

Green Infrastructure Planning

College Curriculum Guide

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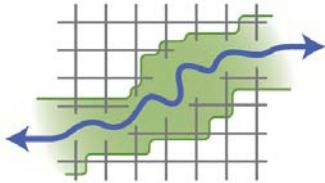
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Introduction

Use of this Guide:

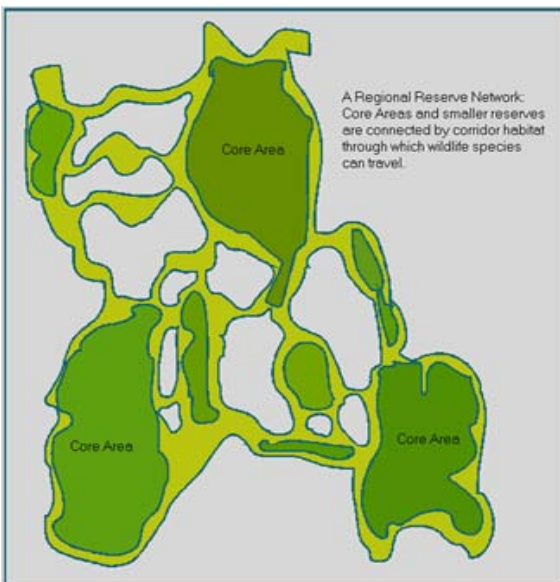
This curriculum guide was funded by the Virginia Department of Forestry through a grant from the USDA Forest Service's Urban and Community Forestry Program. This course was implemented in the Department of Urban and Environmental Planning in fall 2007 at the School of Architecture at the University of Virginia. The class developed at UVA by Karen Firehock **Green Counties: Green Lands** was the first use of new statewide green infrastructure models for planning education.

The guide will be updated as needed to reflect new developments in the field as well as improvements to the course. This guide is intended to be utilized by professors to teach applied green infrastructure planning at the college graduate school level. It can be utilized by four-year colleges, but the assignments should be modified as appropriate to match the degree of work expected of undergraduate students.

This guide is not intended as a textbook. It provides an outline for teaching green infrastructure planning. The guide assumes that professors have ordered the appropriate texts and have the technology or data necessary to implement such a course. Suggested course texts are found in the next section of this guide. A bibliography in Appendix H, points to useful case studies and other texts. This course is intended to be implemented as part of a planning department curriculum but could also be adapted easily to a computer mapping class, a landscape architecture class, a geography class or a conservation biology or natural resources management course.

Where to Apply:

Virginia has just completed a statewide model known as the Virginia Conservation Lands Needs Assessment (http://www.dcr.virginia.gov/natural_heritage/vclna.shtml) that mapped unique, intact



habitat areas (cores) of 100 or more acres, as well as the corridors of 300 meters wide that connect high conservation value cores needed to provide habitat and ensure species diversity. Habitat fragments (intact areas of 10 – 99 acres) may also be included and provide a useful buffer to corridors.

The Virginia modeling effort is an ambitious project that includes not only intact habitats, but also cultural and historic resources, endangered species, and sensitive coastal areas. Similarly, the new Watershed Integrity Model maps the state's high quality watersheds. There are also individual models, such as a forest economics model to locate suitable forestry areas and a growth vulnerability model to predict potential threats from development. These models provide a multi-faceted set of data that can be combined to create new data layers or used as a base

from which to create more specific data layers for local applications. The state has provided a wonderful planning and learning tool that is easily accessed. It is hoped that other universities and

colleges across Virginia will now use these powerful modeling tools in helping students apply land planning theory to real world problems.

Although this curriculum guide is based upon Virginia, it can be adapted for use in other states. In creating a course on green infrastructure planning, professors should consider whether or not there are already good base maps available for developing a green infrastructure plan or whether maps will need to be created. Some states have created useful models for developing a local green infrastructure strategy. In Virginia, the state has mapped its interior forest cores (100-acre minimum) and ranked them for conservation value (high to general) based on ecological services, such as providing designated drinking water, to habitat value, such as interior forest needed by certain bird species. The state has also mapped potential corridors (areas of 300 meters wide for wildlife and plant migration) between the highest ranked cores. This digital model, as well as other models developed by Virginia, are available from the Virginia Department of Conservation free of charge and provide a very useful framework for teaching about and studying green infrastructure planning.

Other states, such as Maryland, mapped their green infrastructure several years ago. Maryland's program is called "Green Print" and is one of the earlier efforts upon which the Virginia program is based. There are also larger-scale efforts, such as a project to map large forested areas in the Southeast known as the Southeastern Ecological Framework conducted by the University of Florida and other partners in 2002. In their large regional southern model, which covers states in the Environmental Protection Agency's Region IV, researchers choose a 5,000 acre minimum threshold for habitat (or hub) size. There are also efforts that cross country boundaries, such as Two Countries One Forest that includes five northeastern U.S. states and New Brunswick, Canada and is intended to focus at an ecoregional scale. There are similarly scaled efforts underway in the Sonoran Dessert (for resources see Appendix A). While these efforts are impressive, it is important to remember that the larger the scale, usually the lower the resolution.

For site specific planning, regional models need to be incorporated with local data in order to see what is happening on the ground. In addition, data used for the models may be old and will need to be updated. A forest put on a map from 2002, may be gone in 2007 or may have been compromised by a new road or a mine. Additionally the mapped resolution is at 30 meters and more detailed resolution may be needed for some areas. Finally, what is studied and mapped depends on the project goals. Most of these models use land cover data and satellite imagery that does not include the legal classifications for land. This means that an area may be mapped as a forest, but zoned for industrial development or a future housing subdivision. Therefore, maps should not be taken at face value but rather overlaid with other zoning and land use maps to paint a detailed picture for what is happening on the ground or what may happen in the future if no regulations are changed.

Conducting projects at the multi-state or eco-region scale is outside of the practical scope of most single-semester college courses. Professors should delineate a scale and sub-area appropriate for class study – ideally something that can be visited in person. While mapping technology and resolution have grown tremendously in precision and applications over the past decade, there is no substitute for including field visits to ground truth the data. This brings up an important point – green infrastructure theory may be taught in the classroom but applications will require some class field trips to look at the landscapes in real time as well as to broaden the lenses through which students seek to understand the setting and context for their planning work.

Applied Planning and Scholarship

Professors who decide to undertake a green infrastructure planning effort, either as a full semester course or a shorter module within an existing course, should also take some time to contact localities and meet with them beforehand to determine if student data and analysis could be used at the local level. The most important element of any applied planning course is that there is an actual recipient of the work. The Planning Accreditation Board provides planning accreditation for schools of planning across the United States. Several of their guidelines for planning education are met by applied courses that provide community service and engage planners in “real-world” problem solving. The following guidelines are excerpted from the April 2006 Planning School Accreditation Board criteria:

Knowledge Components

4.3.8 Collaborative Problem Solving, Plan-making, and Program Design Guidelines:

- Students, especially those without practical planning experience, should have experience in a studio or workshop course directed to plan making and problem solving of real world issues.
- Students should be able to work effectively as members and leaders of planning teams, and to apply an understanding of interpersonal and group dynamics to assure effective group action. The subject area should also include group processes, as well as mediation and negotiation skills.

Public and Professional Service

8.2.1 Link with Teaching: The faculty's instructional efforts (e.g., studio courses, fieldwork classes, community visioning exercises) should where possible, contribute to public service, and the faculty's public service efforts should contribute to the instructional program.

Green Infrastructure Planning History

Green infrastructure is a strategically managed network of natural lands, working landscapes and other open spaces that conserves ecosystem values and function and provides associated benefits to human populations. It is this network of ecological systems that makes human life possible. Green infrastructure planning entails inventorying green assets, identifying opportunities for their protection and/or restoration, and developing a coordinated strategy to channel development and redevelopment to the most appropriate locations. Green infrastructure planning is a unique approach because it combines conservation planning methodologies within a systematic framework that can be applied in the context of developing landscapes. Taking a green infrastructure approach requires identifying and understanding natural systems and protecting those systems first, before development begins, as well as seeking to restore connections and habitats in already-developed landscapes.

As noted earlier, green infrastructure planning is not an entirely new concept and the principles that form the basis for the concept have arisen from multiple disciplines. The fields of conservation biology and ecology contributed central ideas such as “keystone species” that helped to create an understanding that ecological systems are nested and connected and that species have certain habitat needs that are unique. In 1864, George Perkins Marsh, who is often credited as the father of the modern conservation movement, wrote his seminal book *Man and Nature* in which he proposed the idea that humans were degrading their environment and thus have an obligation to become stewards of the land. The field of natural resources management and adaptive management emerged from this early work with the notion that we can actively seek to influence the health of these ecological systems. The need to incorporate intentional green space within urban areas can be credited to Frederick Law Olmsted, the father of the modern landscape architect movement, who integrated modern green spaces

and connected park systems throughout urban areas. Many planners should be familiar with his famous connected park system in the Boston area known as the “Emerald Necklace.”

The field of planning, however, has taken a longer time to begin to incorporate environmental concepts. In 1969, Ian McHarg pioneered the idea of overlaying multiple sources of information as layers on the landscape in order to understand limitations and opportunities for conservation and development in his now famous book “Design with Nature.” This work led to planning based on overlapping multiple layers that now forms the basis for geographic information systems or “GIS” that use digital technology to accomplish what McHarg did with mylar trace overlays. In the 1970s and onward, landscape architect R.T.T. Forman contributed his ideas of landscape mosaics or habitat cores and patches and the need to connect species through corridors.

Despite all the work of these important scholars, planners and designers, the concept of *green infrastructure* as the basis for planning, as opposed to *grey infrastructure* is only just now beginning to take hold. Thus the question arises, why now? Why has the early 21st century given rise to green infrastructure as a new planning paradigm? The answer is both simple and complex but can be summed up in a word “sprawl.” Sprawl is threatening America’s landscape at a rate that is unprecedented. For example, over a 12-year period, population in southern states grew 22.23 percent while the rate of land utilization grew 56.61 percent (*Fulton, Pendall, Nguyen, and Harrison: Who Sprawls Most: How Growth Patterns Differ Across the U.S., July 2001*). At greatest risk are intact forest habitats. To maximize species diversity and health, interior forest dependent species need at least 100 acres of intact, unfragmented forest. Virginia’s forests are at risk as are forests across the southern states. Mixed ownership patterns spanning multiple jurisdictions have resulted in a fragmented landscape. Seventy percent of land ownerships in the South consist of parcels of less than 100 acres (USDA Southern Research Station or SRS) and in Virginia most forested tracts average 30 acres. The USDA Forest Service’s SRS credits the impacts of land parcelization on forest sustainability as far exceeding the impacts of all other forest threats in the South.

Evidence for declining resources abound. Nationwide, almost 2 million acres of farmland and half a million acres of private forest are developing each year, leading to loss of species, groundwater declines, climate change and lost recreation and open space. Loss of habitat not only degrades the quality of life and the environment but it also has real economic consequences. Parks, protected rivers, scenic lands, wildlife habitat, and recreational open space support a tourism industry valued at \$502-billion annually. Preserving and expanding our natural assets is thus central to sound economic policy. Our nation’s health is also at risk. Consider that lands threatened by imminent development produce 79% of the nation’s fruit, 69% of vegetables, 52% of dairy products, 28% of meat, and 27% of grain. Finally, climate change is perhaps the greatest threat to environmental sustainability faced by mankind. While greenhouse gases are proliferating, an important tool for sequestering carbon – the world’s forests – is fast disappearing. Deforestation accounts for 20% of the world’s greenhouse gas emissions.



Farms contain both resources for people and habitat for wildlife

Planning Applications

The growth of Geographic Information System (GIS) tools and computer modeling are now making conservation planning and landscape protection more accessible and easy to implement than ever before. Yet these tools need to be connected to planning on the ground in order to be most effective. For example, in 2007, Virginia completed a model known as the Virginia Conservation Lands Needs Assessment (VCLNA), an historic and ambitious project to provide Virginia with its first statewide map of intact forested habitats and wildlife and plant community connections. The project has taken several years and involved all state land, water and wildlife management agencies. However, a method for utilizing the data to implement local land conservation plans is missing from this effort. The model does not incorporate local zoning, future road and utility plans or local land use plans, such as park and open space plans. Similarly, other large models such as “Two Countries One Forest” that covers New Brunswick Canada and five New England states have difficulty in connecting land conservation priorities to the hundreds of local governments that most affect conservation outcomes on the ground. Yet to make state and regional models viable, we need to apply them at the local level and make them relevant to local needs. Unless the models are linked to local land use planning and strategies, unique habitats and high quality watersheds will not be conserved as there will be no way to apply the models to implement conservation plans locally, where most land use decisions occur. We need to connect the science and analysis to real planning on the ground.

Based on current projections, Virginia will develop more land in the next 40 years than in the last 400. Unless we create tools to assess and protect our natural and cultural resources now, we will lose the very assets that currently provide a high quality of life for us (VA Outdoors Plan, 2007). Similarly, programs that utilize Purchase of Development Rights or Transfer of Development Rights should use the best possible science in targeting lands for conservation or development. Many of these programs lack any scientific or defensible method for how lands are selected for conservation or growth. Finally, not only do we need to make it easy for localities to use and apply this data, we need to make the case for why they should conduct this planning. In short, we need to make land conservation the basis for land planning at the local level. Following are some examples of how green infrastructure networks can be used to inform local planning.

Comprehensive Planning: The state of Virginia requires localities to create and implement a comprehensive plan at least every five years under § 15.2-2230. Plans are developed and reviewed by the local planning commission to determine whether it is advisable to amend the plan. Plans are adopted by the legislative body, such as the board of supervisors or the city council. Under § 15.2-2223 “The local planning commission shall prepare and recommend a comprehensive plan for the physical development of the territory within its jurisdiction and every governing body shall adopt a comprehensive plan for the territory under its jurisdiction.” Green infrastructure can form the basis for the comprehensive plan by designating the proposed patterns and locations for development. For example, plans should lay out which areas to zone for development or for conservation as well as lands that may be acquired in the future for green space. In Virginia Beach and Charlottesville VA, green infrastructure was mapped and included in their comprehensive plans. Since the comprehensive plan provides the basis for zoning decisions, all comprehensive plans should include a green infrastructure assessment.

Under § 10.1-200. Duties related to parks and outdoor recreation; additional powers: “To facilitate and encourage the public use of parks and recreational areas, to further take advantage of the positive economic impact of outdoor recreational facilities to localities and the Commonwealth, to foster the

upkeep and maintenance of such resources, and to provide additional means by which the Governor and the General Assembly may determine necessary general fund appropriations and the need for other funding measures, the Department shall establish and implement a long-range plan for acquisition, maintenance, improvement, protection and conservation for public use of those areas of the Commonwealth best adapted to the development of a comprehensive system of outdoor recreational facilities in all fields, including, but not limited to: parks, forests, camping grounds, fishing and hunting grounds, scenic areas, waters and highways, boat landings, beaches and other areas of public access to navigable waters.”

For examples of how green infrastructure can be incorporated into an urban environment, please see the [Charlottesville Comprehensive Plan](#) in the Resources appendix of this guide. That effort was also conducted by University of Virginia students working in an urban context. In that effort, students mapped street trees, tree canopy, water resources, trail and recreation assets and also helped develop policies for their protection including green building and energy conservation. This chapter provides a model for how green infrastructure fits within comprehensive plans. The Hampton Roads Planning District also did a regional Map and this is found in the resources section as well. The regional map is being used by several localities for their comprehensive planning efforts.

Watershed Planning: Green infrastructure planning is linked to watershed planning, since land uses and development patterns are directly tied to water storage and quality. Waterways, bays and wetlands are critical components of “blue” infrastructure as they provide habitat links for fish and wildlife and they are included in green infrastructure planning. Groundwater resources are also part of green infrastructure. River corridors and stream valleys often provide the only remaining green connections for wildlife to move across the landscape. Wetlands provide areas for water storage and groundwater recharge, while also hosting many unique and rare species of plants and animals. In coastal areas, wetlands provide shellfish grounds and nurseries for young fish. Watershed plans should seek to connect wildlife habitats and provide connections across watersheds.

Open Space and Park Planning: A green infrastructure network informs planners as to where and how they can best acquire and preserve critical lands. By evaluating the costs of land and the ecological and economic returns, planners can determine which are the most strategic parcels to acquire. For example, a planner may determine that a 20 acre site containing endangered species and wetlands needed for habitat as well as stormwater storage is more valuable to acquire, than a 100-acre site that is mostly cleared; even if both sites would cost the same dollars to acquire.

Recreation Planning: Locating nature trails as well as alternative commuting routes for bikers and walkers, can be fitted into a green infrastructure plan. The plan can be used to inform the location of sensitive areas that should be avoided by human intrusion, as well as the best locations for trails due to slope, soils and other connectivity considerations. Similarly, planners may want to route trails closer to unique areas as long as protective measure are taken, such as installing raised boardwalks or less-obtrusive wildlife viewing areas or blinds.

Conservation Easement Planning: Land trusts and other easement programs such as the Virginia Outdoors Foundation program can use green infrastructure plans to determine areas to actively seek for easements. Lands that would provide a critical part of a green infrastructure network should be sought actively by planners. The trust or agency may also want to add additional points or a higher ranking to any applications for easement acquisition that include key areas identified in the network. Finally, green infrastructure networks highlight the importance of landscape connections.

When a parcel of land is put under easement for conservation purposes, the connection of that parcel to the broader landscape should also be considered. For example, it is possible that, over time, a 100 acre forested parcel would lose much of its ecological integrity if all the land around it were developed or nearby new roads blocked wildlife and plant movement. A parcel of land that is not connected to the larger landscape could become an isolated “island.” Land trusts and others should seek to ensure that corridors between protected lands are maintained (or included as additional easements) and that the easement is large enough to protect the integrity of the site.

Forest Planning: Areas that depend upon forestry for their economic base should also consider whether large enough tracts have been protected. The USDA FS has established a national priority of “Conserving Working Forest Landscapes” in seeking to protect larger contiguous forest blocks and connections and the USDA FS Southern Region’s priority is to reduce fractured forests. Those forests that are close to growing metro regions are at high risk. Planners should work with local forest agencies to determine minimum and optimal land areas for viable forest operations.

The Virginia Forest Economics Model can be used as a good start to determine where are the most viable forested tracts. This data must also be overlain with local parcel and ownership data to determine if the area is large enough to manage. For example, a 100 acre forest might be a good size for managing for both timber and wildlife conservation but if there are 50 different owners of two-acre lots, then a unified forest management plan is not a realistic option.

Once the highest value conservation lands have been identified along with those most viable for forestry, a forest planner can begin to target key landowners for forest conservation plans. Having a forest management plan is one way that forest conservation can be ensured. One source of funding to help landowners develop and implement their forestry management plan is to apply for a grant through the Virginia Department of Forestry from the Forestland Enhancement Program.

Purchase or Transfer of Development Rights: Similar to the rationale for open space planning, localities that are engaged in purchasing development rights should develop criteria for where development rights should be purchased. A key wildlife corridor between two protected landscapes may be more important to acquire than another isolated parcel that does not offer much conservation value. For programs that are transferring development rights, both a sending zone and a receiving zone are required. This means that areas that should be developed less densely (less units per acre) or that should be protected altogether, need to be identified early on so that a sending zone can be established based on high quality scientific analysis that establishes its value. A green infrastructure analysis can help planners determine where to locate sending zones (in addition to other considerations such as areas that are too remote to service with public water or sewer). A receiving zone should be identified based on both practical cost considerations such as proximity to existing services, schools and grey infrastructure, as well as the fact that the sending zone does not include rare species, wetlands or other critical habitat that need to be preserved. A green infrastructure plan can be used to show both what should be protected as well as what areas could or should be developed.

Grey Infrastructure, Road and Utility Planning: Green infrastructure plans can also be used to determine where roads should and should not go based on seeking to avoid bisecting large intact habitat blocks. Roads also may be engineered in such a way that critical areas (such as unique wetlands) are avoided and may also provide other green elements such as wildlife underpasses, special lighting or other design elements that seek to avoid wildlife impacts. Roads may also be left unpaved in rural areas in an effort to avoid serving as blockages to insects or other small animals that are reluctant to cross

paved areas. Trimming of tree canopy also may be minimized to leave roads shaded while still providing for public safety. Hot asphalt can impede insect and wildlife travel. For more on road planning in an environmentally-sound manner, see this new publication from the U.S. Department of Transportation [Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects](#) in the resources appendix.

Similarly to roads, utility crossings such as clearings for power lines, are often utilized by wildlife. However, herbicides used to prevent tree growth may be toxic to other life or destroy important habitat. Instead of using chemicals to keep vegetation away from power lines, utilities may choose other species to plant that do not grow tall enough to interfere with power lines. In addition, just as roads should not bi-sect key habitats, power lines should also be sited away from key habitats or viewsheds.

Viewshed and Historic Sites Protection: Viewsheds refer to the area that can be seen and appreciated by the human eye. What constitutes the viewshed is based upon the point of reference. If a view from a historic site atop a mountain, such as Monticello the home of President Thomas Jefferson, is deemed important, then the 360° view may need to be protected. Along a scenic roadway, what can be seen from the road for the length of its designated scenic stretch (e.g. 20 miles on both sides) may be important.

Viewsheds are very important for historic resources. When land adjacent to a historic site is developed, it can mar or even destroy the integrity of the historic site. Similarly, when scenic vistas are lost, visitors may stop coming and residents will lose aspects of the landscape that they most value. There are economic reasons to protect “viewsheds” since they are important to attracting what are known as Heritage Tourists who come to see historic or culturally important sites. Heritage tourists spend, on average, two-and-a-half times as much money than do other tourists. Therefore, protecting the “views” may be important to making the economic argument for green infrastructure protection.

Viewsheds can be mapped using GIS add ons such as Spatial Analyst and Crystal Reports. Viewsheds may be protected by seeking to require buffers or obtaining easements along a scenic road or from an important monument so that pastoral views are conserved. Design guidelines for cell towers or other intrusions to the view can also help to reduce impacts and preserve the integrity of the landscape.

Working With Data

This class requires the use of Arc View for GIS. If students are not proficient in GIS, it may be that a subset of students who are comfortable with GIS could be designated as the “Mapping Team” and take responsibility for digitizing data gathered by the other students. For schools with no access to GIS, instructors will need to determine whether there are existing maps that might be utilized for analysis and planning. In addition, it is suggested that the course have a GIS expert to serve as the teaching assistant.

Green infrastructure planning seeks to preserve large intact forested land areas as well as critical areas such as riparian buffers and surface waters. Therefore, it may be necessary to look for areas that are intact as well as to determine areas that are likely to remain intact in the future by examining future road plans or power line plans. A green infrastructure plan should consider what may happen in the future and may also suggest alternatives if a future road will have major, unintended impacts.

In Virginia, forested cores and smaller habitat fragments have been mapped to determine where areas are intact through the Virginia Natural Landscape Assessment. In addition, Virginia has developed models for cultural and historic resources, forest economics, watershed integrity, and more. Information on models is available at <http://www.dcr.virginia.gov/natural_heritage/vclnhow.shtml>. The state can supply the spatial shape files and data tables for use by students and others. If such modeling has not been done for your state, you may want to overlay roads, railroads, power lines or other disruptions over land use maps to determine which forested areas are intact and which are fragmented or at risk. You may also want to include meadows, marshes and other unique habitats.

Working with data often requires fits and starts in that an idea may be tried and not show much that is useful. For example, in an attempt to discern where the active farms were, we overlaid two sets of data: legal land parcels and use value taxation to try to locate farms only to find that almost every parcel is taxed as a farm. In reality, not all of these parcels are being farmed but this is not easily seen through the data. Another example is in overlaying forests with land ownerships in seeking to locate productive forests. We may know the likelihood that a forest is able to be of high value due to the presence of low slopes and good soil types, but we may not know the quality and health of that forest without a site visit. If your class is working on a large scale, such as a county or regional scale, then it will not be easy to ground truth data and surrogates (such as soil type, land cover and slope) will have to be used to determine where forests are most likely to be productive.

In general, data that will be needed include:

- Topography (topo maps) for determining steep slopes or other landscape features.
- Streams and watershed boundaries and wetland locations and classes
- Waters that are impaired from state 303(d) lists
- Drinking water sources (public wells, water impoundments for public water, intake pipes, upland watershed areas)
- Forested lands (especially 100 acres or more. In VA this has been mapped.)
- Agricultural lands and types of agriculture (soils data may be available)
- Protected areas (lands under easement, parklands, federal lands, wildlife management areas)
- Parcel data for determining ownership
- Roads (primary and secondary) and future road plans to determine threats
- Zoning data for determining allowed uses and future build out
- Comprehensive Plan text and maps for determining desired or future conservation areas and goals
- Maps of rare species locations (or probable locations) from state wildlife and fish agencies
- Steep slope data (can be obtained using GIS to calculate all slopes over x%)

If including cultural resources:

- Areas that are historic (state or federal register properties or those that are eligible)
- Culturally important resources (a community gathering spot, favorite fishing hole, an agro-tourism area or travel route)
- Recreation plans and other open space plans (for determining present and future connections)

Community and Professional Knowledge

In any data gathering effort, there will always be the need to get data from the community of both citizens and professionals. Local foresters may know more about forest conditions than will be revealed on a map. Residents will have knowledge about wildlife, water issues, and community history, in addition to other issues. It's important to schedule interviews with resource professionals to learn what they know and which strategies could be most effective. In the photo to the right, an area forester with the VA Dept. of Forestry explains methods for getting rid of invasive species and how to follow sound forest management principles.



Syllabus and Texts

The syllabus is designed as a three hour weekly class. The syllabus contains topics and suggested assignments. Power point presentation templates available for download are found on the web at www.gicinc.org/teachingtools.htm Those implementing the course should choose a distinct name for their course, but credit to the University of Virginia and the Green Infrastructure Center would be appreciated.

Of the texts listed in the syllabus, instructors may choose either the Designing Greenways or the Green Infrastructure books. Designing Greenways will be more familiar in terminology and approach for those in the landscape architecture and greenways fields. Green Infrastructure is suitable for students of any background and was rated highly by students as very applicable. Nature Friendly Communities has the most detailed case studies and also provides discussion not only for what worked well, but also what did not. It is important that students learn from failures as well as from successes. All of these books are published by Island Press and are available free as review copies and those not selected may then be returned at no charge.

Green Infrastructure Planning Course Description and Syllabus:

Attempts to protect environmental assets often happen *after* land has been zoned or developed. Parkland trails or opens space lands are often relegated to left-over or perimeter land. Land that could best be utilized for filtering storm water, replenishing the groundwater supply or providing habitat corridors for both wildlife and people is often lost to inappropriate zoning and land planning. By considering and inventorying existing environmental functions and values first, land can be designated appropriately for protection and/or restoration before it is fully developed so that wildlife habitat, recreation, storm water treatment, energy savings, aesthetic and cultural values and improved

community health can all be achieved. The framework for assessing and valuing environmental assets is green infrastructure planning. Green infrastructure is defined 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, Benedict and O’Conner, 2005).

Students will assess the existing ‘green infrastructure’ of _____ (name of locality) and develop strategies for protecting environmental assets and channeling future development to the most appropriate locations. Case examples from other localities will be used to inform options for _____ (locality). Students will utilize the existing county comprehensive plan to create effective strategies for implementation of plan goals related to conserving open space and creating livable communities. The course is essential for planners, landscape architects, architects, environmental scientists, biologists, systems engineers or anyone who wants to plan, build or develop in patterns that maximize environmental qualities and protect community health. Students will gain skills in community environmental assessment techniques. Several of the classes include field trips outside.

Requirements: Students will conduct an assessment of a locality’s green assets and develop strategies to be used in planning for land conservation and community development. Grades are based on class participation [20%]; a green asset assessment [40%] and green infrastructure strategy document [30%] and a final essay [10%]. There is more reading early on and more project and mapping work in the latter half of the semester.

Readings:

- ❑ Benedict, Mark A. and McMahon, Edward T. ***Green Infrastructure: Linking Landscapes and Communities***. (Island Press, 2006)
- ❑ Duerksen, Christopher and Snyder, Cara. ***Nature Friendly Communities, Habitat Protection and Land Use Planning***. (Island Press, 2005)
- ❑ Hellmund, Paul Cawood, Smith, Daniel Somers. ***Designing Greenways: Sustainable Landscapes for Nature and People***. Washington, D.C.: Island Press, 2006

Learning Objectives:

In this course students will learn both critical thinking skills and build their knowledge of green infrastructure planning. Specifically, students will learn:

- Key principles for green infrastructure planning and network design.
- How to think about the land as the basis for land planning
- Using GIS tools for mapping and analyzing green infrastructure assets
- Strategies for land conservation and directing development to appropriate areas
- Basics of land and water ecological principles
- Linkages between economic and ecological strategies

Schedule (Note * = suggested field trip. Students should dress appropriately)

Getting Started – Planning the Adventure

[week 1] Course Overview

- Course schedule and project description
- Overview of Green Infrastructure Planning – approaches to assessment and purposes of green infrastructure planning and the role of the comprehensive plan in green asset protection (slide show – see template on CD or web)
- Students requested to fill in skills and interests survey so instructor can assign them to multi-disciplinary team.

Homework for next class: Read *Green Infrastructure* Book pages 1-82, glossary pages 279-285, and County Comprehensive Plan (*skim* most sections. Read especially land use and open space sections in the document.)

Assessing Green Infrastructure

[Week 2] Identifying, Evaluating and Linking Green Assets

- Case Studies of Green Infrastructure Planning
- Class discussion of Comprehensive Plan (or other appropriate open space or local land use plan) – What do they want to know? How will we help them to assess their green assets?
- Discussion of ideas with local representative (e.g. County Administrator as invited guest)
- Teams assigned.

Homework for next class: Read *Green Infrastructure* pages 109 – 222 and *Designing Greenways* pages 1-69

[Week 3] Methods for Green infrastructure Assessment

- Prioritizing resources for protection using a targeted endangered species approach (invited guest such as, the Nature Conservancy)
- Other Methods and Strategies for GI Assessment (see lecture outline)

Homework for next class: Read *Nature Friendly Communities* pages 1 – 120 and (assign a state forest report or other relevant documents. In Virginia use the annual report “State of the Forest and Virginia Forests: Our Common Wealth”)

[Week 4] Forest Management Challenges and Opportunities * Field trip to Locality.

- Invited Area Forester, Dept. of Forestry – How do we determine a healthy versus an unhealthy forest? What makes a forest economically viable for harvest? How are forests conserved? Visit a local forest to learn about management planning.

Homework for next class: Read *Nature Friendly Communities* case studies pages 121-252 and Benedict, Mark A., Allen, Will, and McMahon, Edward T. *Advancing Strategic Conservation in the Commonwealth*

of Virginia: *Using a Green Infrastructure Approach to Conserving and Managing the Commonwealth's Natural Areas, Working Landscapes, Open Space, and Other Critical Resources*. Washington, D.C., The Conservation Fund, 2004. online at: www.greeninfrastructure.net/virginia.

Field Homework: Teams visit locality and research assets and begin to catalog them. What assets are present, unique, in need of further protection? Prepare a two-page summary report, and a photo journal poster (10-12 photos minimum) for following class and share copies with classmates (digital is best if class has a website or email).

Also, each team must draft and turn in a list of issues to investigate along with potential data sources (see template). Professor provides feedback. The purpose of this assignment is to help students think through what types of information will be needed to assess green infrastructure assets and threats.

[Week 5] GIS Training—Mapping Green Infrastructure Assets

- Class workshop to learn to use GIS in class (students who are already experts should be given some hands-on work in class with data).

Homework for next class: Read Nature Friendly Communities case studies pages 253-412 (skim) and *Designing Greenways* pages 70 - 157

[Week 6] Blue Infrastructure -- Water Resources *Field Trip to Locality

- Watersheds -- River Ecology and Flow Issues (by instructor or guest lecturer. Students learn about how to assess stream health by conducting an inventory of stream macroinvertebrates at several locations as well as learn about floodplain formation and stream geomorphology. It is helpful to assess several different types of stream systems such as a steep small headwater stream in the hills and a meandering, more developed system in a valley at a lower elevation to compare and contrast them. It is also useful to compare a pristine and an impacted stream.)

Homework: Review all sections of state website related to green infrastructure assessment in preparation for state lecture http://www.dcr.virginia.gov/natural_heritage/vclna.shtml (note: If outside of Virginia, refer students to other relevant models in your state or learn about what other states are doing).

Modeling Green Infrastructure Futures

[Week 7] Using Models for Green Infrastructure Planning

- Presentation on state models for green infrastructure planning (These models are based on your state. In Virginia can invite Joe Weber and Jennifer Ciminelli, Virginia Department of Conservation and Recreation to explain the state's models.)

[Week 8] Decision Modeling Demonstration

- Class workshop to learn about other models for assessing Growth and Green Infrastructure Scenarios (note: We used Vista Software. Professors may want to invite guest lectures on different models.)

Field Homework: Students schedule team interviews with key experts such as area forester or water resources planner. Students should be prepared to report results during week 11 and maps in next class during week 9.

[Week 9] Data Workshop – *Bring your data for workshop – what trends and futures do we see? What might be needed to reverse these trends or improve upon them?*
Students work on maps in GIS and present their maps to the class for discussion. Students determine what data needs to be combined between teams.

Planning Tools for Green Infrastructure Conservation and Restoration

[Week 10] Comprehensive Planning and Regional Green Infrastructure

- How can we link to the regional assets beyond the locality?
- What programs and policies have already been identified and what else is needed?

[Week 11] Team Reports [1] Forests, 2) Water, 3) Working Lands and Cultural Assets

- Discussion of interview findings and how this informs class work. What strategies could work? Which need to be investigated further?

Homework: Read Hampton Roads Conservation Corridor Study, May 2006 on-line at http://www.hrpd.org/newpep/HRCCS/HRCCS_web.pdf and the Prince George's County GI Tech plan at <http://www.mncppc.org/county/GreenTechSum.pdf>

Homework for next class: Read *Designing Greenways* pages 158 – 258.

Team's prepare draft strategies and submit to instructor by week following (see suggested template).

[Week 12] Recommended Planning Strategies – What tools are needed in our locality?

- Conservation Planning Tools – Regulatory or Incentive Based?
- Discussion of asset assessments, draft ideas and proposed strategies.

Homework: Read *Nature Friendly Communities* case studies pages 122 – 252.

Note: Presentations to locality should be scheduled by instructor and implemented by students during last third of the semester.

Homework for next class: Read *Green Infrastructure* Book pages 225-278 and revise strategies based on class input and turn in again on week following.

[Week 13] Refined Strategy Discussion and Changes

Homework for last class: Students design and turn in final strategies and green infrastructure assessments (note: Instructor may want to allow students to turn this in during the exam period to allow an extra week or more for refinements to be made by students).

[Week 14] Final Green Infrastructure Report and Class Debrief (what worked, what did not)

Assignment Details

Note that 20% of grade is based on class participation both for reading discussions and presentations.

Green Asset Assessment: [40% of grade].

The class will develop a list of the assets we plan to evaluate and the methods for assessment and for recordation of those assets. Teams will develop an assets map and a risks map. The class will work in teams as follows:

- 1) Forests, 2) Water Resources, 3) Working Lands and Cultural Assets.** Students will work in teams of three to four students. Instructor may add in other teams based on class size such as *Recreation or Viewsheds*.

Within each team, students will focus on issues related to habitat intactness and quality, wildlife, connections, economic issues and opportunities, recreation and planning and zoning. Students will record locations for assets using state data and additional local data and characterize the condition of the asset, and map locations on a GIS layer.

GIS Data Management: Students should develop a standard symbology for recording assets on a GIS layer. Each team must turn in all GIS paper and digital files to the instructor by the final class. Each file should be clearly labeled along with a date. Be sure all data links work and only provide final versions (not draft such and such).

Each Team Will Turn In:

- 1) Poster of photos from the locality (12 total) showing issues, threats and opportunities related to the assigned issue (e.g. forest management) and share this with the class.
- 2) List of issues to investigate based on team topics and data needs.
- 3) Assets Map
- 4) Risks Map
- 5) Strategies Map
- 6) Final Priorities Map: One unified map of green infrastructure assets done as full class effort
- 7) Protocols for data analysis and mapping.

Green Infrastructure Strategies: [30% of grade]

Based on the maps and scenarios modeled, students will identify recommended strategies for the locality to pursue. To ensure readability, all students should follow a standard template for recommendations. This should be presented to the locality (e.g. the Planning Commission and Board of Supervisors) along with maps. Students should turn in a draft for comment mid-semester.

Final strategies including all text and maps are due to the instructor by (insert last class date or final exam date) in digital form to the class toolkit and to the email listserve.

Green Infrastructure Essay: [10% of grade]

Each student will write a final essay answering questions about the purpose and applications for green infrastructure planning. The final essay is due (insert last class date or final exam date)

Please note that the class should schedule a presentation to the locality. This should be done in the last third of the semester when work is ready for public viewing but there is still time for changes to be made. Final work should be given to the locality as digital data as well as in printed form.

Appendix A: Student Skills and Interest Survey

Student Skills and Interests Survey

This survey will be used to place students in teams and to inform instruction goals.

Name: _____ Email: _____

Phone: _____ Major: _____

Education (college major, grad schools prior to this university): _____

Professional environmental and/or planning experience: _____

Why are you taking this course? What interested you when you signed up? _____

What do you hope to learn? _____

Technical Skills (check any that apply but note that we will not be using all of these):

Digital Mapping

ArcGIS, extensions Spatial Analyst, CITYGreen, Other _____

Design

Adobe InDesign, Photoshop, Adobe Illustrator, AutoCAD, Hand Drawing

Planning and Survey

Tree Inventories, Vegetation Surveys, Watershed Plans, GPS technology

Data Management

MS Access, MS Excel, Other _____

Appendix B: Issues to Investigate

The following assignment is to be completed by students and critiqued by the instructor. A few example entries are provided in the first column.

Issue	Why Important	Data Sources
Water quality of streams	Clean water is important for drinking water supplies and for agricultural and businesses.	List of TMDL (impaired waters). State water quality assessment reports. Local data from Stream Friends Group.
Wildlife distribution	Wildlife are important to the community and locations of wildlife will be used to prioritize which lands to conserve.	State Wildlife Action Plan State list of endangered species. Fish and game survey data Natural Heritage Program data

Appendix C: Team Strategy Template

(One example is provided that was written by students. A typical strategy document should have ten to twenty strategies per team or can be done as one document.)

Team Strategies for _____ Locality(s)

Strategies for Forestland Conservation

Students: _____

Introduction: _____ County is a rural county in central Virginia just to the east of the Blue Ridge. In its Comprehensive Plan, the County has two primary goals as related to its forestlands: maintaining and encouraging a viable forest economy; and forest conservation. The following are recommended strategies that the County can pursue in order to meet both stated goals.

Strategy 1: Forestry Management Plans

Issue: Both of the county's goals are threatened by poorly managed timber operations of landowners unfamiliar with best management practices (BMPs). Without comprehensive and well prepared forestry management plans, timber can be harvested in such a way that the long term economic and ecological vitality of the forested tract can be damaged. This harms both the availability of ecological services such as water and air purification as well as the viability of the land to stay in long term forested use.

Tool: Encourage the application of forestry management plans (FMPs) for all rural tracts intended on being used for forestry. In particular, area foresters should target those tracts deemed essential by the green infrastructure plan for the creation and application of these plans. FMPs should be developed on a voluntary basis for each individual parcel through the interaction between state or local foresters and landowners so that plans meet the ecological and economic needs of particular tracts. Implementation of the plans are currently voluntary, but more emphasis needs to be placed on following up with owners on a regular basis to encourage and ensure an appropriate implementation. An important component for this tool is that state or local foresters have direct interaction and a close relationship with landowners.

Where to Apply the Tool: Forestry management plans should be prepared for all harvested or potentially harvested forest parcels in the County, but specific parcels should be targeted for outreach based on their importance in the green infrastructure plan and GIS analysis.

Cost: Additional capacity to develop forestry management plans will be needed in order to provide enough expertise to develop, implement, and follow up on the needed number of management plans. This capacity can come from the Department of Forestry, who would supply these services for free or for a fee. The second option is more viable and in order to pay the consultation fee required to develop these plans, there are several statewide grants available. One source of funding to help landowners develop and implement their forestry management plan is to apply for and receive a grant through the Virginia Department of Forestry from the Forestland Enhancement Program. Non-industrial private landowners can qualify for these grants, which help pay for the creation of management plans and certain other stewardship activities. This is a particularly good strategy because it encourages forest owners to follow the Forestry Management Plans that are drafted as a part of the grant, "landowners must be willing to maintain cost-shared practices for a minimum of 10 years. During this 10-year period, if the landowner or a future landowner destroys the practice, the landowner must refund the cost-share assistance plus a 10% penalty charge." The details of the different payment plans available under this program can be found in Appendix 1. A second source of funding is to offer local sales tax breaks to those landowners whose marketable timber is harvested from tracts with an implemented FMP on record.

Resource and Contact Information: Department of Forestry, Regional Forester for Madison County

Appendix D: Data Methods Protocol Template

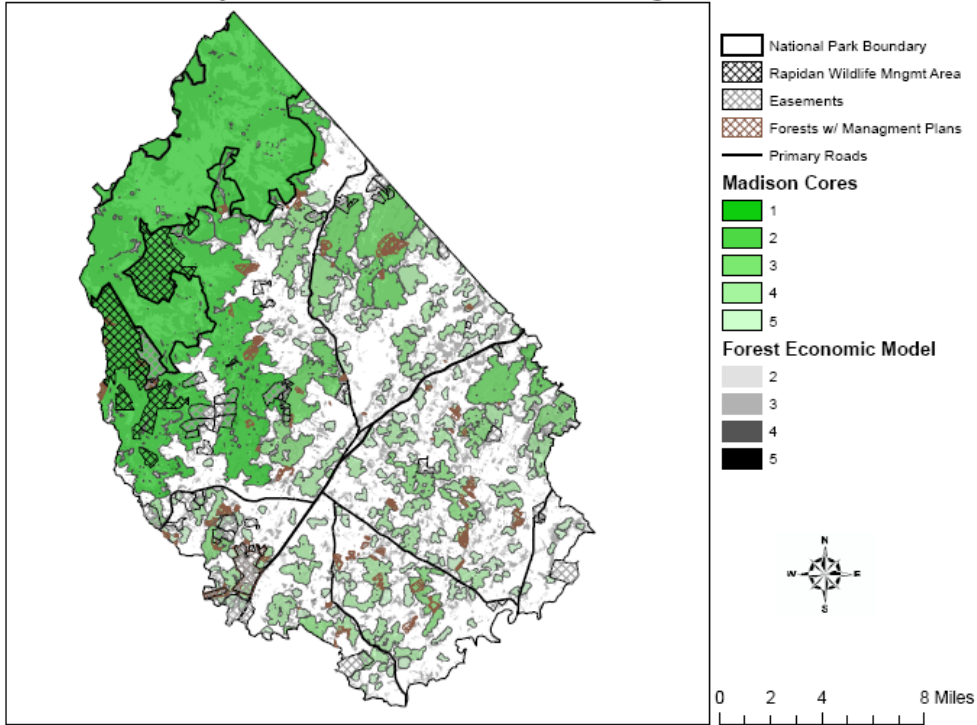
Students should document all steps in data processing so that the locality and others may understand and critique their work. Each team produced a protocol table. This is an example.

Input Data Layer	Data Processing	Output Data Layer	Green Infrastructure Goal
<i>Existing data used for analysis</i>	<i>GIS tools/geoprocessing used</i>	<i>Shapefile name and what it represents</i>	<i>What was the purpose?</i>
ConsLandsClip.shp, easements.shp, ifris_stands_mad.shp, and sap_tracts_stands.shp	Merge all four files.	ProtectLandMerge.shp	To have one shapefile with all protected lands.
ProtectLandMerge.shp and CountyCores_Class.shp	Intersect the two files.	ProtectedCoreIntersect.shp	What is left is protected cores, which we will link back with the core file to get a percent protection.
ProtectedCoreIntersect.shp	Dissolve the file using the field CoreID. Create a new field called 'Acreage' (data type of double) and use 'Calculate geometry' to populate the field (choose Area and units of acres).	ProtectedCoreDissolve.shp	Want to know the total amount of protected land for each cores, not individual areas within each core.
ProtectedCoreDissolve.shp and CountyCores_Class.shp	Join ProtectedCoreDissolve.shp to CountyCores_Class.shp using CoreID. Create a new field in CountyCores_Class.shp called 'PercentPro' (data type). Populate this field with the acreage of protected land divided by the total area of the core.		At the end of this step, you will have the percent of protected land within each forested core.

Appendix E: Sample Green Infrastructure Maps (note these are draft maps)

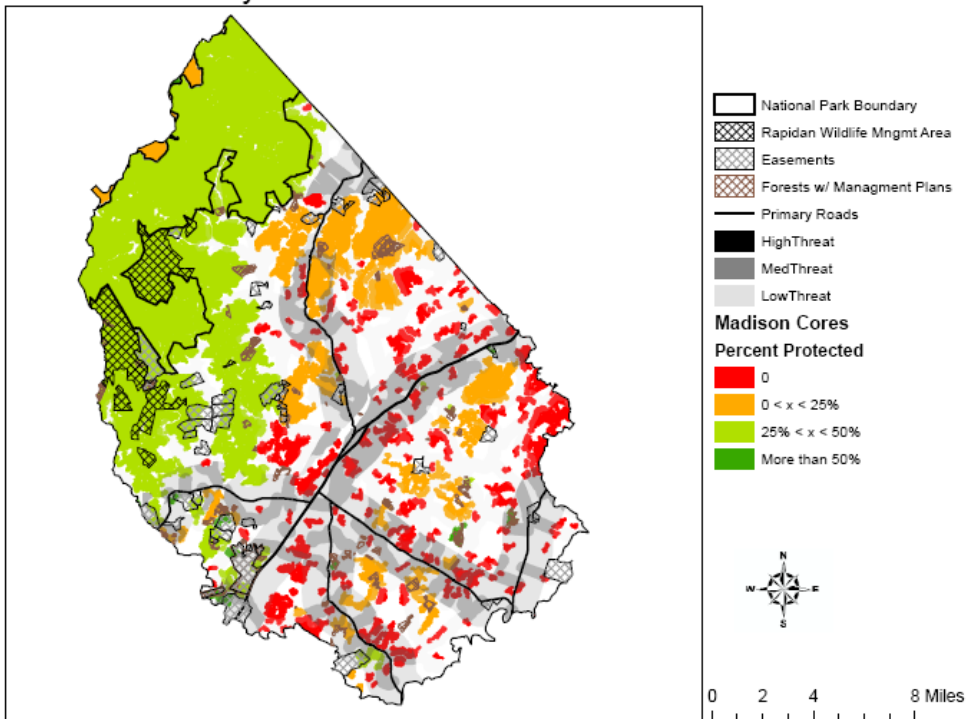
The following maps are a small sample of maps produced by students for the fall UVA 2007 class. Each team produced an assets map, a risks, map and a strategy map. The final map “priority natural habitats” shows a merged map where all data were combined to determine areas for priority focus.

Madison County Forests: Economic & Ecological Assets



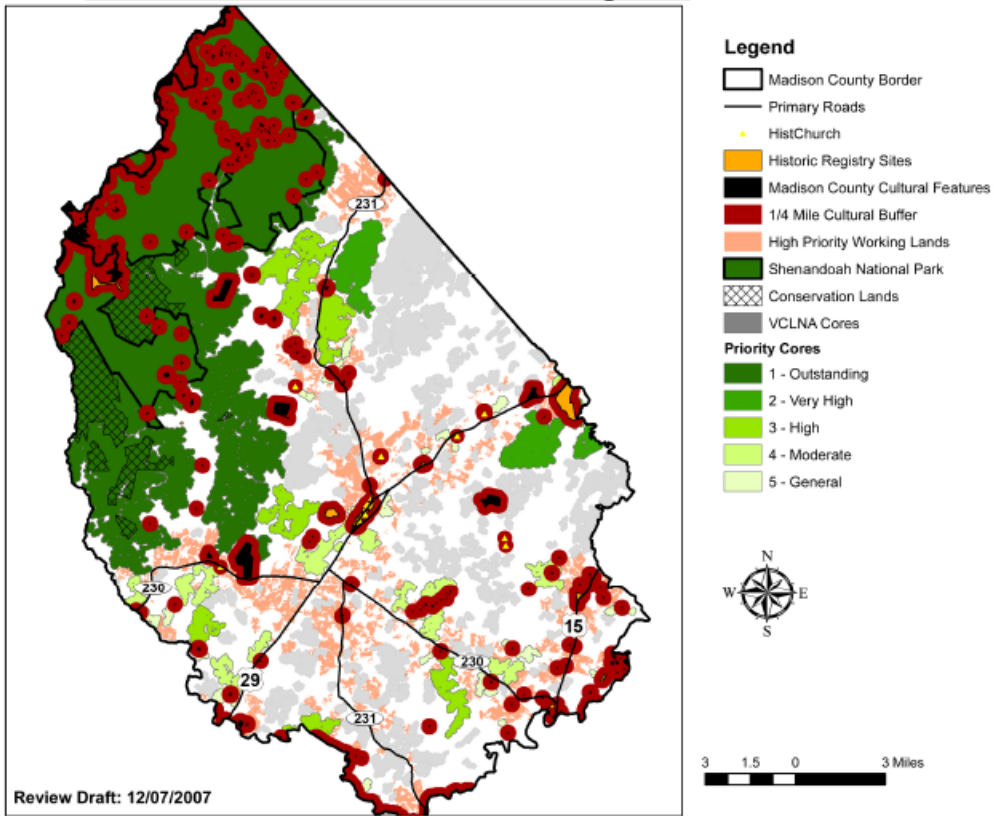
Review Draft: December 5th, 2007

Madison County Forests: Threatened Cores

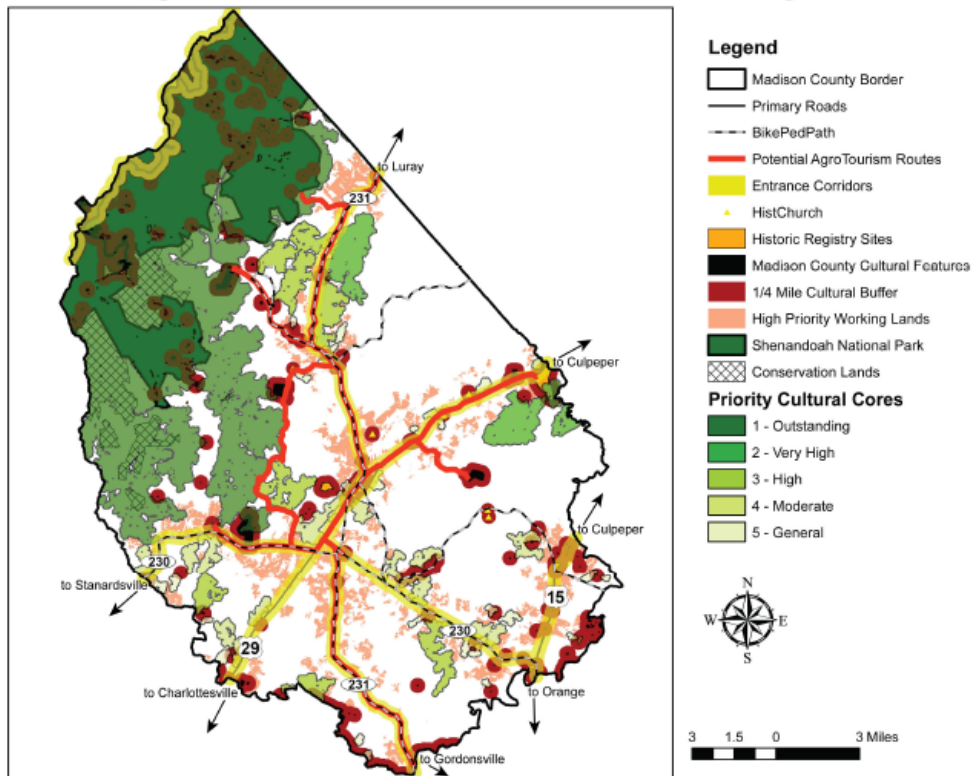


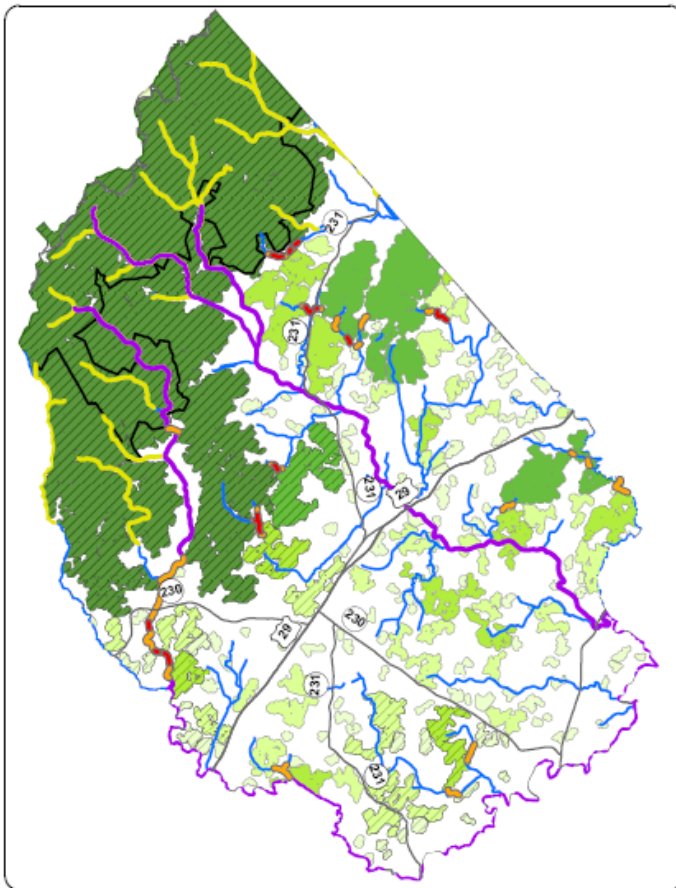
Review Draft: December 5th, 2007

Prioritized Cores Based On Cultural Significance

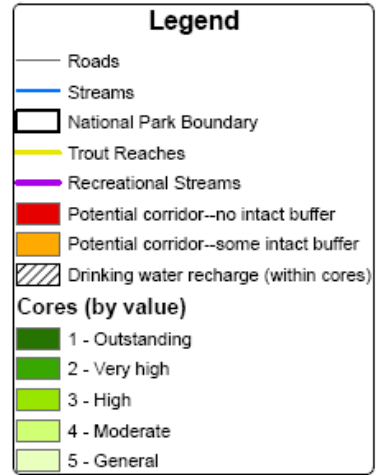


Agrotourist Routes And Entrance Corridor Strategies

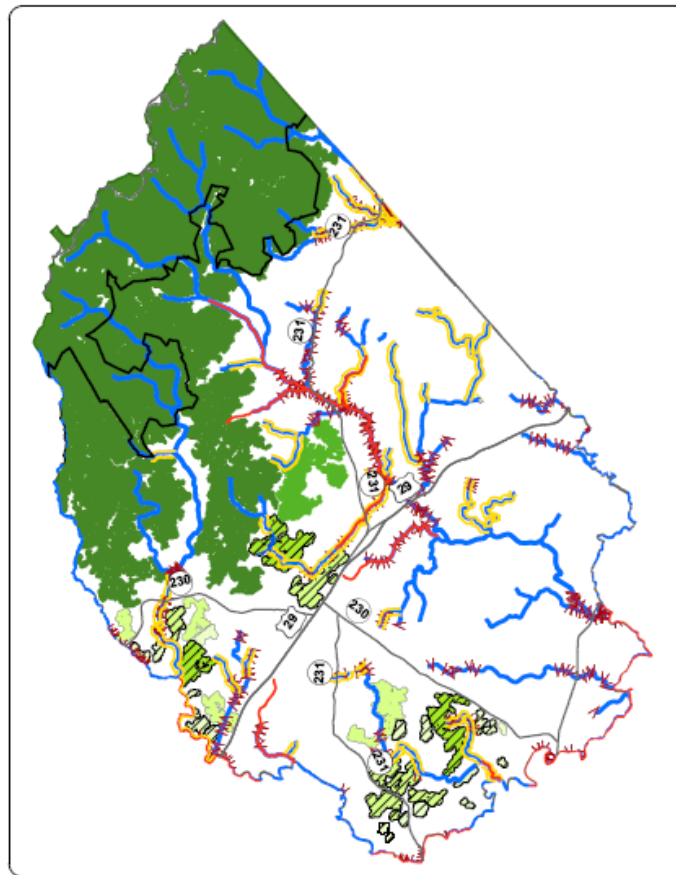




Water Resource Assets in Madison County



Review Draft: 12/5/2007

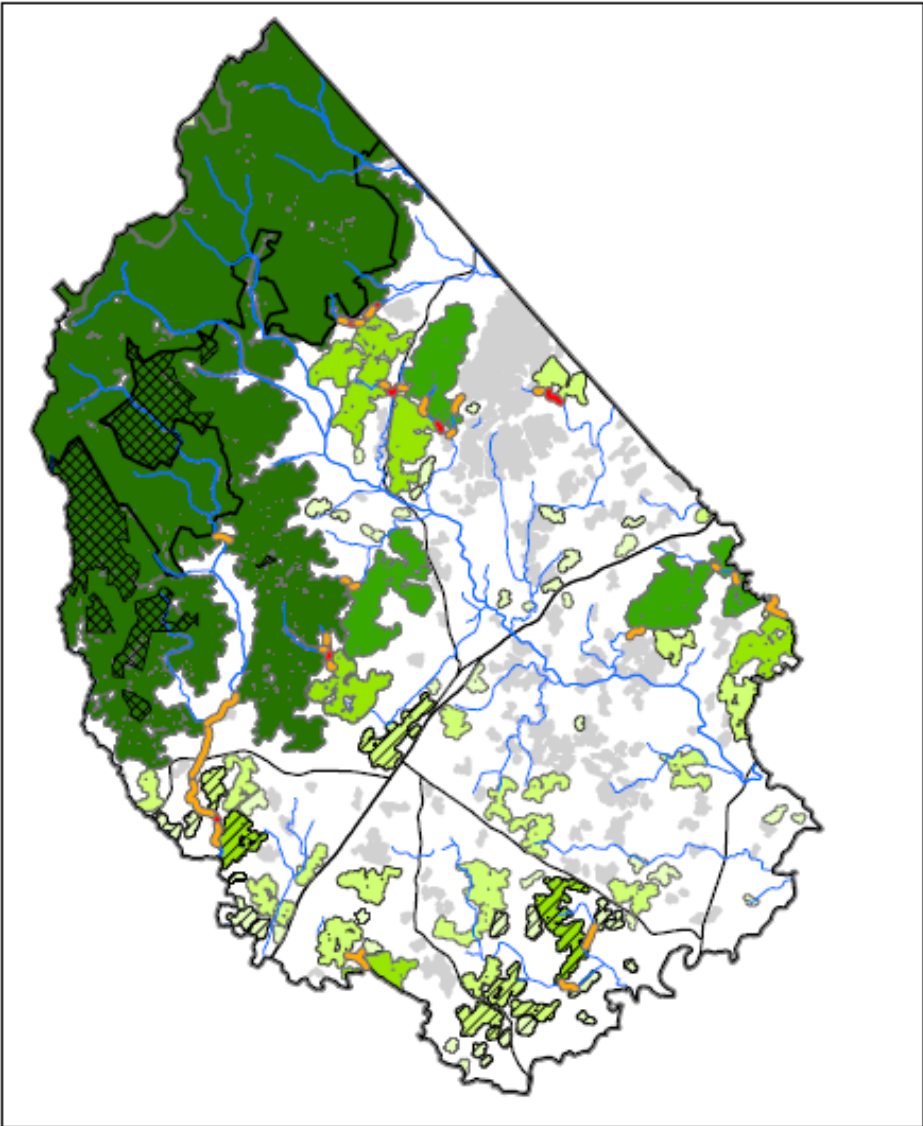


Water Resources at Risk in Madison County



Review Draft: 12/5/2007

Priority Natural Habitats in Madison County, VA



Legend

- Madison County
- Potential corridors--some intact buffer
- Potential corridors--no intact buffer
- Rapidan Wildlife Management Area
- Streams
- National park boundary
- Roads
- 50% + drinking water recharge
- Cores

Natural Habitats

- 1 - High
- 2 - Medium High
- 3 - Medium
- 4 - Medium Low
- 5 - Low



Review Draft 12/5/2007

Appendix F: Sample Final Essay Questions

This is individual work and may be incorporated into an essay or answered as individual questions. Suggested length is five pages single-spaced or 10 pages double-spaced.

Final Essay: The essay is not an exam in the sense that there are no “wrong” answers. It is a chance for your instructor to measure what you have learned and to ensure that what you learned is what was intended. This will help you organize your thoughts at the end of the semester and provide a measure of how well the concepts were picked up by each individual student. If you have done the readings and participated in class, you already know the answers. Do take the time to write clearly and concisely. You may consult your texts, but answers to questions must be in your own words (do not copy from books). The topic is provided along with sub-questions that should be covered by your essay.

Essays must be **typed** and **single-spaced** in MS word 12 point font. The appropriate length is 5 pages. However, clear and complete content is more important than length, so do not write filler simply to achieve five pages. You do not have to cover the subtopics in the order given below, but they should be covered in your essay along with other aspects that you think are important to consider. This essay counts for 10% of your grade.

Essay Topic: **What is green infrastructure planning?**

Subtopics:

- What is green (as opposed to grey) infrastructure?
- What are cores (hubs) and corridors and how are they intended to function?
- What are the main principles of green infrastructure planning?
- What are the functions (ecological, economic, and social) that could be met by a green infrastructure plan?
- Why is green infrastructure an important basis for a holistic planning paradigm?
- How do cultural, forestal and aquatic resources factor into a green infrastructure strategy?
- What types of data are needed for developing a comprehensive green infrastructure strategy?
- What are different aspects that might be emphasized for a rural versus an urban strategy?
- What are the selling points or key messages that you would use to make the case for green infrastructure planning to a state agency, a local government, a private developer or an individual landowner? Are there any cautions or caveats (things to be aware of)?
- How is a green infrastructure strategy different from (or similar to) how planning is practiced today? Ian McHarg <http://en.wikipedia.org/wiki/Ian_McHarg> wrote *Design with Nature* in 1969. Why have such ideas taken so long to become popular? Why is the idea of green infrastructure taking hold now and how might it be practiced in the future?

Methods – What to map, protect or enhance and why?

Firehock Class Notes -- Do not cite. Fall 2007

Two considerations: What to evaluate and at what scale?

One cannot monitor and map everything everywhere. So, we need to have a rational approach for what to assess and why. Connections for habitats across the landscape and compatible land uses are key considerations. First some definitions:*

Ecoregions: Large areas of the Earth's surface that have similarities in floral and faunal composition due to large scale predictable patterns of solar radiation and moisture. Virginia has three ecoregions. Classified based on climate, soils, geology, vegetation cover types (or marine). Could also divide regions by watersheds etc.

Community: interacting assemblages of species that co-occur with some degree of predictability and consistency.

Ecosystem: Interactions of these communities with the abiotic or physical environment such as through the transfer of energy and matter (Whittaker, 1975)

*Also landscapes can be *any* size!

Target approaches: Set conservation targets and then identify how to achieve them. Need to determine what to protect

- Will you take a Noah's Ark Approach – e.g. some **representation of everything?**
- Need a determined viable population – how much is needed to survive and not go extinct (**resilience**)?
- Or as much as possible, wherever possible (**redundancy**)?

(For more on representation, resilience and redundancy see Shafer and Stein, 2000).

Can set targets by species biological significance or a target species:

Significance: Either within cores or across landscape - -identify rare or endangered species such as everywhere the endangered James spiny mussel occurs (this is a target used by The Nature Conservancy) is an area that will be targeted or prioritized for conservation actions.

Or, set based on serving as an indicator of habitat quality or the presence of other species:

Occurrence: Areas where a particular species occurs indicates a certain minimum habitat quality (based on the needs of that species). This is an indicator approach. If this species is present, then habitat is of a certain quality. The presence of that species indicates the habitat is of adequate quality. For example, the Louisiana Waterthrush prefers cool, clean streams with adequate forest canopy or could find a particular bird that prefers interior forests.

Umbrella Species: One can monitor an *umbrella species* to indicate the likelihood of other species. This species is generally found in the presence of certain other species its presence indicates a likelihood that other species will be there as well.

However, the problem in using targets is that we often do not know the range of a species or its particular habitat needs.

International Union for the Conservation of Nature and Natural Resources: The IUCN monitors the state of the world's species and suggests strategies for conservation of threatened species as well as evaluating proposed reserves and conducting studies. <http://www.iucn.org/en/about/> IUCN models are supported by 181 countries.

Big Question: What is the approach for your green infrastructure strategy? Should you seek reserves (protect one or more unique or large areas) or an integrated approach that connects habitats throughout the landscape?

Spatial hierarchy for biodiversity protection (bigger is better):

- First, set values for areas.
- Can use simple algorithms set in GIS such as “buffer all streams by 100 feet” but need to set these based on established science.
- Cores (100 acres), fragments (10-99 acres), corridors (300 meters wide and not intersected by fragmenting feature, such as road or power lines).
- Rank key or critical cores based on: Rare species, unique attributes (such as wetlands) or cultural values such as historic sites, tribal lands or parks.

Physical proxies: map streams, wetlands, steep slopes, soils and related vegetation types (as surrogates for knowing species). Pressy (2000) developed landscape targets mainly from abiotic (physical) features. Some suggest that both biotic and abiotic features should be combined (Kirkpatrick and Brown, 1994).

Gap Analysis:

Gap analysis is a science-based method to identify the degree to which native animal species and natural communities are represented in our mix of conservation lands. When species and communities are not adequately represented in the existing network of conservation lands this constitutes conservation "gaps." For more on the national GAP program see <<http://gapanalysis.nbii.gov>>

- First done to evaluate reserve areas and now for planning new conservation areas.
- Difficult to use in areas that are highly fragmented (Pressy, 2000).
- Uses remote sensing and vegetation surveys to predict likely species.

Following section copied from Gap Website Gap Analysis Handbook (www.gap.uidaho.edu/handbook)

Gap Analysis consists of three main data layers, a landcover layer, a layer showing the predicted distributions of vertebrate species, and a stewardship layer.

The first step is to map land cover of the dominant plant species.

Map vegetation to the alliance level. Alliances are natural assemblages of plant species. They are used because the patterns of natural terrestrial landcover are a reflection of the physical and chemical factors that shape the environment of a given land area.

Plants are also determinate for overall biological diversity as their structures and composition significantly affects species-level interactions.

Landcover is mapped using Landsat Thematic Mapper raw and hypercluster imagery from the Eros Data Center MRLC program. MRLC is the federal consortium for obtaining, processing, and archiving satellite imagery.

Also need other local data such as maps, other conservation plans, air photos; air video; and ground points.

Corridor Example from Gap website: How can potential connectors between protected areas be identified?

Use Gap Analysis vertebrate data to build habitat suitability models for desired species and combine this information with road density information to determine the routes that offer the best chance of success for wildlife moving across the area.

The Example: Using GAP Data to Analyze Wildlife Movement Corridors

Researchers with the Craighead Environmental Research Institute used Montana GAP vertebrate data to determine the best routes for grizzly bear, elk and cougar, moving across the core protected areas of the Northern Rockies -- the Salmon-Selway, Northern Continental Divide, and Greater Yellowstone Ecosystems (Walker, 1997).

Potential movement corridors were analyzed to find those with habitat most suitable for a wide variety of species. Three coverages were developed: a coverage of habitat quality, a coverage of the length of the forest and grass/shrubland interface, and road density.

These coverages were combined to create kilometer-scale cost surfaces of movement. From this data, corridors with probable routes were identified, along with critical barriers, bottlenecks, and other high risk habitat. The analysis helped to identify high priority conservation areas for wildlife that could improve the connectivity between protected areas.

To best model regional scale corridor routes the following assumptions were made:

- 1) Good corridors are comprised primarily of preferred habitat types
- 2) Humans pose problems for successful transit--their residences attract animals that become habituated to easy access to food; and also displace animals from important habitat.

3) Current human developments are permanent. They did not analyze routes that would involve closing roads or altering land management practices.

4) The least-cost path, based upon the previous assumptions, offers an animal the greatest probability of survival in traversing the entire distance.

Least-cost travel grids were generated for each combination of the three species and three core protected areas.

A biologically defensible assessment of probable corridor routes was generated.

(end of above gap web site text)

Use a Threats and Opportunity Approach: by proximity to human development or needs (can use in concert with GAP for greater effect). For example, is the area:

- 1) Close to water supply area, so need protection of surrounding land?
- 2) Likely to develop so need to preserve corridors (e.g. may be less ecologically unique but under greater threat)?
- 3) Used or desired for recreation (need to assess compatibility with wildlife, soils, plants and inter-user conflicts)?
- 4) Possessing the potential for restoration (brownfield) or reconnection (isolated area)?
- 5) Of local importance or cultural importance as identified by the community (historic landscape)?

Class Discussion Questions: What would we map and measure?

- How do principles of conservation biology and landscape ecology relate to planning?
- Are some elements more important than others and should we assign to them a higher ranking? For example, if one forested core also served as the town's water recharge area, would we assign that forest greater priority than one that does not?
- For Virginia, can we augment or enrich the existing data set? For example, i.d. new threats, ground truth corridors? Collect or map better and more spatially refined data?
- When does it make sense to engage in species tracking and mapping?
- How do we use decision support software to generate build out scenarios and suggestions for the future?

Appendix H: Green Infrastructure Resources and Publications

Green Infrastructure Planning – Summary Resource List

Adams, Jonathan S. *The Future of the Wild: Radical Conservation for a Crowded World*. Beacon Press: Boston, 2006.

Benedict, Mark A. and McMahon, Edward T. *Green Infrastructure: Linking Landscapes and Communities*. Island Press: Washington, D.C., 2006.

Benedict, Mark A. and McMahon. *Green Infrastructure: Smart Conservation for the 21st Century*. Washington, D.C., Sprawl Watch Clearing House, May 2002.
Online at www.conservationfund.org/pdf/greeninfrastructure.pdf

Dale, Virginia H. “Ecological Principles and Guidelines for Managing the Use of Land” *Ecological Applications*: Vol. 10, No. 3, pp. 639–670.

Dale, V.H. and Haeuber, R.A. (editors). *Applying Ecological Principles to Land Management*. Springer-Verlag: New York, 2001.

Dale, V.H. and English, M.R. (editors). *Tools to Aid Environmental Decision Making*. Springer-Verlag: New York, 1999.

Dramstad, Wenche E., et al. *Landscape Ecology Principles in Landscape Architecture and Land Use Planning*. Island Press: Washington D.C., 1996.

Duerksen, Christopher and Snyder, Cara. *Nature Friendly Communities, Habitat Protection, and Land Use Planning*. Island Press: Washington, D.C., 2005.

Hellmund, Paul Cawood, Smith, Daniel Somers. *Designing Greenways: Sustainable Landscapes for Nature and People*. Island Press: Washington, D.C. , 2006

Ian McHarg, Ian. *Design with Nature*. Falcon Press, 1969.

Johnson, Bart and Hill, Kristina (editors). *Ecology and Design*. Washington D.C.: Island Press, 2001.

The Nature Conservancy. *Precious Heritage: The Status of Biodiversity in the United States*. The Nature Conservancy: Washington, D.C., 2000.

How Much is an Ecosystem Worth? Assessing the Economic Value of Conservation. The World Conservation Union, the Nature Conservancy and The International Bank for Reconstruction and Development/The World Bank. The Nature Conservancy: Washington, D.C., 2000.
http://www.biodiversityeconomics.org/applications/library_documents/lib_document.rm?document_id=710

An Analytic Framework for Assessing Factors that Influence Sustainability of Uses of Wild Living Natural Resources. The World Conservation Union
http://www.iucn.org/themes/ssc/susg/docs/analytic_framework_nov01.PDF

Building Green Infrastructure: Land Conservation as a Watershed Protection Strategy. Trust for Public Land: San Francisco, 2000.

The State of the Chesapeake's Forests, The Conservation Fund, Arlington, Virginia

Land and Water Planning

Environmental Law Institute. *Planning for Biodiversity: Authorities in State Land Use Laws*. Washington, D.C.: Environmental Law Institute, 2003.

McElfish, James M. *Nature Friendly Ordinances*. Washington, D.C.: Environmental Law Institute, 2004.

Nolon, John. *Open Ground: Effective Local Strategies for Protecting Natural Resources*. Environmental Law Institute: Washington, D.C., 2003.

Nolon, John. *New Ground: The Advent of Local Environmental Law*. Environmental Law Institute: Washington, D.C. 2003.

Riley, Ann L. *Restoring Streams in Cities*. Washington D.C., Island Press, 2001.

Randolph, John, *Environmental Land Use Planning and Management*, Island Press: Washington, DC, 2003. (useful class textbook for environmental land planning)

Online Resources

DATA and SOFTWARE:

Source for statistics on Southern Forests: www.srs.fs.usda.gov

Trust for Public Lands Building Green Infrastructure Report:
www.tpl.org/tier3_cdl.cfm?content_item_id=915&folder_id=745

National Biological Information Infrastructure: www.nbio.gov/datainfo

National Wetlands Inventory: <http://www.fws.gov/nwi/>

CITYGreen available from American Forests: A GIS spatial mapping tool that helps calculate the pollution reduction benefits of expanding urban tree canopy as well as storm water and pollution abatement savings for individual sites. <http://www.americanforests.org/productsandpubs/citygreen/>

GREEN INFRASTRUCTURE EXAMPLES AND CASE STUDIES:

Albemarle County, VA Biodiversity Plan (2004):

www.albemarle.org/upload/images/Forms_Center/Departments/Board_of_Supervisors/Forms/Agenda/2004Files/20041201/Biodiversityworkgroup.htm

Canadian U.S. Bioregion Plan: www.2c1forest.org

Charlottesville, Virginia Comprehensive Plan: Chapter 8 Environment -- green infrastructure strategies
<http://www.charlottesville.org/Index.aspx?page=1745> (Click on Chapter Eight: Environment)

The Conservation Fund Green Infrastructure Network: (see on-line case list)
www.greeninfrastructure.net/what_we_do

Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects. U.S. Department of Transportation: http://www.environment.fhwa.dot.gov/ecological/eco_index.asp

Florida Ecological Network Program (1995):
www.geoplan.ufl.edu/projects/greenways/greenwayindex.html

Greenprint for King County, WA (March 2005): dnr.metrokc.gov/wlr/greenprint
Maryland GreenPrint Program (2001): www.dnr.state.md.us/greenways/greenprint

Hampton Roads Conservation Corridor Study, May 2006:
www.hrpdc.org/newpep/HRCCS/HRCCS_web.pdf

Kinston/Lenoir County, NC Green Infrastructure Plan (2002): www.greeninfrastructure.net/kinston-lenoir_county_profile

Mountains to Sound Project (Puget Sound, WA, 2005): www.mtsgreenway.org/about/index.html

Massachusetts Biomap Project (2001): www.mass.gov/dfwele/dfw/nhesp/nhbiomap.htm

Metro Greenprint Project (Twin Cities, MN, 1997): www.dnr.state.mn.us/greenways/index.html

Natural Connections, Green Infrastructure in Wisconsin, Illinois, and Indiana (2000):
www.greenmapping.org

Pima County Multi-Species Restoration Plan (Pima County, AZ, 2006)
www.co.pima.az.us/cmo/sdcp

Prince Georges County, MD Countywide Green Infrastructure Plan (2005):
www.mncppc.org/county/greeninfrastructure.htm

Saginaw Greenways Initiative Report (Saginaw Bay, MI, 2000):
www.msu.edu/~jaroszjo/greenway/main.htm

Virginia-Specific

Albemarle County Biodiversity Work Group. *Albemarle County Biodiversity: A Report on its History, Current Conditions, and Threats, with Strategies for Future Protection*. Albemarle County, VA, Albemarle County, 2004. Online at:

www.albemarle.org/upload/images/Forms_Center/Departments/Board_of_Supervisors/Forms/Agenda/2004Files/20041201/Biodiversityreportattachb.pdf

Benedict, Mark A., Allen, Will, and McMahon, Edward T. *Advancing Strategic Conservation in the Commonwealth of Virginia: Using a Green Infrastructure Approach to Conserving and Managing the Commonwealth's Natural Areas, Working Landscapes, Open Space, and Other Critical Resources*. Washington, D.C., The Conservation Fund, 2004. online at:

www.greeninfrastructure.net/pdf/advancingsc_fullreport_2004-08.pdf

Comprehensive Planning in VA <<http://leg1.state.va.us/000/1st/LS003202.HTM>>

Conservation lands database: www.state.va.us/dcr/dnh/conslandindex.htm

Virginia Conservation Lands Needs Assessment: www.dcr.virginia.gov/natural_heritage/vclna.shtml

Virginia Natural Heritage Program: National heritage resources database

www.state.va.us/dcr/dnh/nhrinfo.htm