectives listed above are being met, but the work is taking longer than planned. However, work on the database has been accomplished and, subsequently, the task currently being undertaken has been to begin inventory and mapping of sites of public and private interest in regards to their environmental and historical significance, of trails covering both water and land areas, and of connections between adjoining counties and states within the northwest section of the county. The information gathered in this process is being transferred to a geographic information system by Kris Hughes and Frank MacKenzie from the Wicomico County Planning and Zoning Office. Furthermore, at the meeting, discussion began about themes which could be incorporated into the differing trails. Recreational routes which could be accessed by trails or by car tours, environmental themes which included low impact areas, and historical themes were all discussed. From this topic, discussion about creating hubs, areas from which numerous greenways extend outwards, resulted. Gary Mackes, Director of the Department of Parks and Recreation , concluded the meeting by expressing his hopes that ultimately, the resulting network of trails which the Commission designs will allow the people of Wicomico County to "discover the other things here through greenways" (Levinthal, 2000).

Following completion of the inventory stage, Aaron Levinthal then hopes to identify the hubs, connectors, and sites of concentration based upon clusters of significant resources. Development of specific trails will then follow, as will the formation of outdoor classrooms which will be used for conveying environmental and cultural information. Within the area of Wicomico County, culture is closely tied to the environment due to existing, and historical, extractive economies, as well as a rich Native American heritage. Thus, the environment and culture can not be examined separately. However, ecological factors to be taken into consideration are the impacts of use on sites by humans, particularly the numbers of users and the impacts large numbers would have on fragile wetland ecosystems. Of importance to Aaron Levinthal is conveying respect and stewardship of the land to the potential users. For those greenways which incorporate river trails, the carrying capacity of the river and access to waterways are currently being considered. Buffers along the banks are also being considered. Eventually, a master plan will be formed; however, currently, the Greenways Commission is still in early planning stages and has not yet decided what will be the best means by which to meet the County's goals (Levinthal, 2000).

Keys for Figure 3 and Figure 4

Prince George's County Protected Lands and Greenway Corridors

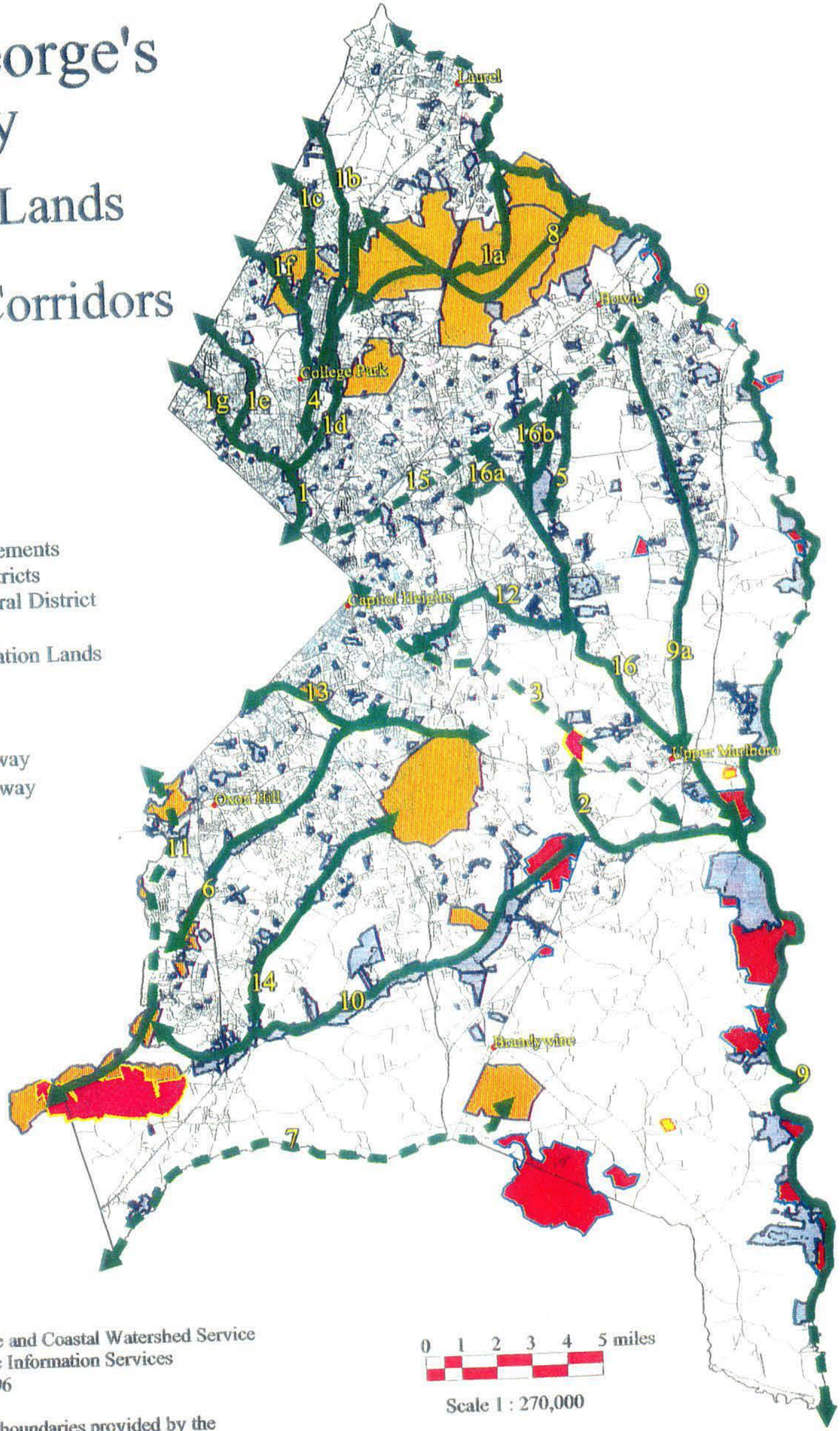
1. Anacostia Headwaters Greenway
    - 1a. Beverdam Creek
    - 1b. Indian Creek
    - 1c. Little Paint Branch
    - 1d. Northeast Branch
    - 1e. Northwest Branch
    - 1f. Paint Branch
    - 1g. Sligo Creek
2. Charles Branch
3. Chesapeake Beach Rail Trail
4. D.C. Trolley Right-of-Way Rail Trail
5. Glenn Dale Greenway
6. Henson Creek
7. Mattawoman Creek
8. Northern Greenway
9. Patuxent Regional Greenway
    - 9a. Collington Branch
10. Piscataway Creek Greenway
11. Potomac River Greenway
12. Southwest Branch
13. Suitland Parkway
14. Tinkers Creek
15. WB&A Trail
16. Western Branch
    - 16a. Folley Branch
    - 16b. Lottsford Branch and Horsepen Branch

Wicomico County Protected Lands and Greenway Corridors

1. Nanticoke River Greenway
2. Nassawango Creek Preserve
3. Pocomoke River Regional Greenway
4. Salisbury-Hebron Rail Trail
5. Salisbury/Pocomoke River Greenway
6. Salisbury Urban Greenway
7. Wicomico River Greenway

Prince George's County

Protected Lands and Greenway Corridors

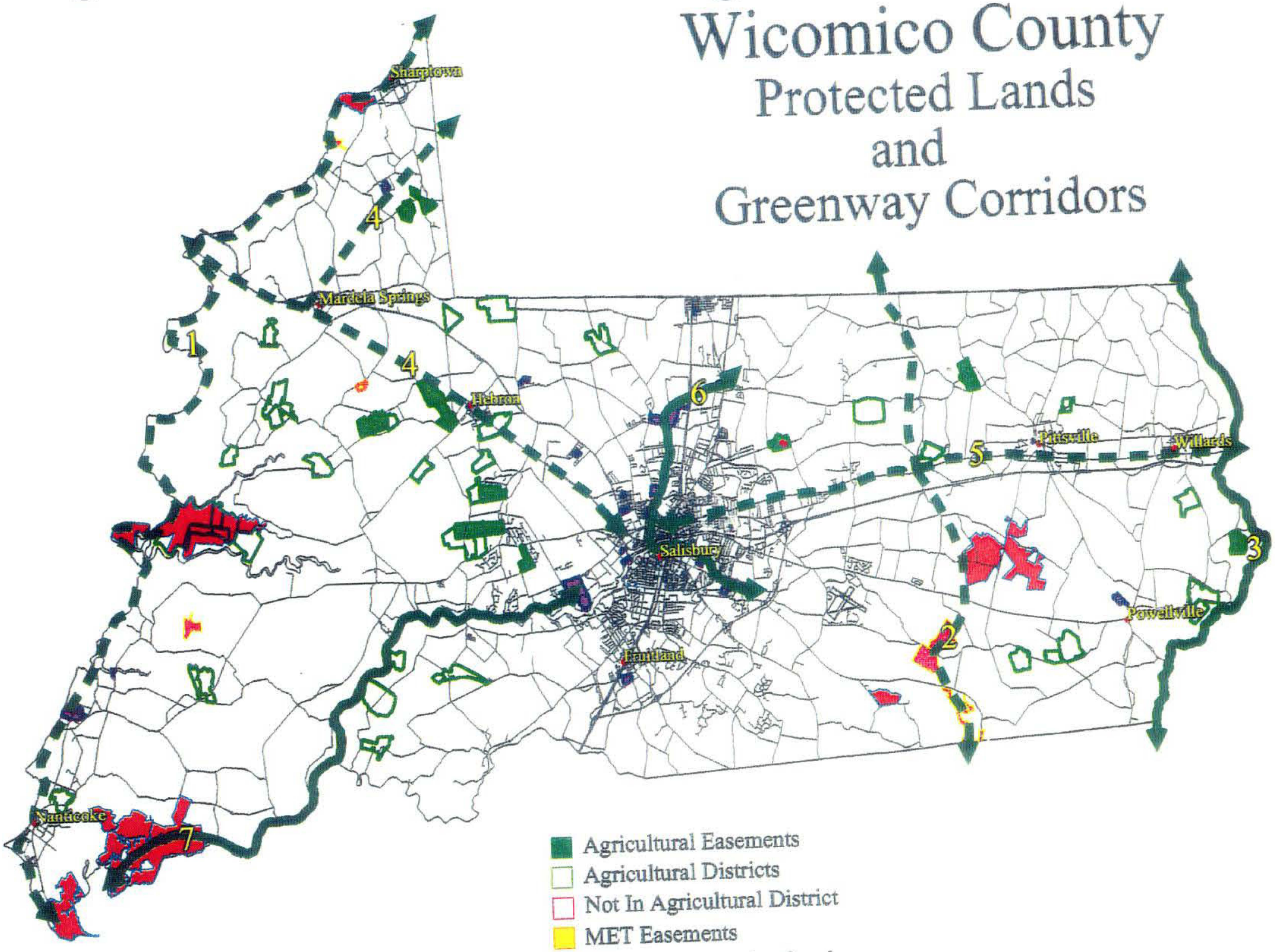


- Agricultural Easements
- Agricultural Districts
- Not in Agricultural District
- MET Easements
- Private Conservation Lands
- County Parks
- State Lands
- Federal Lands
- Existing Greenway
- Potential Greenway

Chesapeake and Coastal Watershed Service
Geographic Information Services
August 1996

Roads and boundaries provided by the Maryland State Highway Administration.

Wicomico County
Protected Lands and Greenway Corridors



- Agricultural Easements
- Agricultural Districts
- Not In Agricultural District
- MET Easements
- Private Conservation Lands
- County Parks
- State Lands
- Existing Greenways
- Potential Greenways

0 1 2 3 4 5 miles

Scale 1 : 250,000

Chesapeake and Coastal Watershed Service
Geographic Information Services
July 1996

Roads and boundaries provided by the Maryland State Highway Administration.

Conclusion

The design process for greenway systems includes both a general method and a more specific method which takes into consideration the ecologically significant characteristics of the land. Wicomico County has begun to develop their greenway network with the general considerations in mind. In comparison, the design process for the Patuxent Regional Greenway shows no evidence of having gone through several of the general stages, including the inventory stage and the formation of a master plan. Despite having not participated in these beginning stages, the Patuxent Regional Greenway still is capable of serving as an example of a greenway designed to maintain an ecologically significant area, as can the three case studies presented.

Ecological considerations which are of importance to consider in Wicomico County's design process are those of biological diversity and of water quality protection. The examples of greenway design presented above deal specifically with ways in which to construct greenways so as to obtain these benefits. Specifically, Wicomico County should include within in its planning stages the methods they will employ to obtain these benefits. Possible methods discussed include: ecologically considerate trail designs, limitations on access to both trails and waterways, and numerous other suggestions. By clearly stating and defining the measures they will take, Wicomico County can create a system of greenways which produce a number of benefits - recreational, transportation, and economic. But, they can also create a system which preserves the critical areas and tidal wetlands unique to the land and the species which such areas support.

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