FINAL REPORT
SOUTHEASTERN ECOLOGICAL FRAMEWORK

Submitted to the
Planning and Analysis Branch
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Executive Summary

The southeastern United States still harbors globally significant biodiversity and other important natural resources despite decades of habitat loss and ecosystem alterations. The Southeast is also the fastest growing region in the United States. The trend appears to be driven by climate, economic stability, cultural attractions and the natural environment. This growth will continue to deplete and degrade the critical ecological resources that remain, and it is imperative that comprehensive efforts to efficiently and effectively protect these resources are developed rapidly. This report represents exploration of a regional conservation strategy needed to conserve the integrity of ecological systems essential for human well-being.

The Southeastern Ecological Framework (SEF) is a decision support tool created through systematic landscape analysis of ecological significance and the identification of critical landscape linkages in a way that can be replicated, enhanced with new data, and applied at different scales. It is intended to provide a foundation for the adoption and implementation of effective and efficient conservation measures to minimize environmental degradation and protect important ecosystem services. It has been developed for all eight southeastern states contained within the boundaries of the Environmental Protection Agency Region 4: Florida, Georgia, South Carolina, North Carolina, Alabama, Mississippi, Tennessee and Kentucky by staff of the Planning and Analysis Branch of EPA Region 4 and researchers at the University of Florida. Work on the project began in October 1998 and was completed in December 2001.

The Framework was derived using Geographic Information Systems (GIS), a computer mapping technology that links maps and related information. Data on which the work was built were acquired for the entire region and from individual states within the region. Data availability and consistency is improving rapidly, but is currently somewhat limited for projects of this scale. The land area identified in the Framework represents 43 percent of the land in the eight states. Of that 43 percent, 22 percent is in existing conservation lands, 12 percent in open water (rivers, lakes and reservoirs), 14 percent is in wetlands outside existing conservation lands and 52 percent is in privately held uplands (that include 100 year floodplains).

When the SEF was completed, three applications of it were developed to demonstrate its conservation usefulness at different scales. The first was a region-wide application: prioritization of the SEF to identify the most significant conservation priorities for the region. The second was analysis of the Mississippi Delta with the goal of developing a planning resource to highlight ecological priorities for a variety of natural resource programs, both federal and non-federal. The final application was at the local scale: the development of a conservation plan for Murray County, Georgia that included analysis of the usefulness of the SEF for local conservation purposes.

This report includes some valuable tools for use by others: Guide to Resources for Regional Conservation Planning (Section IX), a listing of critical resources used in the development of this report and of value to anyone engaged in a similar endeavor; a Data Library (Section X) compiled on three compact disks that include input data, data analyses and results for the original SEF delineation and the three applications; and a listing of Conservation Tools and Strategies that can be employed in land conservation including both regulatory, incentive-based and voluntary strategies (Appendix H).

While the work undertaken was supported by Region 4 of the U.S. Environmental Protection Agency, the products developed have potential value for other federal agencies, state and local agencies and for non-governmental organizations. It is the sincere hope of all involved, that the process and work products can be creatively employed to enhance effective conservation efforts in the southeastern United States and elsewhere.

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The collaborative opportunity was created and approved by former EPA Region 4 Administrator, John Hankinson. John recognized the need for EPA to think beyond its immediate charge and to consider ways in which federal agencies might collaborate to enhance their performance. This effort was but one example of his commitment to conservation and the goals of efficiency and innovation.

Finally, we continue to acknowledge the contribution made by Dr. Larry Harris. Dr. Harris of the University of Florida has played an ongoing and instrumental role in describing the ecological basis for ecological networks and highlighting specific project sites in Florida where protected ecological linkages would compound the benefit and long-term viability of existing conservation lands. Dr. Harris' lead scientific role in promoting landscape linkages and integrated habitat systems in Florida and worldwide can be traced back to his pioneering book, The Fragmented Forest: Island Biogeography Theory and the Preservation of Biotic Diversity, which was published in 1984. Dr. Harris presented his thoughts on a statewide strategy for wildlife conservation in the November 1985 issue of ENFO, a periodic publication of the Florida Conservation Foundation. In his article, "Conservation Corridors - A Highway System for Wildlife", Dr. Harris not only provided the scientific rationale for conservation corridors as part of an integrated habitat system, but he also presented specific steps he considered essential to a statewide wildlife conservation strategy. Since that time, Dr. Harris and his students have continued to provide scientific support for and technical assistance in the planning of integrated conservation systems in Florida and elsewhere. Most recently, Dr. Harris' knowledge and participation on the Florida Greenways Commission provided the ecological foundation for Florida's Statewide Greenways System.

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Section I: Southeastern Ecological Framework Project: Principles & Introduction

A. INTRODUCTION

The Southeastern Ecological Framework (SEF) is a decision support tool created through systematic landscape analysis of ecological significance and the identification of critical landscape linkages in a way that can be replicated, enhanced with new data, and applied at different scales. It is intended to provide a foundation for the adoption and implementation of effective and efficient conservation measures to minimize environmental degradation and protect important ecosystem services. It has been developed for all eight southeastern states contained within the boundaries of the Environmental Protection Agency Region 4: Florida, Georgia, South Carolina, North Carolina, Alabama, Mississippi, Tennessee and Kentucky by staff of the Planning and Analysis Branch of EPA Region 4 and researchers at the University of Florida. Work on the project began in October 1998 and was completed in December 2001.

The states within EPA Region 4 incorporate significant ecoregional diversity ranging from the coastal plain, piedmont, parts of the Mississippi Delta, the southern Appalachian Mountains, and the interior plateaus of Tennessee and Kentucky. These different ecoregions are also ecologically connected in a variety of ways, including obvious watershed relationships where the headwaters in the Appalachians become rivers that run to either the Atlantic or Gulf of Mexico. Many of these riparian ecosystems, especially in the western half of Region 4, harbor aquatic biodiversity of international significance (Chaplin et al. 2000). Historically, wide-ranging species including the Florida panther/eastern cougar, black bear, red wolf, bison, and even elk occurred throughout all or significant portions of the region. Forest biodiversity was historically important, with vast old growth forests once ranging from the longleaf pine forests and forested swamps of the southeastern coastal plain to the spruce-fir forests on the tops of the Appalachians, and remaining and regenerated forests in the southeast still harbor significant biodiversity (Echternacht and Harris 1993). Florida contains other unique landscapes and natural communities including ancient scrub and the Everglades that harbor extremely significant components of the region's biodiversity (Harris et al. 2001). In a resent assessment of biodiversity in the United States (Chaplin et al. 2000), EPA Region 4 was identified as containing two of the five most significant biodiversity hotspots in the country: the Southern Appalachians and the Florida panhandle.

Over the past 300 years there have been many significant landscape and ecosystem alterations. Silvicultural activities and clearing for agriculture have removed essentially all of the old-growth forest characteristics (Davis 1996) and millions of acres of forest cover. Most wide-ranging species are completely gone or severely reduced through a combination of historic over-harvest, persecution, and habitat loss and fragmentation. Conversions of natural forest ecosystems to plantation forestry are ongoing. Dams and channelization have significantly altered most riverine ecosystems. And ever-increasingly, the conversion of lands to intensive suburban and urban uses has resulted in even greater habitat fragmentation, water resource impacts, and the degradation of ecological integrity.

The cumulative effect of all of these alterations is that many ecosystem types remaining in the southeast currently occupy less than 50% of their historic areas and some have less than 5%. Longleaf pine forests once occupied 90 million acres throughout the South; now they are reduced to less than 3 million acres (SENRLG 2001). Seventy-eight percent of the pre-settlement bottomland hardwoods and twenty-eight percent of pre-settlement wetlands have been lost as of 1986 (Hefner 1994). One result of these losses has been a steady erosion of the region's biodiversity. Based on the extent of decline, current rarity, number of Threatened and Endangered species, and level and urgency of threats, Noss and Peters (1996) identified ten states nationwide with the highest risk of biotic impoverishment and six of these states are found within EPA Region 4: Florida, Georgia, North Carolina, South Carolina, Alabama, and Tennessee.

Increasing urbanization in the southeastern United States also is straining the ability of natural and semi-natural ecosystems to provide critical ecosystem services. Ecosystem or ecological services can be defined as the processes through which natural ecosystems sustain and fulfill human communities (Daily 1997). Intact ecosystems remaining in the southeast are under increasing pressure to provide ecological services such as water quality maintenance and enhancement, drinking water, storm water management, flood control, particulate matter removal and carbon sequestration, as well as food and shelter for native species (Noss 1996; Costanza 1997; Daily 1997; Daily 2000). The protection of functional landscapes that provide the full variety of ecological services to maintain healthy, sustainable economies, quality of life, and biodiversity are integral to the Environmental Protection Agency's mission 'to protect human health and to safeguard the natural environment – air, water, and land – upon which life depends'. These issues are consistent with the concept of "green infrastructure", which can be defined as the natural support system that maintains native species and natural ecological services, sustains air and water resources and contributes to the health and quality of life for human communities (Benedict 2000).

Resources, both natural and economic, are becoming more limited. For EPA to be effective in its mission, it is imperative to assign priorities that optimize both natural and economic resources. The effective protection of natural resources and environmental quality will be dependent on analysis and planning efforts at a variety of scales. This includes critical efforts to involve people in conservation efforts at the local level. However, effective conservation also requires analysis and planning at large scales in order to understand functional relationships between regions and landscapes and to integrate efforts. Landscape ecology, which focuses on the functional relationships between ecosystems, various land uses and spatial ecological processes has become an increasingly important discipline for natural resource conservation (Forman 1995). One of the primary lessons of landscape ecology is that context matters. Natural resource conservation and land use planning must consider the effects of actions within their largest spatial and temporal perspectives (Forman 1987). Within both landscape ecology and conservation biology, habitat fragmentation is considered to be a primary threat to biodiversity and functional ecological processes and services. Addressing habitat fragmentation must therefore be a top priority for resource agencies. Strategies are needed that help to protect and restore natural levels of spatial and temporal heterogeneity that are necessary for maintaining intact ecosystems and biodiversity while minimizing the effects of fragmentation (Harris et al. 1996a).

The identification of linked regional networks of lands critical for conserving natural resources is a key strategy for applying landscape ecology principles in planning efforts to avoid and minimize the degradation of ecological integrity caused by habitat fragmentation. By identifying a large scale, regional conservation framework, it is possible to provide a foundation in which protection of the important ecological properties and processes can be optimized for multiple benefits at local and regional scales (Noss 1996). Trends in regional conservation during the past 5 years have moved toward regional approaches to natural resource protection in an attempt to address issues of scale and complexity. Many organizations such as the World Wildlife Fund, The Nature Conservancy, and the Trust for Public Land are attempting to develop geographical information system tools for identifying hot spots, priority areas, or the last great remaining places to better facilitate effective conservation.

The Southeastern Ecological Framework represents a similar strategy to identify areas of natural resource conservation significance, or green infrastructure, at a regional scale. The Southeastern Ecological Framework is a first iteration of a region-wide assessment of areas critical for conserving natural resources including important ecological services and biodiversity that will help promote the need for regional conservation assessments and planning and will continue to be improved as more data and assessment techniques are developed in the near future.

B. BACKGROUND PRINCIPLES & CONCEPTS USED IN THE SEF PROJECT

a. Conservation Biology

Conservation biology is a relatively new science that began in the 1970s and was formally recognized as a discipline through books edited by Michael Soulé et al (1980; 1986; 1987) and the emergence of the journal Conservation Biology in 1987. In the comprehensive textbook *Principles of Conservation Biology* written by Meffe, Carroll and Contributors (1997), conservation biology is defined as “a new, synthetic field that applies the principles of ecology, biogeography, population genetics, economics, sociology, anthropology, philosophy, and other theoretically based disciplines to the maintenance of biological diversity throughout the world”. The uniqueness and importance of conservation biology can be attributed to three factors, 1) the breakdown of the barriers between “pure” and “applied” research, 2) a shift in orientation towards stewardship and concern for biodiversity and natural ecosystems rather than sustained yield of a few species, and 3) full recognition that contributions from nonbiologists will be required to conserve the earth’s biological diversity. The primary goal of conservation biology is “to understand natural ecological systems well enough to maintain their diversity in the face of an exploding human population” (Meffe and Carroll 1997). Development of the Southeastern Ecological Framework and its predecessor, the Florida Ecological Network (FEN), are attempts at strategic public policy focused on addressing this primary goal of conservation biology.

Principles of conservation biology underpin the assumptions made in the FEN and SEF models. Among the most important of these are the following:

1. In order to preserve biodiversity,
    a. ecological processes must be maintained,
    b. external threats minimized and external benefits maximized, and
    c. evolutionary processes must be conserved.
2. Biodiversity has both intrinsic value and instrumental value to human beings.
3. Both biocentric and anthropocentric world views justify efforts to conserve biological diversity and ecological function.
4. Biodiversity can be measured at many scales from genetic diversity to ecosystem and biome diversity. Protection for all is essential.
5. Among the most serious threats to biodiversity are habitat loss, habitat fragmentation and

habitat alteration.

6. Additional threats to biodiversity include introduced species, overexploitation, pollution and toxification (Meffe and Carroll 1997).

b. Landscape Ecology

Another relatively new science formed a second foundation for the development of the FEN and the SEF: landscape ecology, which emphasizes broad spatial scales and the interactions between spatial patterns and ecological processes (Forman 1995). Landscape ecology has become increasingly important in regional planning and conservation because it focuses on the relationships and interactions of different ecosystems and landuses, and empirical data and principles derived from landscape ecology research can be used to make better regional and land use planning decisions. Richard Forman and others have provided theoretical discussions and basic principles that are reflected in the FEN and SEF processes and results. Two specific recommendations from Forman that have been incorporated are described below.

"The ethics of isolation: In land-use decisions and actions it is unethical to evaluate an area in isolation from its surroundings, or from its development over time." (Forman 1987; Forman 1995)

This concept was paramount in the development of the FEN and the SEF: one must look beyond the boundaries of existing conservation areas to understand the context in which they occur. In order to protect the ecological integrity of these lands, the potential for maintaining or improving their ecological context must be explored. This is precisely what the FEN and the SEF attempt to do.

If this principle is completely adhered to, it does, however, pose a challenge. It requires that any given area being studied should include a review or analysis of the next larger context. In other words, to understand Florida, one must also understand the southeastern United States and Florida's marine context; to understand the southeastern United States, one must understand the eastern seaboard and Mississippi Valley systems, etc. When completing the FEN, we did a modest amount of analysis beyond the boundaries of Florida, e.g., to identify existing conservation lands to the north and west. When completing the SEF, this larger context was not addressed. Therefore the findings of the SEF are less reliable at the edges of the study area than they are at its core. It is only fair to acknowledge this limitation of the work, and one of the next steps should be to work across region boundaries to integrate the SEF with conservation planning efforts in adjacent regions.

"Four indispensable components in the landscape are: A few large patches of natural vegetation, wide vegetation corridors along major water courses, connectivity for movement of key species among the large patches and heterogeneous bits of nature throughout human developed areas." (Forman 1995)

Again Forman provided clear direction for planners concerned about ecological integrity at the landscape scale. The approach followed in the FEN and SEF clearly addressed three of these four landscape components: large patches of natural vegetation, wide vegetation corridors along major water courses and connectivity for movement of key species. These models did not address "heterogeneous bits of nature throughout human developed areas" because they are necessarily relatively small and lack connectivity. To develop a complete conservation plan, at any scale, it would be essential to add in this last component. However, the principles of landscape ecology are relevant to conservation planning at a variety of scales and can lead to more comprehensive and integrated natural resource protection strategies. Such an approach can be termed a regional landscape approach to conservation where the importance of interactions between the built environment, rural lands, and native ecosystems is recognized and planning and management are conducted at appropriately large spatial and temporal scales so that land uses are effectively integrated to maximize compatibility and ensure the conservation of natural resources.

c. Conservation Planning Concepts

Conservation in the United States has evolved slowly, but progressively since its origins in the middle of the nineteenth century. Important benchmarks prior to 1965 include the following:

1830s	Hot Springs Arkansas National Reservation established
1860s	Yosemite Valley granted protection by the State of California
1872	Yellowstone National Park set aside "is hereby reserved and withdrawn from settlement, occupancy, or sale... and set apart as a public park or pleasuring ground for the benefit and enjoyment of the people."
1885	Adirondacks Forest Preserve established by the State of New York
1890	Sierra National Parks established - Yosemite (previously a State Park), Sequoia, General Grant (now in Sequoia) & Petrified Forest
1891	Forest Reserves established on Public Domain (Harrison/Roosevelt)
1897	Forest Management Act passed by Congress - utilitarian purposes including grazing
1903	1st National Wildlife Sanctuary established in Florida
1906	Antiquities Act passed by Congress to provide archaeological site protection
1916	Twenty national monuments set aside under Antiquities Act
1916	National Parks Act passed by Congress - "use without impairment"
1964	Wilderness Act passed by Congress - "untrammeled by man, where man himself is a visitor"

Beginning with the efforts to pass the Wilderness Act and continuing to this day, conservation goals have shifted from the setting aside of “pleasuring grounds” and productive forest lands to the goals of protecting biological diversity and the supply of other ecological services provided to humans by healthy, functioning ecosystems, like clean water and clean air. This shift in emphasis was supported by the development of the science of landscape ecology that allowed for the study of spatially large and complex systems over time previously described.

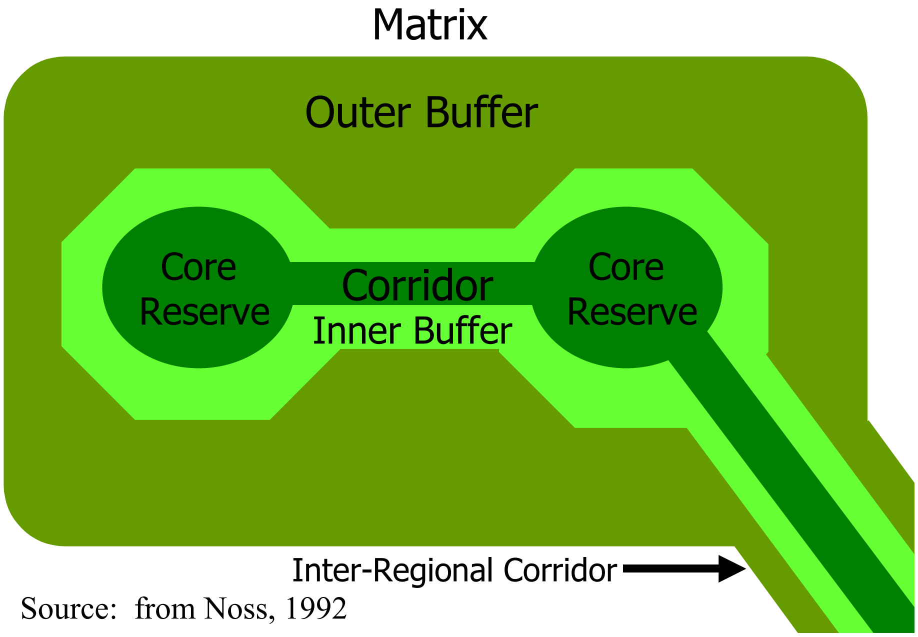
There are five specific conservation strategies important to mention as they directly lead to or are roughly equivalent to the integrated landscape approach embodied by the identification of the SEF. These are the Endangered Species Act, Gap Analysis, Reserve Design, Florida Statewide Greenways Network and Green Infrastructure Planning.

The earliest of these, the **Endangered Species Act**, first adopted by Congress in 1969 and strengthened significantly in 1973, focuses on the protection of habitat to support species identified as "endangered", i.e., under clear threat of extinction. The Endangered Species Act also provided an important transition in thinking by recognizing the need to conserve entire ecosystems, with the goal "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" (Noss et al. 1997). One result was the identification of habitats necessary to support sustainable populations of species, regardless of the scenic, recreational or other anthropocentric uses of the identified lands and waters. The notion that national parks are often not sufficient to protect many species has a long history (Wright et al. 1933; Wright and Thompson 1934; Shelford 1936; Cahalane 1948), but it has gained increasing attention since the passage of the endangered species act and the growth of conservation biology (Harris 1984; Newmark 1985; Newmark 1987; Newmark 1995; Harris et al. 1996b). Such studies began to reveal that large public holdings, for example the Greater Yellowstone Ecosystem, were not sufficient to protect some species considered essential for ecosystem integrity (Keiter and Boyce 1991).

Following this development came a systematic analysis of habitat distribution and biodiversity hotspots called **Gap Analysis** in the late 1980s. Developed by Scott et al (1993), the approach required the delineation of habitat types and a comparison of those distributions with lands under protective status on a state by state basis. The result was the identification of the "gaps" in protection, i.e., those habitat types (and therefore their associated plant and animal species) that were underrepresented in each state's system of parks and preserves. When first completed for the state of Idaho, it revealed that mountain habitats were relatively well represented, but not surprisingly, the habitat types found on lands most appealing for human settlement were poorly represented. Application of the technique has continued for many states across the nation and should be largely completed in the next few years. The Gap Analysis strategy contributed three major elements to subsequent conservation efforts: 1) maps of habitat distribution for large areas, 2) a system of analysis that was clear and could be replicated or modified through the adoption of different assumptions and 3) a strategic product that gave clear direction for future conservation efforts, i.e., if one wants to see all species originally occurring within a geographic area preserved, then these are the areas where conservation actions must be taken.

Reserve Design, which is the science and art of delineating networks of protected areas that will effectively conserve biodiversity, has developed since the 1970s through a variety of separate and collaborative efforts. Principle figures in the development of reserve design include Larry Harris, Reed Noss and Michael Soulé and others. Started in the discussions regarding the applicability of the theory of island biogeography described by MacArthur and Wilson (1967) and enhanced by the development of conservation biology and landscape ecology, Harris, Noss and Soulé developed the concept of integrated networks of protected areas that would function together to protect functional ecological systems rather than the traditional strategy of spatially isolated areas (Noss 1983; Harris 1984; Noss and Harris 1986; Noss 1987a; Noss and Cooperrider 1994; Harris et al. 1996b; Soulé and Terborgh 1999). The idea is well-represented by the simple conceptual diagram developed by Noss (1992) (Fig 1).

Figure I-1. Model Ecological Reserve Network.

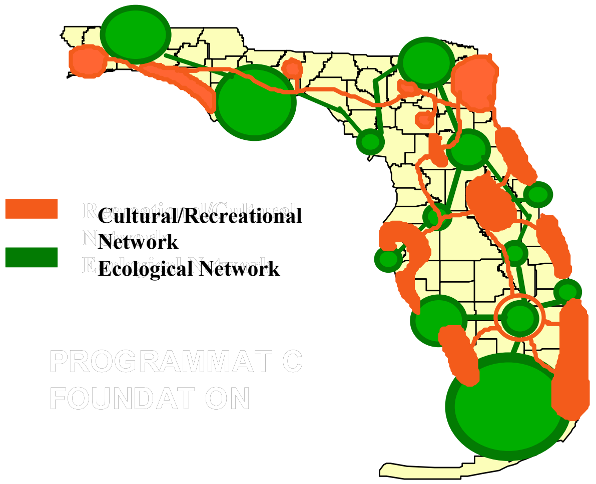


Source: from Noss, 1992

The major contribution of these thinkers is their emphasis on protecting large, functionally connected landscapes that are more likely to protect viable populations of native species, functional ecological processes, and evolutionary forces. Contrasting with Gap Analysis that simply identified the underprotected habitat types, reserve design emphasizes the incorporation of key habitats and biodiversity hotspots into viable ecological units that will sustain biodiversity over time. Connectivity is especially important to support migratory patterns of species, to provide enough space to species requiring large areas to support viable populations, and to support spatial ecological processes that require intact landscapes. In the southeastern United States, the two processes that best embody the need for connectivity are fire, that largely defines the distribution of upland pine habitats; and flooding, that defines the distribution of floodplain species and cuts through the three major physiographic regions of the southeast, the mountains, piedmont and coastal plain. If these systems are interrupted through fragmentation and other impacts, their health and integrity will be compromised (Harris et al. 1996a).

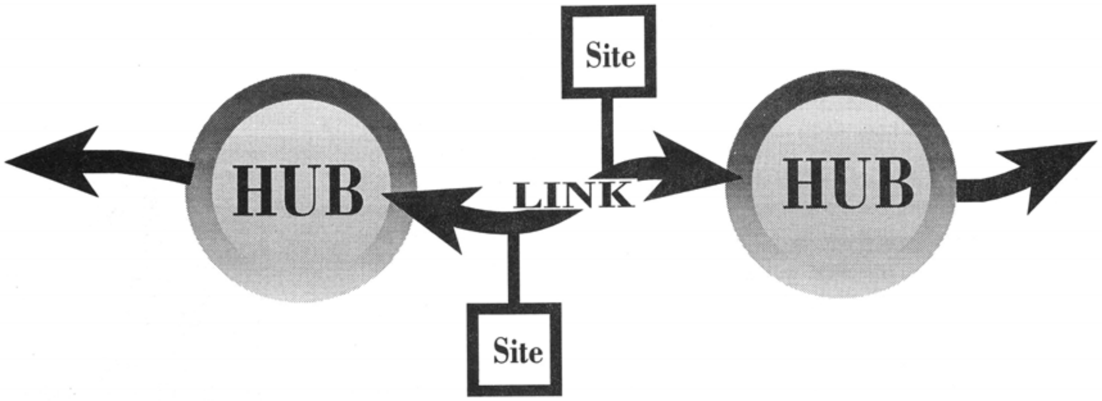
In Florida the application of reserve design principles has been forwarded since the 1980s as a means to effectively conserve biological diversity in the face of rapid human population growth and habitat fragmentation (Harris 1984; Harris 1985; Noss and Harris 1986; Noss 1987a; Harris and Gallagher 1989; Harris and Atkins 1991; Harris and Scheck 1991). In 1991, with financial support from The Conservation Fund and 1000 Friends of Florida, an effort began to determine the usefulness of establishing a **Florida Statewide Greenways Network**. Governor Lawton Chiles appointed a Commission to make this determination and under the leadership of executive director Mark Benedict, a report went to the Governor in December 1994 stating that indeed, a statewide greenways system would benefit the people of Florida. The ambitious plan not only included a concept for the protection of linked conservation lands, but also for a linked recreation system to provide access among population centers and from those population centers to natural and cultural amenities. The following diagram was adopted by the Commission as a representation of their vision (Fig 2).

Figure I-2. Design concept for the Florida Greenways System (Florida Greenways Commission 1994).



Further, the Commission modified the Noss Reserve Diagram by incorporating smaller areas into a linked system and suggesting that the diagram could be equally applied to the design of a reserve system and a recreation system (Fig. 3).

Figure I-3. Design concept for the Florida Greenways System (Florida Greenways Commission 1994).



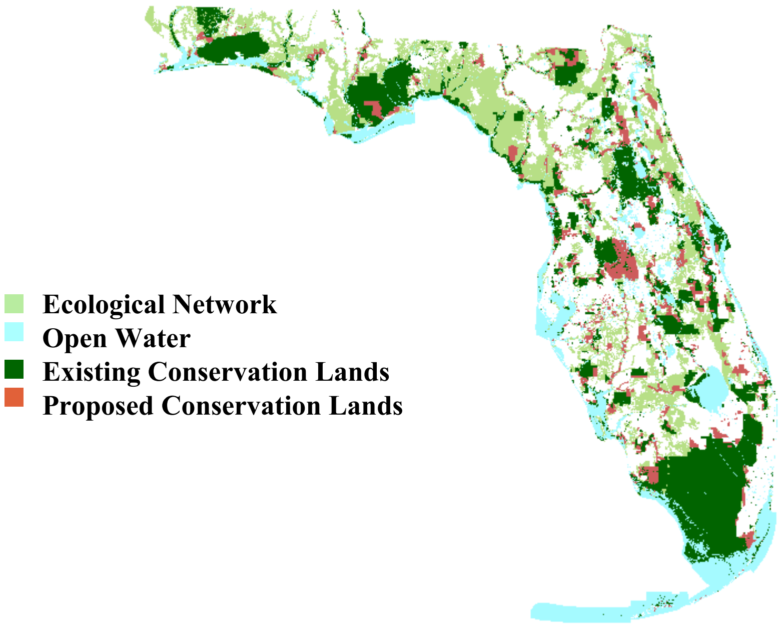
In 1994 researchers from the University of Florida lead by Margaret Carr and Paul Zwick began to develop a tool for identification of the potential for linked recreational and ecological systems in Florida. Joined by Tom Hoctor and for a period Mark Benedict, the team developed a process for identifying the linked ecological system, referred to as the Florida Ecological Network, that captured an amalgam of the ecological concepts previously mentioned:

- it was systematic and could be updated and replicated;

- it incorporated a strong foundation of habitat and viability modeling for key species of conservation interest in a gap analysis-type of effort completed by the Florida Fish and Wildlife Conservation Commission (Cox et al. 1994; Kautz and Cox 2001);
- it considered habitat requirements of endangered species as well as wide-ranging species;
- it incorporated information on the locations of high quality natural areas completed by Florida Natural Areas Inventory, which is the state's natural heritage program;
- it incorporated aquatic areas of significance and delineated buffers around them and all major rivers across the state;
- it emphasized identification of linked areas of ecological significance, especially connectivity among areas of fire-maintained communities and riparian systems shaped by flooding,
- the product was a strategic tool for use in prioritizing protection efforts with the goal of improved results given the same level of effort and funding.

In 1999 the Florida legislature adopted the plan developed by the team and currently the results (Fig. 4) are being used in several key ways. They are used as evaluative criteria for the 3 billion dollar Florida Forever land acquisition program authorized by the voters for a 10 year period ending in 2010 and they are similarly used by the Office of Greenways and Trails as criteria for evaluating potential greenways acquisitions. Local governments have used the results to enhance their local government comprehensive plans and conservation NGOs have used the results to lobby for protection strategies. State agencies also use the results to identify potential environmental obstacles for future projects in particular, the Department of Transportation uses the results to anticipate problem areas for new road corridors.

Figure I-4. The Florida Ecological Network including incorporated existing and proposed conservation lands.



The process of **Green Infrastructure Planning** is essentially the same as that applied in the development of the Florida Statewide Greenways Network. Its distinction lies in its power as a descriptor or analogy to communicate the importance and intent of the process to the public. Just as other forms of infrastructure are perceived to be critical for human comfort and well-being, like roads, emergency services, drinking water systems, waste water systems, etc., green infrastructure makes clear that protection for healthy, functioning ecosystems is essential for human survival and vitality. The approach, recently described in a monograph of the Sprawl Watch Clearinghouse by Benedict and McMahon (2002), does help to clearly convey this importance.

The development of the Southeastern Ecological Framework directly evolved from these recent conservation concepts, most especially from the Florida Statewide Greenways Network. It is a strategic conservation approach that could potentially benefit conservation efforts nationwide. Internationally, similar projects and processes have been developed and are ongoing in Europe (Jongman 1995), in Mesoamerica through the Paseo Pantera Project and in the United States and Canada through the Yellowstone to Yukon Project (Soulé and Terborgh 1999).

Section II: Delineation of the Southeastern Ecological Framework

A. MODEL BACKGROUND

The Southeastern Ecological Framework (SEF) was developed by the University of Florida based on their experience in creating the Florida Ecological Network (FEN) for the State of Florida. In Florida, conservation efforts have steadily progressed towards the identification and protection of an integrated system of protected areas that would sustain the state's rich native biodiversity while also protecting important ecological function and other natural resources. Following the work of Harris and Noss (Harris 1984; Noss and Harris 1986; Noss 1987a; Harris and Atkins 1991), the state adopted the concept of an integrated habitat network as part of the Florida Greenways Program in 1992. Although greenways are often associated with linear recreational features such as rails-to-trails, the Florida concept was to include wildlife corridors, landscape linkages, and landscape-level conservation areas within an ecological network connecting public and private conservation lands across the state.

As part of the process to develop a statewide greenways plan, the University of Florida was funded to develop a spatial analysis model to help identify the best opportunities to protect ecological connectivity statewide. Geographical Information System (GIS) software was used to analyze all of the best available data on land use and significant ecological areas including important habitats for native species, significant natural communities, wetlands, roadless areas, floodplains, and high quality aquatic ecosystems. This information was then integrated in a process that identified the FEN containing all of the largest areas of ecological and natural resource significance and the landscape linkages necessary to protect a functional statewide network. The process was collaborative and overseen by three separate state-appointed greenways councils. During the development of the model, technical input was obtained from the Florida Greenways Commission, the Florida Greenways Coordinating Council, other state, regional, and federal agencies, scientists, university personnel, conservation groups, planners and the general public in over 20 sessions. When the modeling was completed, the results were thoroughly reviewed in public meetings statewide as part of the development of the Greenways Implementation Plan completed in 1999, and the work was published in Conservation Biology, in August, 2000 (Hoctor et al. 2000).

The FEN delineation process combined a systematic landscape analysis of ecological significance and the identification of critical landscape linkages in a way that could be replicated, enhanced with new data, and applied at different scales. The FEN connects and integrates existing conservation areas with unprotected areas of high ecological significance. This information can be used in concert with other information on conservation priorities to develop a more integrated landscape protection strategy. Such an integrated network will protect important ecological functions, community and landscape juxtapositions, and the need for biotic movement more thoroughly than the present collection of isolated conservation areas (Noss and Cooperrider 1994; Harris et al. 1996b).

Other efforts built on the same principles began in the United States in the 1990s. Using the FEN model as a starting point, the state of Maryland has developed a Green Infrastructure Assessment to identify areas of highest conservation significance and opportunities to maintain and restore ecological connectivity. The Nature Conservancy (TNC) is conducting a nationwide ecoregional planning process to systematically identify the most important areas for conserving biological diversity using landscape ecology principles and a focus on natural communities and focal species. The Wildlands Project is engaged in various regional biodiversity reserve design analysis projects with a special focus on wide-ranging species. Defenders of Wildlife recently completed an analysis of areas most significant for conserving Oregon's biodiversity combined with efforts to develop policy strategies and incentives to effect protection. Though the objectives and methods used in each of these initiatives are somewhat different, all hinge on the fact that large-scale planning is an essential part of efforts to protect ecosystem integrity.

The usefulness of GIS for analysis and planning at a local scale is not in question. Two factors, however, are enhancing the use of GIS for regional planning. The primary factor is the rapid development of effective GIS modeling tools. More sophisticated software and hardware capable of handling complex analyses of large spatial data sets are being developed to assist in analysis and synthesis of spatial information at a regional planning scale. Impediments to its wider application, such as thematic data accuracy and uncertainty, data handling and management, positional accuracy and the lack of regional data sets, are being eliminated. For example, the increasing consistency of data across political jurisdictions affords significant breakthroughs in data modeling. The development of national data sets for floodplains, hydrology, digital elevation, national land cover and the eventual release of some state data sets, such as Federal GAP Analysis and Natural Heritage data, provide a unique opportunity to integrate information to analyze ecological quality and degradation at large scales.

The second significant factor driving the increase and importance of regional conservation planning efforts is the growing public awareness of the need for greenspace protection. Sentiment for greenspace protection and the valuation of ecosystem services has been growing steadily over the past few years. In 1998, 124 state and local open space protection referenda were passed on the November ballot (Land Trust Alliance 1999). Local decision makers are increasingly being charged with developing comprehensive plans that incorporate habitat protection, water and air quality, and economic vitality for their communities.

Regional conservation planning tools such as the SEF can play a key role in helping federal and state agencies, local governments, and non-profit organizations make coordinated natural resource conservation decisions that provide co-benefits for local and regional ecosystem services protection. The SEF provides a foundation for regional landscape and natural resource planning. Its value as an organizing theme to focus and coordinate environmental protection of large scale ecological systems can be significant for state, federal and non-profit agencies involved in natural resource protection. Some examples of applicability include watershed protection, biodiversity and wildlife conservation, wetlands mitigation banking and restoration, land use planning, road right-of-way planning and wellhead protection program activities. The value of the SEF as an organizing theme for Region 4 EPA is equally important for the goals to integrate landscape functionality into program decision making, prioritize agency programs, and allocate resources efficiently.

B. GIS MODELING TECHNIQUES AND ISSUES

a. The Use of GIS Modeling

GIS modeling, in this paper, refers specifically to a multiple-step process that uses GIS to identify geographic areas of interest. GIS models are also referred to as "spatially-explicit models" since they involve identification of specific features on the Earth's surface, with the location of the features being of key interest. The use of GIS for modeling is a powerful tool, but the user should be aware of certain issues in order to make appropriate and accurate decisions in the modeling process.

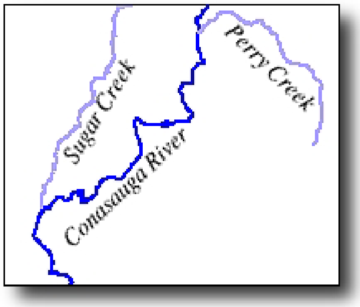
b. GIS Basics

A Geographic Information System is a computer system for capturing, storing, retrieving, analyzing, and displaying spatially explicit data, or data that are linked to a position on the Earth's surface. Geographic data is generally stored in layers, each of which represents a particular theme, such as land use, roads or hydrology (University of Edinburgh and AGI 1996). Data layers are spatially overlaid for analysis of overlapping features, such as finding residential areas within the 100-year floodplain. GIS has been useful in a variety of applications, including land management, land use planning, natural resource management, business and real estate, conservation planning, and public utility management.

c. Vector GIS

There are two main types of geographic information systems data, vector and raster. The primary difference between the two types is the way in which geographic information (features and attributes) is stored. In vector GIS, features are always represented with either points, lines, or polygons, and associated attributes (information about the features) are stored with each feature. In the example vector dataset below, streams are represented with lines. Each line has a numeric ID (Stream-id), and an associated attribute (Stream Name).

Figure II-1. Example of a Vector Dataset.



Stream–id	Stream Name
1	Conasauga River
2	Sugar Creek
3	Perry Creek

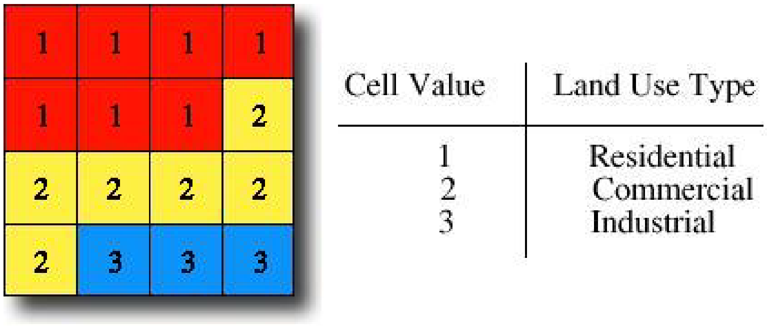
d. Raster GIS

Raster-based GIS is a way of storing geographic information into a matrix that is divided into a grid of equally sized cells. Grid cells are also called pixels, and are most typically square shaped. Each cell represents an area on the Earth's surface, for example a cell could represent one-square meter, or ten square meters, etc. In raster GIS, attribute information is stored with each cell. Each cell is assigned a value, which corresponds to what it contains on the ground.

For example, the figure below shows a grid of land use, where land use types are represented by grid cells with values of 1, 2, or 3. The numbers 1, 2, 3 are stored with each cell and correspond, in this case, to a land use type.

Figure II-2. Example of a Raster Dataset.

Raster-based GIS was used for delineation of the SEF because of the speed and simplicity of analytical operations.



1	1	1	1
1	1	1	2
2	2	2	2
2	3	3	3

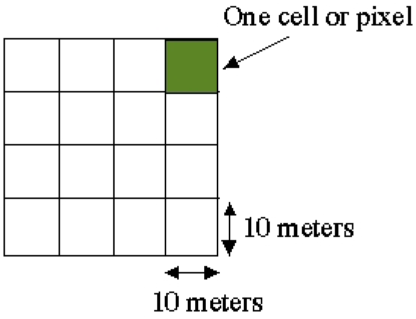
Cell Value	Land Use Type
1	Residential
2	Commercial
3	Industrial

e. Cell Size & Resolution

Cell size is defined by the user, and corresponds to the length of one side of one grid cell. Cell size determines cell area, or the area on the Earth's surface that each cell represents. Cell area is equal to cell size squared.

The cell size determines the grid's resolution, or the finest level of detail that can be depicted on the map. For example, if a cell size of 10 meters is chosen, then the finest level of detail for that map will be 10 meters in width and height, and 100 square meters in area. Features smaller than the cell size can be shown, but they will be represented larger than actual size. For example, a road that is approximately 5 meters wide (actual width) can be represented on a 10 meter grid, but its width will appear as 10 meters. Also, smaller cell sizes correspond to higher resolutions.

Figure II-3. Cell Size Example.

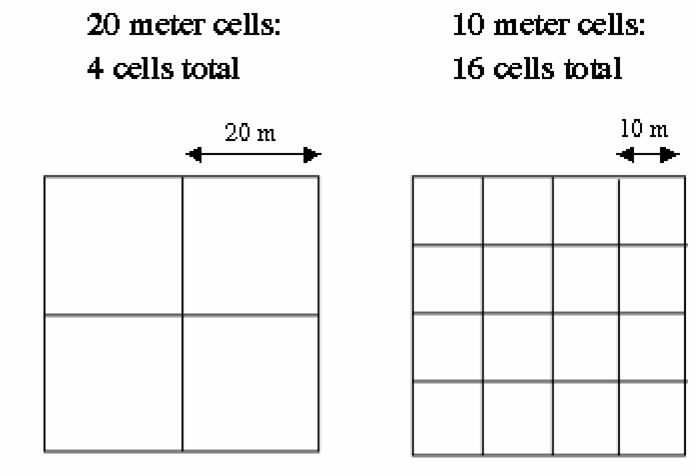


Cell Size = 100 square meters

When working with raster-based GIS, choosing an appropriate cell size is an important issue that involves consideration of: the features being represented/modeled, the geographic extent of the area of interest, and any existing input data that is already in raster format. Cell size is important because it determines the level of accuracy in the features represented (resolution) and it dictates computer processing time to run analyses. Of course, the computer hardware being used also dictates the processing time, but cell size is integral.

For a grid of the same extent, a smaller cell size will result in a greater total amount of cells in the grid, and hence longer computer processing times for analyses. In the figure below, two grids of equal extent but differing cell sizes are shown. The grid with 20 meter cells has a total of 4 cells, and the grid with 10 meter cells has a total of 16 cells. The greater the number of total cells, the longer the time it takes the computer to process an analytical function, overlay, or mathematical computation. Small cell sizes should be chosen only when the area of extent is relatively small and has small features and details that need representation.

Figure II-4. Cell Size and Total Number of Cells per Grid.



Furthermore, when choosing a cell size for a raster GIS analysis, it is important to consider any existing raster data sets to be used. The cell size chosen would ideally be compatible, if not equal to the cell size of existing raster data sets.

There is no exact formula for determining the appropriate cell size, but rather it involves trial, error, and testing of different cell sizes and their respective processing times to come up with a size that matches the project goals, needs, and time schedule. In delineating the SEF, the identification of many PEA data layers was done at a cell size of 30 meters. However, processing steps required to delineate other PEA data layers and other SEF modeling steps required the use of 90 meter cells, and the final SEF is represented as a resolution of 90 meter cells.

f. Data Availability

Depending on the geographic area and the subject of interest, data can be in abundance or scarce. Data can be found from various sources, including state and federal agencies, research institutions, and Data Clearing House websites. These websites compile and organize data for easily accessible distribution.

In any GIS-based project or analysis, the first step is to develop goals and create a list of necessary data. The next step involves taking an inventory of existing available data. Thereafter, data gaps can be evaluated and decisions can be made as to whether there is time or resources to create primary data necessary, or whether there is a surrogate data source available. Data availability is often the limiting factor in GIS based research projects and sometimes less than ideal data must be used in order to complete an analysis. However, the availability of GIS data is increasing, as GIS has quickly become a popular tool for various planning and management applications.

C. GOAL AND OBJECTIVES OF THE SOUTHEASTERN ECOLOGICAL FRAMEWORK

The following overall project goal and objectives were adopted by the University of Florida team and staff of the Environmental Protection Agency. They served to direct the project, including modeling decisions and weightings based on the data available to address them.

Goal: Use a regional landscape approach to identify an ecologically functional system of areas of ecological significance in the southeastern United States.

Objective A) Include ecological elements that:

protect ecosystems, landscapes and processes native to the southeastern United States across their natural range of distribution and variation, including coastal, riverine and upland landscapes, while giving special consideration to those inadequately protected by existing conservation programs;

protect the full range of biodiversity in the southeastern United States, including viable populations of native plant and animal species that are endangered, threatened, rare or otherwise imperiled;

conserve surficial and groundwater resources for the benefit of the region's native ecosystems, landscapes, residents and visitors;

incorporate ecologically compatible working landscapes that minimize the impacts of human-built environments on native ecosystems and landscapes;

incorporate disturbed lands that through restoration will enhance the ecological function of the Regional System.

Objective B) Incorporate functional ecological linkages, including river floodplains, ridgelines and other linear native landscape features that will enhance the ecological viability and manageability of presently isolated biological reserves.

Objective C) Include ecological elements with a mind to their ability to absorb and dissipate the effects of naturally occurring events, such as hurricanes, fire, and flood across the landscape.

Objective D) Maintain ecological and evolutionary processes, such as disturbance regimes, nutrient cycles, biotic interactions and range shifts, by protecting functionally juxtaposed landscape gradients of aquatic, wetland and upland ecosystems.

D. THE MODELING PROCESS TO DELINEATE THE SOUTHEASTERN ECOLOGICAL FRAMEWORK

The SEF modeling process is based on the methodology used to delineate the FEN (Hoctor et al. 2000). The FEN decision support model was created to facilitate the identification of key areas of ecological connectivity as part of Florida's land conservation programs. Since 1990, Florida has spent at least 300 million dollars per year to protect lands significant for conserving natural resources including biodiversity. The program criteria have evolved and pre-2000 assessments generally addressed issues of biodiversity, rarity or sensitivity on a case-by-case basis. Although over 500,000 hectares have been purchased through these programs, the Florida Greenways Commission (1994) felt that a more comprehensive approach to land acquisition was needed to ensure the viability of protected lands. Hence, in 1995, the University of Florida was asked to design a GIS-based model that could be used as a decision support tool for identifying all of the larger, potentially intact areas of ecological significance and opportunities for connectivity statewide. Once modeled, reviewed, and approved, a statewide ecological network could then be used to help integrate and coordinate land protection programs. The Florida Greenways Coordinating Council approved the FEN in 1999 after a detailed, statewide review process, and the Florida Legislature passed implementing legislation in 2000. The FEN is now being used as a primary planning tool to evaluate lands for the new state land acquisition program, Florida Forever.

The FEN modeling process is based on two parts of the primary reserve model advocated for effectively conserving biodiversity and other natural resources (Harris 1984; Noss and Harris 1986; Noss and Cooperrider 1994). In this model, core areas, landscape linkages or connectivity zones, and buffer zones are identified in integrated networks designed to:

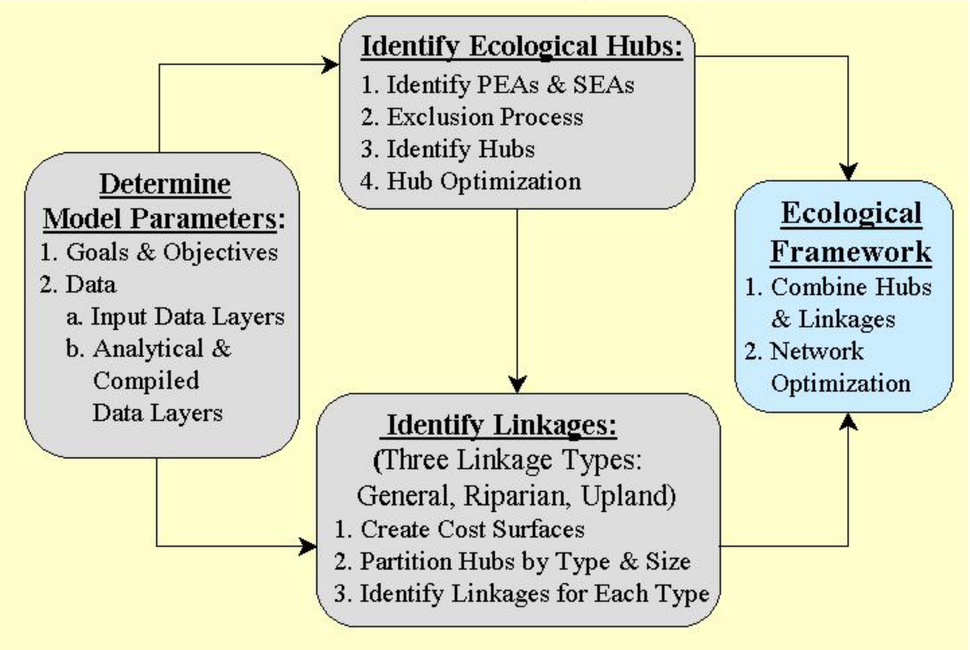
1) maximize protection for the most sensitive species;
2) provide enough space for viable populations of wide-ranging species;
3) maintain functional ecological processes and services, and provide opportunities for biota to functionally respond to future environmental changes.

The FEN modeling process combines these parts into two primary components: the identification of ecological hubs and the identification of landscape linkages. Ecological hubs are larger areas of ecological significance that have the best potential for conserving biodiversity and functional ecological processes. Ecological hubs may be a combination of both core areas and buffer zones depending on existing and future management objectives of protected lands. Landscape linkages are the existing and potential zones of connectivity between ecological hubs that are expected to provide better opportunities for maintaining viable populations of species of conservation interest, functional ecological processes, and for protecting riparian resources.

The three primary steps, the identification of priority and significant ecological areas, the identification of ecological hubs, and the delineation of landscape linkages were conducted in both the FEN and the SEF although some assessment techniques used in the process, such as the land suitability analysis used to delineate landscape linkages, were slightly different (Fig. 4). The identification of the Southeastern Ecological Framework involved four primary steps. First, in what can be termed the inventory phase, all relevant available Geographical Information System data were collected, including regional, sub-regional, and state data layers. These GIS data were then assessed to determine areas of ecological conservation significance (Priority

Ecological Areas and Significant Ecological Areas) as well as land use and landscape features that could impact ecological integrity. Second, the largest intact areas of ecological significance (Hubs) were delineated. Third, a GIS model was developed to identify the best opportunities to maintain ecological connectedness (Corridors) between selected Hubs. Finally, all framework components were integrated and optimized to create the Southeastern Ecological Framework. These steps are discussed in more detail below and complete flowcharts of the modeling process are included in Appendix A.

Figure II-5. Southeastern Ecological Framework Modeling Process.



a. Identification of Priority Ecological Areas (PEAs) and Significant Ecological Areas (SEAs)

PEAs and SEAs are identified using state and/or regionally available data sets and analyses. PEAs are the areas with the highest ecological significance identified using the best available GIS data and analyses. PEAs are the primary building blocks of the modeling process and are used to identify the larger ecologically significant areas in the region (Hubs) and the best opportunities to maintain ecological connectivity. All of the PEA criteria (See Table 1) are combined into one cumulative PEA dataset where all PEAs are treated equally. PEA data layers represent a variety of criteria that address the identification of areas important for conserving regional biodiversity and ecosystem services. However, they are based on available data and do not represent a complete depiction of all areas that may be important for biodiversity conservation and ecosystem services. Many PEA data layers are based on data and methods used in the FEN modeling process that was developed in consultation with many agencies and experts. Therefore, it was deemed appropriate to incorporate similar methods including thresholds used to delineate PEAs in the SEF modeling process. The identification of PEAs and SEAs and the SEF modeling process in general should be an iterative process that is modified as more and better data becomes available to identify areas important for conserving biodiversity and ecosystem services. Therefore, the existing list of PEAs and SEAs included in Table II-1 and Table II-2 should be considered an example of types of data and analyses presently available to identify areas of ecological significance regionally. More information on additional analyses that would be useful for more thorough future assessments is included in the discussion section below.

Table II-1. Criteria for selecting Priority Ecological Areas for the Southeastern Ecological Framework.

Data layer	Priority Area Criterion	States in which criterion used	Explanation/Rationale
Areas of high habitat diversity	Index of habitat diversity identifying areas with 5 or 6 different habitat types within a 90-meter pixel 27x27 (5.9 sq. km) neighborhood using National Land Cover Data (NLCD).	All states	Diverse habitats have the potential to support a wide range of flora and fauna, viewed as consistent with project goals. A threshold of 5 or greater was selected based on reviewing iterative results using different thresholds and comparing. Five or more habitat types was sufficiently restrictive to capture areas was highest habitat diversity based on NLCD data.
Significant natural edge habitat	Identifies areas that incorporate both significant natural open habitat and forest areas using NLCD.	All states	Natural edge habitats have the potential for harboring significant biodiversity.
Wetlands	As defined by the overlap of wetlands identified in both NLCD and wetlands in USGS 1:100,000 hydrology data or wetlands in LUDA data (USGS land use/land cover data).	All states	Areas represent wetlands with habitat to potentially support wetland dependent and partially wetland dependent species and important ecosystem services. Functional wetlands and especially large wetland basins are a primary focal resource of the model.
Areas with significant longleaf pine stands	Mature longleaf pine forests from the Eastwide Forest Areas Inventory Dataset. Longleaf pine stands are defined as stands that are at least 50 years old.	All applicable states	Longleaf pine forests used to dominate the southeastern coastal plain and are extremely significant for many species of conservation interest including federally listed species and candidates for listing.
Old-growth forest stands	Old growth stands from the Eastwide Forest Areas Inventory Dataset. Old growth stands are defined as stands that are at least 100 years old.	All states	Old growth forests represent areas that have the potential to harbor flora and fauna particularly sensitive to disturbance. Old growth forests are also exceedingly rare in the southeastern U.S. and are an important ecological resource.
Potential black bear habitat	NLCD forest, not within ½ mile of Class 1 roads, road density of less than 2 miles per sq. mile AND greater than or equal to 10000 acres **within 100 kilometers** of occupied bear habitat.	All states	Black bear are a useful umbrella species for identifying large areas of relatively intact habitat that may be important for many other species of conservation interest.

Data layer	Priority Area Criterion	States in which criterion used	Explanation/Rationale
Existing public conservation lands & private preserves (e.g., Audubon, TNC)	All available existing conservation lands data within region 4, obtained from both state and regional sources	All states	Though management practices vary widely, all existing conservation lands are potentially significant building blocks for a regional ecological framework.
Lands identified as part of the Coastal Barrier Resources Act	Undeveloped Coastal Barrier Areas (COBRA) as identified using Q3 Flood Data in the Federal Emergency Management Agency's Flood Insurance Rate Maps (FIRMs) with open water excluded.	All states	These areas are typically coastal barrier islands identified by the federal government as undeveloped and inappropriate for future development. Such sites are important for conserving coastal ecosystems & ecological services.
Roadless areas	Areas **5000 acres** or larger with no roads (excluding large water bodies) of any kind based on 1990 TIGER roads	All states	Roadless areas are important to species sensitive to humans, are typically buffered from disturbance and provide connectivity for species isolated by roads. A 5,000-acre area was used based on federal roadless standards, average home range size for the black bear (*Ursus americanus*), & recommendations by reviewers.
Areas with high stream start reach densities	Defined as areas in the top 10% in stream start reach densities in the region with forested cover.	All states	Areas with high stream start reach densities represent areas that influence multiple watersheds, that are potentially relatively steep and thus vulnerable to erosion and that have the potential to harbor and protect aquatic biodiversity and water quality downstream.
National Estuarine Research Reserves, Shellfish Harvesting Waters, Wild and Scenic Rivers	All such designated aquatic ecosystems: All existing NERRs including a 1000 meter buffer, Wild and Scenic Rivers including a 1000 meter buffer, State Scenic Rivers (Florida only) including a 1000 meter buffer, approved and conditionally approved shellfish harvesting areas including 1000 meter buffer.	All states	These designated aquatic areas serve as good indicators for a level of quality that likely support functional aquatic ecosystems. Identification of immediate buffers will aid efforts to protect water quality and ecosystem functions. Such water quality and aquatic resource based designations can also serve as surrogates for identifying sites important for aquatic biodiversity.
Element Occurrence data on rare species and communities	Buffered element occurrences of rare species and communities, and areas with high densities of rare species occurrences. Buffer distances were based on precision (indicating the distance in which the occurrence was observed) or species or community type. Buffer distances ranged from 90 to 1800 meters. All buffered occurrences had a Global rarity of G1, G2 or G3 or had a State rarity ranking of S1/ S2 & were observed after 1975.	Florida, Georgia, Alabama	Occurrence of rare species and communities are a primary source of areas significant for biodiversity conservation.

Data layer	Priority Area Criterion	States in which criterion used	Explanation/Rationale
Proposed public conservation lands and easements	All such lands	Florida	Approximately 6% of the state has been identified for purchase through Florida's conservation land acquisition program. Parcels were selected based on a presence of high quality natural communities, habitat for rare species, opportunities to protect connectivity, or other conditions supportive of conservation objectives.
Florida State Aquatic Preserves	All such designated aquatic features including a 1000 meter buffer	Florida	Designated aquatic preserves represent important aquatic ecosystems that have a greater likelihood of harboring functional ecological processes and intact native aquatic biological diversity.
FNAI[b] Potential Natural Areas (PNAs)	Only PNAs within the top two priority levels (out of five).	Florida	Includes most of the remaining sites available to conserve native ecosystems in Florida, though some disturbance may be present and status of tracked species may not be completely known. Threshold was based on recommendation by The Nature Conservancy.
FNAI[b] Areas of Conservation Interest (ACIs)	All ACIs	Florida	ACIs were identified outside existing public lands using aerial photos, natural heritage data & expert knowledge. ACIs are high quality, relatively pristine sites that contain occurrences of rare species.
FWC[a] Strategic Habitat Conservation Areas (SHCA)	All SHCAs	Florida	Includes lands outside existing protected areas needed to maintain or restore minimally viable populations of 30 focal vertebrate species, rare natural community types, important wetlands for wading birds, and globally rare plant species. Many focal species used in this analysis are umbrella or indicator species whose conservation requirements meet the needs of other species & the natural communities identified represent a "coarse filter" approach to protect suites of species.
FWC[a] Vertebrate Species Hotspots	Based on FWC recommendations, all areas with values 10 and greater were designated priority ecological areas.	Florida	Data set was created by adding together potential habitat maps for over 100 vertebrate focal species. The original dataset consisted of values 1-26. Areas with 10 or more species indicate high areas of overlap in habitat for species of conservation interest.
North Carolina Significant Natural Heritage Areas	Significant natural areas ranked either A or B in a statewide inventory.	North Carolina	Areas supporting significant natural communities and species of conservation interest considered to be of state or national significance.

Data layer	Priority Area Criterion	States in which criterion used	Explanation/Rationale
North Carolina land trust priority areas	All areas identified in a workshop by North Carolina land trusts as priority conservation areas.	North Carolina	Priority conservation areas for natural features throughout North Carolina
Coastal Fish Nursery Areas	Coastal waters important for the initial post-larval and juvenile development of young finfish and crustaceans in North Carolina, including a 1000-meter buffer.	North Carolina	These areas are important for maintaining commercial and recreational fisheries and the ecological integrity of estuarine and marine ecosystems in North Carolina and nearby coastal states. Buffers indicate adjacent areas where water quality impacts are of concern.
Anadromous Fish Spawning Areas	Important anadromous fish spawning areas identified by the Division of Marine Fisheries, including a 1000-meter buffer.	North Carolina	These areas are important for maintaining commercial and recreational fisheries and the ecological integrity of estuarine and marine ecosystems in North Carolina and nearby coastal states. Buffers indicate adjacent areas where water quality impacts are of particular concern.
Coastal Reserve Research Areas	State-owned coastal research areas that are completely protected, including a 1000-meter buffer.	North Carolina	Intact estuarine ecosystems important for estuarine and marine biodiversity and research activities. Buffers indicate adjacent areas where water quality impacts are of particular concern.
Bump up criterion	All SEAs that overlap with significant riparian areas (see SEA criteria below)	All States	Riparian ecosystems are one of the primary focal resources for this modeling effort. It was determined that all areas where significant riparian areas overlapped with other SEA criteria would be "bumped up" into PEAs.

[a] The Florida Fish and Wildlife Conservation Commission was previously named the Florida Game and Fresh Water Fish Commission.

[b] Florida Natural Areas Inventory

SEAs are secondary areas that either may be "bumped up" to PEA status in some cases or are used in the landscape linkage identification process. They are other areas within the region that are of ecological significance but are not considered to be as important as PEAs. The SEA criteria (See Table 2) are combined into one cumulative grid where all SEA criteria are treated equally.

Table II-2. Criteria for selecting Significant Ecological Areas for the Southeastern Ecological Framework.

Data layer	Priority Area Criterion	States in which criterion used	Explanation/Rationale
Areas of high habitat diversity	Areas that have 4 different habitat types within a 27x27 neighborhood using 90-meter pixels and NLCD landcover/landuse data.	All states	Diverse habitats have the potential to support a wide range of flora and fauna, viewed as consistent with project goals. Based on iterative comparisons, areas with 4 different habitat types using NLCD appeared to be a useful additional indicator of areas with significant habitat diversity.
Potential black bear habitat	NLCD forest, not within ½ mile of Class 1 roads, road density of less than 2 miles per sq. mile AND greater than or equal to 10000 acres within **100-140** kilometers of occupied bear habitat.	All states	Black bear are a useful umbrella species for identifying large areas of relatively intact habitat that may be important for many other species of conservation interest. The SEA zone is farther from occupied bear habitat.
Roadless areas	Areas **2500 to 5000 acres** with no roads (excluding large water bodies) of any kind based on 1990 TIGER roads.	All states	Roadless areas, important to species sensitive to humans, are typically buffered from disturbance and provide connectivity for species isolated by roads. The SEA threshold was based on recommendations by reviewers.
Areas with high stream start reach densities	Defined as areas in the top 10% in stream start reach densities with forest cover **within each ecoregion**. EPA Region for is broken into various ecoregions (such as Southeastern Coastal Plain , Blue Ridge Mountains, etc.) based on geology, soils, climate, etc. These ecoregions were used as a unit of analysis for any factor that might vary significantly among ecoregions.	All states	Areas with high stream start reach densities represent areas that influence multiple watersheds, that are potentially relatively steep and thus vulnerable to erosion and that have the potential to harbor and protect aquatic biodiversity and water quality downstream. The SEA criterion is based on ecoregions, which allows for the identification of high stream reach densities within all ecoregions in the region.
Significant riparian areas	NLCD wetlands adjacent to streams (within 180 meters), intact riparian vegetation adjacent to streams (delineated as pixels with 75% density of natural/semi-natural landcover in a 5x5 neighborhood within a 180m stream buffer), and 100-year FEMA floodplains (where data was available).	All states	Riparian resources were one of the primary focal resources within the model. These various data sources and analyses delineate riparian areas of significance. NLCD wetlands are a more liberal identification of wetlands than contained in the PEA wetland analysis, intact riparian vegetation is important for water quality and wildlife habitat and corridors, and 100 year floodplains are important for flood control, functional ecological processes, etc.
FNAI[b] Potential Natural Areas (PNAs)	Priority level 3 through 5 areas from the Florida statewide inventory of potentially significant natural areas.	Florida	Includes most of the remaining sites available to conserve native ecosystems in Florida, though some disturbance may be present and status of tracked species may not be completely known.

Data layer	Priority Area Criterion	States in which criterion used	Explanation/Rationale
FWC[a] Vertebrate Species Hotspots	Based on FWC recommendations, areas supporting potential habitat for 6-9 focal vertebrate species.	Florida	Data set was created by adding together potential habitat maps for over 100 vertebrate focal species. The original dataset consisted of values 1-26. Areas with 6-9 or more species indicate significant areas of overlap in habitat for species of conservation interest.
North Carolina Significant Natural Heritage Areas	Significant natural areas ranked C in a statewide inventory.	North Carolina	Areas supporting significant natural communities and species of conservation interest considered to be of regional significance within North Carolina.

[a] The Florida Fish and Wildlife Conservation Commission was previously named the Florida Game and Fresh Water Fish Commission.

[b] Florida Natural Areas Inventory

b. Priority Ecological Area Exclusion

After PEAs were identified, portions overlapping any areas of incompatible land use, high road density, or negative edge effect zones were removed. The result, called the PEAX grid, contains the remaining Priority Ecological Areas that do not overlap with incompatible land uses or landscape features.

The features deleted include:

1. All areas of Category III (urban, residential, commercial) and Category II (intensive agriculture) land use.
2. Areas with road densities greater than or equal to 3 miles per square mile that greatly exceed general road density standards for protecting sensitive species (Noss 1992), using all roads except jeep trails within the 1990 TIGER roads data set.
3. All areas within "neighborhoods" with extensive urban land use in 90-meter 3X3, 9X9, and 27X27 windows. All areas with greater than or equal to 60% urban land use within all three window sizes are deleted. These areas were removed based on the high level of influence from intensive land uses that typically results in significantly impaired ecological function and the erosion of biodiversity.
4. All areas within 270 meters of a block of urban land use greater or equal to 100 acres that are close enough to urban areas to be significantly affected by negative edge effects.

c. Delineation of Hubs

All remaining PEAs after exclusion (PEAX) that are greater than or equal to 5000 acres are identified as Hubs for the Framework model. The 5000-acre threshold was the same criterion used in the Florida Ecological Network model, which was based on extensive discussion at review meetings during its development. Such areas are large enough to support many species and ecological processes while still including relatively small areas of ecological significance. However, smaller size classes can also be easily identified to serve as additional areas of significance to facilitate the use of PEA criteria for conservation planning at local scales.

After Hubs are identified, they are “optimized” by filling internal and smoothing outside edges gaps that contain compatible land uses. Internal gaps less than or equal to 25,000 acres are filled. Outside edges are smoothed using a combined expand and shrink algorithm that smoothes minor indentations. This optimization step is completed to reduce the potential internal fragmentation of the Hubs and reduce the potential negative effects associated with nearby incompatible land uses. The threshold of 25,000 acres was based on an examination of hubs and the goal to identify large, intact landscapes capable of sustaining functional ecological processes.

d. Identification of Landscape Linkages

The linkage portion of the model is then run to identify the best opportunities for physical ecological connections between appropriate Hubs. Linkage types include:

1. Riparian linkages including all major river systems and coastal water bodies such as lagoons and connected estuaries.
2. Upland linkages (Used primarily in mountain and plateau ecoregions)
3. General Hub-to-Hub linkages (Considers wetlands and uplands as potentially suitable and was used primarily in the Coastal Plain and Piedmont ecoregions)

Landscape Linkages are identified with an AML-based user interface in Arc-Info. The least cost path function, which can be used to identify the lowest cost, or conversely, the most suitable path between destinations was the primary algorithm used in the interface. Cost surfaces were created for each linkage type, where most appropriate landscape features for supporting a landscape linkage are given the lowest number (1) and the least suitable landscape features are assigned the highest number. The cost surfaces for each linkage type are available in Appendix B.

Landscape linkages are then identified using a process where hub pairs are selected for potential connection, resulting least cost paths are examined, and accepted least cost paths are buffered based on the length of the linkage and the characteristics of the particular landscape. After buffering least cost paths, all linkages are "smoothed" using an algorithm that deletes outlier cells. The upland linkages are also optimized by adding Category II (agricultural) land uses within 500 meters of the least cost path. The values in the cost surface represent the resistance to going through an individual cell. As an example, the path would go through 99 cells valued as 1 instead of going through a single cell valued as 100.

All three cost surfaces include the identification of large blocks of intact natural or semi-natural vegetation to help locate landscape linkages in wide, intact areas instead of narrow corridors whenever possible. These intact areas are separated into two classes: large and moderate. Large intact areas are defined as natural and semi-natural vegetation within both a 590 hectare area and 65 hectare area containing 90% or more natural or semi-natural vegetation in blocks 5000 acres or larger and without primary roads. Moderate intact areas are defined as natural and semi-natural vegetation within both a 590 hectare area and 65 hectare area containing 90% or more natural or semi-natural vegetation in blocks 1000 acres or larger and without primary roads.

e. Integration and Optimization of Framework Components

All the optimized hubs and linkages are combined to form the preliminary SEF. Then additional optimization is conducted to delineate the final SEF. This includes adding all PEAs after exclusion that are connected to the preliminary Ecological Framework; smoothing external edges; filling in areas containing suitable land use in narrow, linear gaps that are surrounded by the Ecological Framework; and filling in large internal gaps (less than or equal to 50,000 acres) inside the Ecological Framework that contain suitable land uses. Again, as with hub optimization, these steps are conducted to ensure that the largest available areas of compatible land uses are incorporated into functional blocks more likely to support functional ecological processes and sustainable biodiversity.

E. RESULTS

a. Priority Ecological Areas and Significant Ecological Areas

Based on this assessment of areas of ecological and natural resource significance across EPA Region 4, there still appears to be large areas of intact natural and semi-natural land cover that have a significant role in producing ecological services and harboring biological diversity. Priority Ecological Areas (PEAs) encompass 46% of Region 4, and Significant Ecological Areas incorporate 43% of Region 4. When combined, these data cover 60% of Region 4 (Fig. 5). These numbers should be interpreted with some caution however because PEAs and SEAs before the exclusion step of the model represent a coarse assessment of ecological significance. After the exclusion process, where all areas potentially incompatible with the objective to identify larger, intact areas are removed, the remaining PEAs encompass only 34% of Region 4 and SEAs after exclusion incorporate only 30% of the region. When combined, PEAs after exclusion (PEAX) (Fig. 6) and SEAs after exclusion (SEAX) cover 42% of Region 4. One of the primary reasons for the difference between PEAs and SEAs before and after the exclusion process is that more intensive agricultural uses are removed from roadless areas (important in south-central Florida) and from 100 year floodplains, which were incorporated in the Significant Riparian SEA analysis (Table 3).

Table II-3. PEA and SEA Composition for EPA Region 4.

Data Layer	Percentage of Region 4
Priority Ecological Areas (PEAs)	46%
Significant Ecological Areas (SEAs)	43%
PEAs and SEAs combined	60%
Priority Ecological Areas after exclusion process (PEAX)	34%
Significant Ecological Areas after exclusion process (SEAX)	30%
PEAX and SEAX combined	42%

Figure II-6. Priority and Significant Ecological Areas.

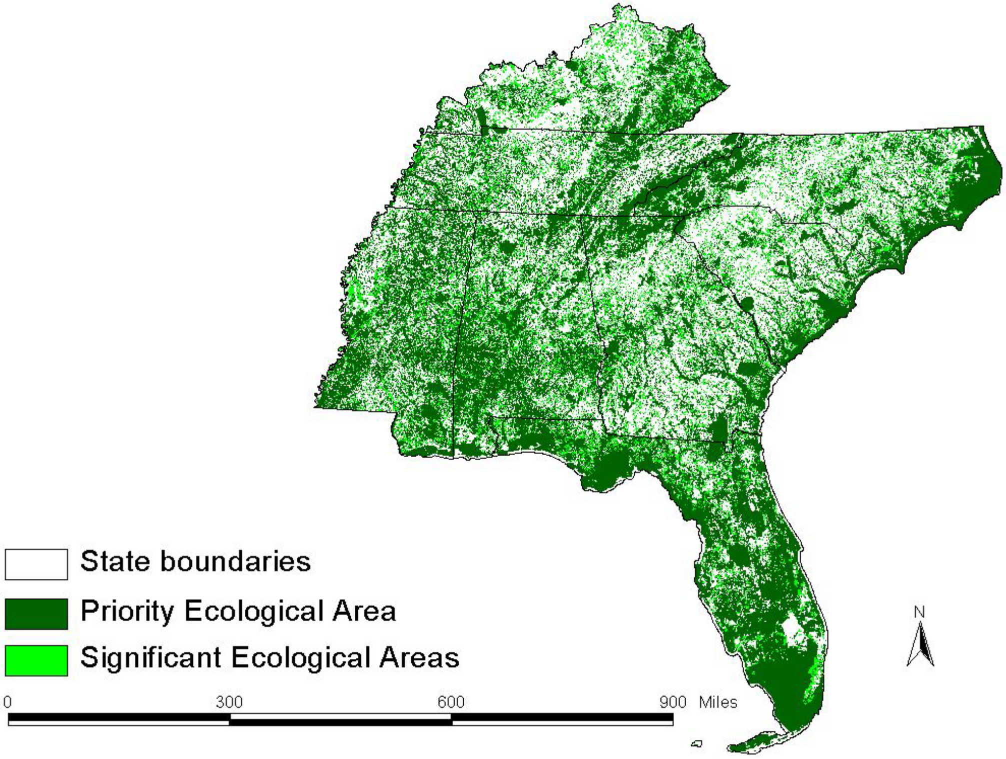
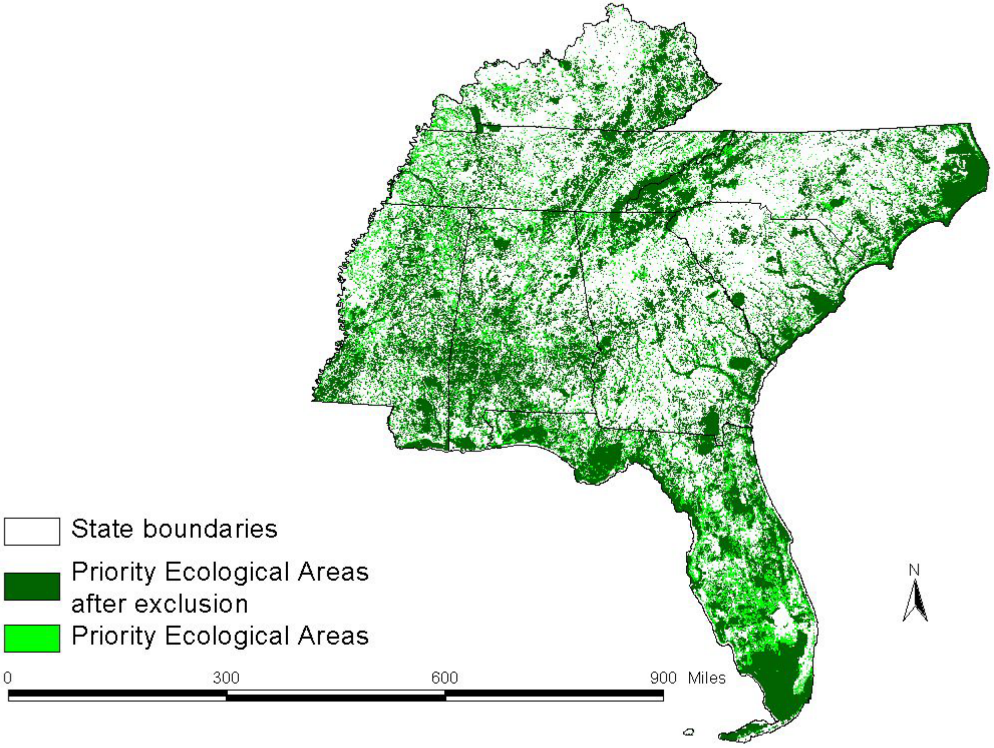


Figure II-7. Priority Ecological Areas before and after the exclusion process.



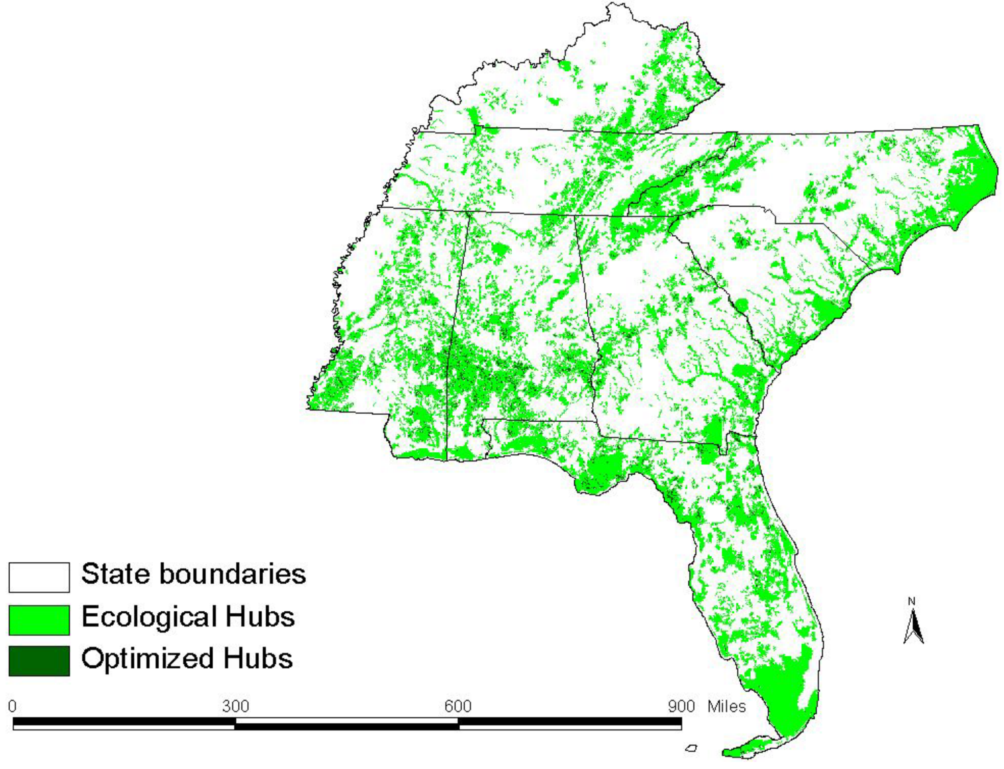
b. Hubs

Hubs represent the Priority Ecological Areas after the exclusion process that are also 5,000 acres or larger. These represent larger intact areas that can serve as the building blocks for local to regional networks of protected lands. In this model Hubs became the focal step of the linkage process, where all opportunities to protect existing or restore connectivity between Hubs was assessed. There are still many areas within Region 4 that meet the criteria for being ecological Hubs with 28% of the region within Hubs. Hubs were then optimized spatially to fill gaps that contained suitable land cover and to create more intact edges wherever possible. Optimized Hubs add slightly more acreage and incorporate 30% of Region 4 (Table 4). The largest differences between Hubs before and after optimization can be seen in Fig. 7, especially in southwestern Alabama where some larger gaps within the hubs were filled.

Table II-4. Hub and Optimized Hub Percentages for EPA Region 4.

Hub Category	Percentage of Region 4
Hubs before Optimization	28%
Hubs after Optimization	30%

Figure II-8. Optimized Hubs and Hubs before spatial optimization. The two versions of hubs are overlain in this fashion so that the areas added in the spatial optimization process can be seen in dark green.



c. The EPA Region 4 Southeastern Ecological Framework

The Southeastern Ecological Framework (SEF) includes all Optimized Hubs, all ecological linkages or corridors along major rivers and other suitable landscape features that could functionally connect various Hubs, and then additional areas added to the Framework in the same manner as Optimized Hubs to fill in gaps that support compatible land uses and to smooth edges. Approximately 70% of the SEF is comprised of Optimized Hubs. The rest of the SEF was added during the linkage process to connect hubs and through final optimization. Approximately 22% of the SEF is existing conservation lands and an additional 12% of the SEF is in open water bodies including rivers, lakes, estuaries, bays, etc. Therefore approximately 34% of the SEF is protected in some form as conservation lands or generally as public domain waters. In addition, approximately 23% of the SEF is within wetlands (using both wetlands from 1:100:000 hydrology data and NLCD), and 14% of the SEF is wetlands outside of existing conservation lands or areas of open water. Therefore, a total of 48% of the Southeastern Ecological Framework is within existing conservation lands, open water, or wetlands (Table 5). Table 5 includes a breakdown of the SEF by major land use type. The SEF comprises 43% of Region 4, and Table 5 also includes a breakdown of the 43% of total area that the SEF covers by land use type.

Table II-5. Breakdown of land use categories within the Southeastern Ecological Framework.

Land Use Type	Percentage of SEF	Percentage of Region 4
Existing Conservation Lands	22%	9%
Open Water (outside existing conservation lands)	12%	5%
Wetlands (outside existing conservation lands)	14%	6%
Uplands (outside of existing conservation lands but including uplands within 100 year floodplains)	52%	23%
Totals	100%	43%

The Southeastern Ecological Framework incorporates all large conservation lands, large wetland basins and intact riparian areas around all major rivers, all major natural and semi-natural roadless areas, and other intact areas of ecological significance throughout Region 4. Approximately 98% of existing conservation lands in Region 4 are incorporated within the SEF (Table 6). The SEF also contains 77% of the wetlands and 56% of all forested lands within the region. Coincidentally only about 2% of the SEF is comprised of agricultural lands (pastures or croplands) and only approximately 2% of the agricultural lands in Region 4 are found within the SEF. The agricultural lands that do occur within the SEF are either within the boundaries of conservation areas or were added as part of landscape linkages in some cases, particularly within the ranchlands of south-central Florida and in some linkages along the fall line along the piedmont and coastal plain boundary.

Table II-6. Percentage of land use categories within Region 4 and their representation within the Southeastern Ecological Framework.

Land Use Type	Percentage of Region 4	Percentage of Total found within SEF
Existing Conservation Lands	9%	98%
Open Water	7%	83%
Wetlands	13%	77%
Uplands (including uplands within 100 year floodplains)	80%	34%
Forested Lands (both uplands and wetlands)	60%	56%
Agricultural Lands	25%	2%

Within the Southeastern Coastal Plain, the Southeastern Ecological Framework is primarily composed of broad river floodplains and wetland basins, upland forests dominated by pinelands including plantations and natural stands, and much of the coastal water bodies within shellfish harvesting areas, estuarine research reserves, and conservation lands (Fig. 8). Within the coastal plain, the Everglades and ranchlands around Lake Okeechobee are also important components of the Framework. One of the larger areas of interest within the coastal plain occurs primarily in southwestern Alabama where a broad area in the Mobile/Tombigbee/Alabama Rivers watershed including broad forested floodplains and private forestlands that are connected to the National Forest lands and the Pascagoula River watershed in southeastern Mississippi. With some of these features combined, the SEF in the Southeastern Coastal Plain includes several broad connected networks. One of these features is along the Gulf Coast from the Big Bend area of Florida and the Apalachicola National Forest to the Pascagoula River basin. Along the east coast, there is a broad landscape linkage ranging all the way from the Ocala National Forest in central Florida to at least the Croatan National Forest in eastern North Carolina.

The Piedmont, found in the middle portions of Georgia, South Carolina, and North Carolina, is dominated by numerous riverine corridors running through the ecoregion from the Appalachians to the Southeastern Coastal Plain. The Piedmont also contains one of the most prominent features of the SEF: a system of linked conservation lands hubs approximately following the fall line all the way from Fort Benning Military Reservation in western Georgia to central North Carolina and the Fort Bragg Military Reservation.

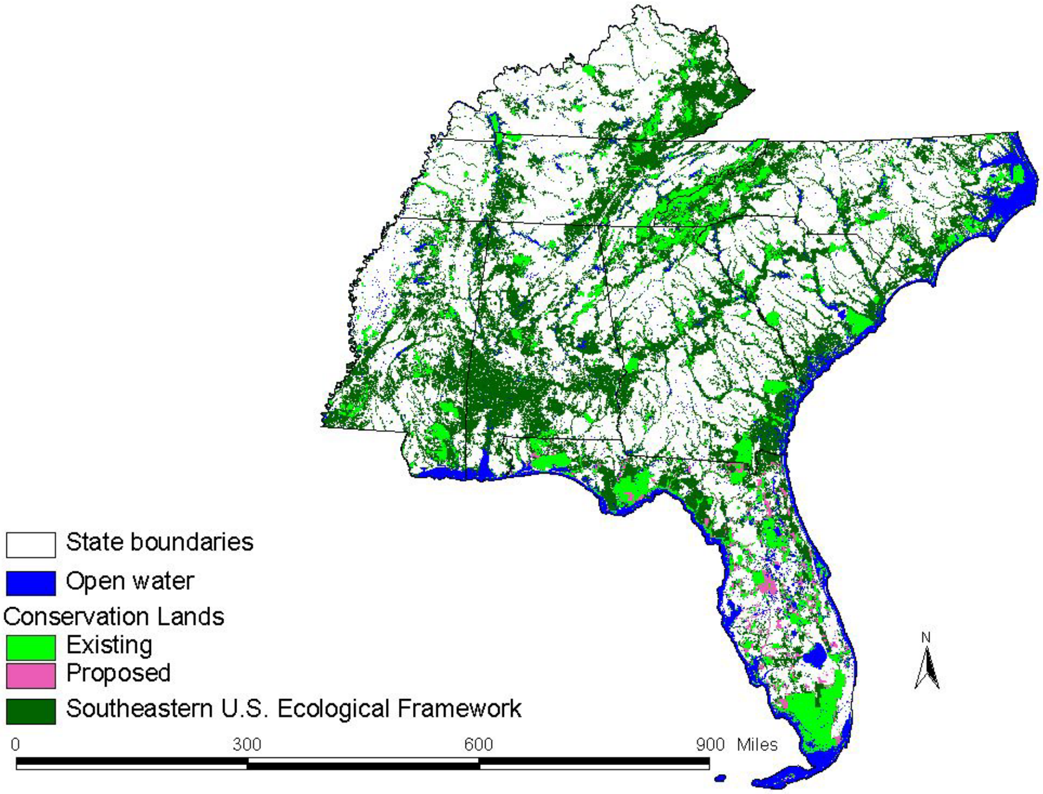
Two major ridge systems of the Appalachians are found within Region 4 and are also represented within the Southeastern Ecological Framework. National Forest lands and Great Smoky Mountains National Park dominate the SEF within the Southwestern Appalachians and the Blue Ridge Mountain ecoregions. However, private forest lands are important for providing large landscape connections between the various units, and often fragmented ownerships, of National Forest lands and other conservation areas. Within the SEF these connections run all the way from the Talladega National Forest in central Alabama to the Cherokee National Forest in northeastern Tennessee. The Central Appalachians and Alleghany Plateau in central Tennessee and eastern Kentucky have less public conservation lands but the SEF still includes broad areas of private forest lands and conservation lands in a connected network from Huntsville, Alabama to the Daniel Boone National Forest east of Lexington, Kentucky. The valley ecoregion between the two major Appalachian ridge systems within Region 4 is primarily agricultural and the SEF in this area is mostly limited to riparian zones in the upper Tennessee River watershed.

Riverine corridors are the primary feature in the SEF within the Interior Plateau of northern Alabama, central Tennessee, and Kentucky. Several prominent features stand out within the ecoregion including broad areas of forested land along the lower Tennessee River and the upper Cumberland River.

The Mississippi Delta and river valley plains ecoregions are currently dominated by agriculture with very little land included within the SEF except for around some of the major riverine corridors. However, the SEF also incorporates a broad area of forested lands in southwestern Mississippi that is anchored by the Homocihitto National Forest.

Across the ecoregions within Region 4, The Southeastern Ecological Framework includes some components that may provide functional linkages ranging from the Appalachians to the coasts. These opportunities are of course mostly restricted to several major riverine corridors. Issues that may preclude such connectivity include narrowings or bottlenecks along all the river corridors especially near or within urbanized areas and major reservoir systems. However, examples of the rivers that may provide existing or future opportunities for linkages between ecoregions include: the Pee Dee River in North Carolina and South Carolina; the Savannah and Ogeechee Rivers along the Georgia and South Carolina border; the Altamaha River watershed in eastern Georgia; the lower Chattahoochee and Apalachicola Rivers; the Choctawhatchee River in southeastern Alabama and Florida; and the Tombigbee and Sipsey Rivers in western Alabama.

Figure II-9. The Southeastern Ecological Framework for EPA Region 4 including existing conservation lands for all states and officially proposed conservation land projects in Florida.



Users of these data should be aware that some areas of significance identified during the SEF modeling process were not incorporated into the boundaries of the Southeastern Ecological

Framework. For instance, not all PEAs or SEAs are incorporated in the SEF. Priority Ecological Areas after the exclusion process (PEAX) and Significant Ecological Areas after the exclusion process (SEAX) have 16% and 26% of their total area outside of the SEF respectively. PEAs and SEAs are also important data layers for identifying areas of conservation significance for a variety of other potential applications. When using the data from this project for conservation planning purposes at a variety of scales, PEAs and SEAs outside of the SEF can be useful for determining how other areas of conservation interest may spatially relate to the SEF and the particular objectives of the project under consideration.

F. DISCUSSION

The modeling process utilized in both the Florida Ecological Network and the SEF has important strengths that facilitate its ability to serve as a rapid assessment technique for different regions or scales. The process combines a systematic landscape analysis of ecological significance, large intact landscapes, and opportunities for ecological connectivity in a way that can be replicated, enhanced with new data, and applied at different scales. The identification of Priority Ecological Areas and corridors is query-based, which allows great flexibility in model inputs and decision-making processes. Without relying on complex weighting schemes, the modeling process can be adapted to various situations with different objectives and data sources. Criteria, thresholds, and the scale of the analysis can easily be changed, which can either be used to modify the existing model results or to re-run the model as resources allow. This affords the opportunity to develop the model process for other regions and allows for iterative identification processes as new data becomes available. The model can also be applied from local to regional scales, and local versions of the modeling process can be created using even more resolute and specific data sets to assist in connecting local conservation planning initiatives with larger scale ecological processes. In addition, ever-increasing sophistication of computer technology is allowing for large regional assessments to be done using more resolute data and analyses. For example, due to data processing and storage constraints the FEN model was conducted using 180 meter grid cells, while much of the SEF assessment was run with 30 meter cells with the final model results having a resolution of 90 meters.

The same modeling process was used by the University of Florida to delineate the SEF. Though some assessment techniques used in the process, such as the land suitability analysis used to delineate landscape linkages, were slightly different (and, in our view, improved) in the SEF modeling process, the primary difference in the two models is the specificity and consistency of the data available in the assessments. Florida has good quality data on land use, land cover, and biodiversity, which were all used in the delineation of the FEN. Though significant progress is being made in other states and nationally to develop similar data, the SEF assessment had to be conducted with less comprehensive regional and state data sets.

In Florida, two data sets were available to assess land use and land cover as part of the FEN assessment. One data set was based on Landsat imagery and the other on high-resolution aerial photography. Both data sets allowed for a detailed assessment of land use and land cover. In particular, the level of natural community classification allowed for the identification of some of the coarser-scale natural communities of significance including longleaf pine, sand hills, scrub, tropical hammocks, and coastal strand. In the SEF, land use and land cover information was predominantly based (except in Florida) on the National Land Cover Data (NLCD) formerly known as the Multi Resolution Land Cover (MRLC) dataset (Vogelmann et al. 1998). Although this data set is of an appropriate resolution for regional scale analysis (classified using 30 meter Landsat imagery), the classification is too coarse to allow for standard representation analysis of natural communities. For instance, all forest communities (including plantations) are lumped into four classes: upland deciduous, evergreen, mixed, and woody wetlands.

The Florida Fish and Wildlife Conservation Commission completed a GIS analysis in 1994 that identified all of the areas needed to protect viable populations of over 30 species of conservation interest (Cox et al. 1994; Kautz and Cox 2001). These species are indicator species representing both important natural communities and umbrella species requiring large areas to support viable populations. The black bear (*Ursus americanus*) was used in the SEF model as a focal, umbrella species to identify larger blocks of intact habitat for this species that would provide habitat for other species of conservation interest. Although similar assessments focus on biodiversity, such as the federal GAP Analysis Program and The Nature Conservancy's ecoregional planning initiative, these analyses are not yet completed at a scale (multi-state regions) that could have been used in this assessment of ecological significance and function.

Florida's natural heritage program, Florida Natural Areas Inventory, developed a detailed GIS data layer identifying all potentially significant natural areas statewide (Cox et al. 1994). Although a similar data set was used for North Carolina, natural heritage programs in other states within Region 4 do not currently have this kind of data available. In addition, due primarily to data ownership concerns by various natural heritage programs, the SEF was developed without having species and natural community element occurrence data in all eight states. The delineation of the SEF included element occurrence data for Alabama, Georgia and Florida. However, this data has since been obtained for North Carolina and Mississippi, and more information on areas of biodiversity significance region-wide will likely be obtained from the Association of Biodiversity Information (ABI). This additional biodiversity has been incorporated into the modeling process to prioritize specific areas of the SEF for biodiversity protection, and should also be used to enhance future iterations of the SEF.

Overall, the FEN contains more specific biodiversity information that is more consistent with efforts to identify reserve networks than does the SEF. This should not, however, be used to discount the modeling efforts used to delineate the SEF. As mentioned above, state-of-the-art biodiversity analyses and reserve design processes are developing rapidly. Though all of these efforts will provide more detailed biodiversity information in the near future, none of them are yet specific enough to answer all of the detailed questions about sites, area sizes and conditions needed to protect viable populations of all species of conservation interest. In general, there are currently no comprehensive regional biodiversity assessments available, and both the FEN and the SEF are based on the best information available at the time of the assessment. Ideally, future iterations of the SEF model will incorporate additional biodiversity information from these and potentially other initiatives.

Furthermore, the SEF is meant to be more than a biodiversity assessment and reserve design tool. It can also be termed a "green infrastructure rapid assessment technique" used to identify not only important areas for biodiversity but also areas significant for maintaining ecosystem services that support human communities (Benedict 2000). Though more specific information and analyses of hydrological processes, key watersheds, air quality, and other indicators of ecological integrity and ecosystem services would be valuable, the focus of the SEF analysis on large wetland basins, intact riparian buffers, large forested areas, and intact coastal lands serves as a useful first step for identifying the areas potentially most important for maintaining water quality, air quality, flood control, and storm protection. The SEF can be considered to be a rapid assessment tool for quickly identifying larger intact landscapes and other important areas of ecological significance for both biodiversity and ecological services using the best available information. As with biodiversity data, as better hydrological, air quality, and other ecosystem service and ecological process data becomes available, such data should be incorporated in future iterations of the SEF and in other regional models where SEF methodology may be applied. In addition, Region 4 EPA, with the help of the University of Florida, is conducting an ecological framework assessment for the Mississippi Delta that incorporates more information on ecological restoration priorities, which could be used as a modified approach to the modeling process in regions with higher levels of disturbed ecosystems.

One of the most discussed issues in the development FEN modeling process was the determination of the minimum hub size. Several participants felt that areas at least as small as 1000 acres should also be considered because areas do not have to be 5,000 acres or larger to be ecologically significant and because the completed Florida Ecological Network could draw attention away from the conservation significance of smaller, isolated tracts. The same size threshold was used to identify Hubs within the SEF modeling process. Therefore, it should be clear to all potential users of this information that delineation of the SEF focuses on the larger areas of ecological significance and the opportunities for connectivity between these areas. However, isolated sites can also contain critical elements of biodiversity or have other ecological significance that should be considered in other conservation planning projects (Forman 1995; Shafer 1995). As stated in the results section, the PEA and SEA data layers do identify some smaller areas of significance and therefore these data layers should be assessed for their utility in conservation planning efforts at smaller scales.

One primary issue in efforts to protect ecological connectivity represented by the Southeastern Ecological Framework is roads. Although there are some significant roadless areas that were identified and incorporated into the SEF, the Southeastern United States is generally covered by a dense highway and road system that promotes habitat fragmentation, the isolation of populations of sensitive species, roadkills, and various negative hydrological effects. Approximately 150,000 kilometers of roads cross the SEF and 79% of the SEF is within 1 kilometer of a road. Also, 70% of the SEF has a road density greater than 1 mile per square mile, which is considered to be an important threshold for the potential of areas to support species sensitive to road impacts including black bears and other wide-ranging species (Thiel 1985; Pelton 1986; Van Dyke et al. 1986; Mech et al. 1988; Noss 1992; Noss and Cooperrider 1994). Clearly there is a need to retrofit the existing road system to minimize habitat fragmentation and other ecological impacts associated with roads if ecological connectivity and integrity are to be restored. The Florida Department of Transportation has made significant progress to address existing impacts and to avoid future conflicts (Foster and Humphrey 1992; Roof & Wooding 1996; Smith 1999). The EPA should work closely with the U.S. Department of Transportation, the Federal Highway Administration, and the state departments of transportation to use existing funding sources and develop new ones to support planning and retrofitting that will increase the compatibility of our road systems with the natural resource conservation objectives forwarded by the SEF.

The identification of areas of ecological significance and the design of reserve networks must be an iterative process to be successful. New information and technology will continue to become available and must be considered. In fact, one could argue that the work has only just begun with the first iteration of an ecological network or framework. Furthermore, the SEF can serve as a catalyst that creates better opportunities for enhanced iterations or assessment techniques by fostering discussion and leading to partnerships. In our experience, the FEN and the SEF help people and organizations better visualize the concept of regional scale ecological and biodiversity planning. This important step then provides the opportunity for more discussion about available data and assessment methods that can strengthen future iterations. The SEF has already lead to discussions with organizations such as The Nature Conservancy about integrating additional biodiversity information sources and analyses into a much more comprehensive effort in the future. These discussions should also lead to the development of similar applications in other regions, and we look forward to working with the EPA and other partners to apply this concept beyond the Southeastern United States.

Section III: Applications of the Southeastern Ecological Framework

A. INTRODUCTION

Once important landscape features have been identified, there are a myriad of applications and protection strategies available. Those of greatest interest to the EPA are strategies consistent with their regulatory authorities, e.g., protection of drinking water and air quality. For these approaches, the SEF can help focus resources on critical areas, heightening scrutiny of permit reviews and directing resource allocation towards sensitive areas. For governmental entities with conservation land acquisition programs, whether federal, state or local, the SEF can help identify areas that should receive priority consideration. Similarly, the SEF is potentially useful to land trusts and other conservation oriented non-governmental organizations that want to strategically focus their conservation programs. Lastly, the SEF has great potential for local governments where most responsibility for land use decision-making rests. Use of the SEF can help identify those areas for which local regulatory protections are most deserved.

a. EPA Applicability

The Southeastern Ecological Framework is an innovative approach to land use decision management across EPA program responsibilities. It provides the opportunity for program managers to visualize their responsibilities in the context of the ecosystem as a whole, rather than the traditional stove pipe perspective. A narrow or single focus perspective may have served EPA well in the past, when Congress provided money for specific mandated activities. However, the days of walking down a rivers edge and identifying the bad guys are gone for the most part. New culprits are often non-point sources or the cumulative impact of a dozen facilities that are all meeting best management practices, individually, yet whose combined impact is debilitating. To address these issues, program managers are going to have to be aligned with other programs both within and outside their division, across federal agencies and with various partners at the state, local and community level.

New approaches to creating synergy for environmental protection will have to be designed if progress is to continue. The SEF provides such an opportunity for coordinating and prioritizing EPA's work. This is evident in the support that SEF provides for five of the agency's Strategic Planning Goals (See Table 1).

Table III-1. The Southeastern Ecological Framework as a Decision Support Tool to Achieve EPA Goals and Objectives.

Goal 1: Clean Air
Objective 1.1. Attain NAAQS. Reduce the risk to human health and the environment by protecting and improving air quality so that air throughout the country meets national clean air standards by 2005 for carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead; by 2012 for ozone; and by 2018 for particulate matter (PM). To accomplish this in Indian country, the tribes and EPA will, by 2005, have developed the infrastructure and skills to assess, understand, and control air quality and protect Native Americans and others from unacceptable risks to their health, environment, and cultural uses of natural resources.
S-O 1.1.1 Attain Ozone NAAQS. By 2012, air throughout the country meets the national standards for ozone.
S-O 1.1.2. Attain PM NAAQS. By 2018, air throughout the country meets the national standards for PM.

Goal 2: Clean and Safe Water

Objective 2.1 Ensure Safe Drinking Water and Recreational Waters. By 2005, protect human health so that 95 percent of the population served by community water systems will receive water that meets health-based drinking water standards, consumption of contaminated fish and shellfish will be reduced, and exposure to microbial and other forms of contamination in waters used for recreation will be reduced.

S-O 2.1.3. Protect Source Water and Manage Injection Wells. By 2005, demonstrate the effectiveness of both voluntary and regulatory activities to protect sources of drinking water by (1) ensuring that 50 percent of the population served by community water systems will receive their water from systems with source water protection programs in place and (2) managing identified, high-risk Class V wells in 100 percent of priority protection areas (e.g., wellhead, source water, sole source aquifer) and all Class I, II, III injection wells.

Objective 2.2. Protect Watersheds and Aquatic Communities. By 2005, increase by 175 the number of watersheds where 80 percent or more of assessed waters meet water quality standards, including standards that support healthy aquatic communities. (The 1998 baseline is 501 watersheds out of a national total of 2,262.

S-O 2.2.2. Increase Wetlands Area. By 2005, and in each year thereafter, the work of federal, state, tribal, and local agencies; the private sector; hunting and fishing organizations; and citizen groups will result in a net increase of 100,000 acres of wetlands.

Objective 2.3 Reduce Loadings and Air Deposition. By 2005, reduce pollutant loadings from key point and nonpoint sources by at least 11 percent form 1992 levels. Air deposition of key pollutants will be reduced to 1990 levels.

S-O 2.3.2. Reduce Nonpoint Source Loadings. By 2005, through the work of federal, state, tribal, and local agencies and the private sector, nonpoint source loadings (especially sediment and nutrient loads) will be reduced or prevented, including a 20 percent reduction from 1992 levels of erosion from cropland (i.e. reduction of 235 million tons of soil eroded).

Goal 6: Reduction of Global and Cross-Border Environmental Risks

Objective 6.2. Reduce Greenhouse Gas Emissions. By 2010, U.S. greenhouse gas emissions will be substantially reduced through programs and policies that also lead to reduced costs to consumers of energy and reduced emissions leading to cleaner air and water. In addition, EPA will carry out assessments and analyses and promote education to provide an understanding of the consequences of global change needed for decision-making.

S-O 6.2.2. Implement International Commitments Under FCCC. Through 2005, the United States will continue to implement its international commitments under the Framework of the Convention on Climate Change regarding greenhouse gas emissions, sequestration, and education. EPA will formulate policy options and analyze their economic and other implications to support U.S. decision- making and catalyze developing countries to adopt and meet international commitments.

Goal 7: Quality Environmental Information

Objective 7.2 Provide Access to Tools for Using Environmental Information. By 2006, EPA will provide access to new analytical or interpretive tools beyond 2000 levels so that the public can more easily and accurately use and interpret environmental information.

S-O 7.2.2. Develop Tools to Query Data and Provide Access to New Types of Data. By 2006, EPA will develop new analytical tools that will enable all stakeholders and state and tribal partners to query data for their own specific purposes; provide access to new types of environmental or health data that are relevant to localities; facilitate the public=s ability to access and use Agency, state, and other data; and increase by 10 percent, compared to 2000, the number of communities with real-time, geographically-based environmental information.

Goal 8: Sound Science, Improved Understanding of Environmental Risk, and Greater Innovation to Address Environmental Problems

Objective 8.1 Conduct Research for Ecosystem Assessment and Restoration. Provide the scientific understanding to measure, model, maintain, and/or restore, at multiple spatial scales, the present and future integrity of highly valued ecosystems.

Objective 8.5 Quantify Environmental Results of Partnership Approaches. Increase partnership based projects with counties, cities, states, tribes, resource conservation districts, and/or bioregions, bringing together needed external and internal stakeholders, and quantify the tangible and sustainable environmental results of integrated holistic, partnership approaches.

Objective 8.6 Incorporate Innovative Approaches. Incorporate innovative approaches to environmental management into EPA programs, so that EPA and external partners achieve greater and more cost-effective public health and environmental protection.

S-O 8.6.2 Make Innovations in Core Agency Functions and Perform Program Evaluation. EPA will make innovations in its programs and culture according to the strategic opportunities that its partners, its stakeholders, and the private sector will help identify by the use of pilot projects capable of being transferred into core functions such as permitting, rule writing, and compliance. In addition, EPA will build its capacity to perform program evaluations in order to improve Agency programs and practices.

Objective 8.7 Demonstrate Regional Capability to Assist Environmental Decision Making. Demonstrate regional capacity to assist environmental decision-making by assessing environmental conditions and trends, health and ecological risks, and the environmental effectiveness of management action in priority geographic areas.

The first goal that SEF supports is improvements to air quality that fall under the attainment of National Ambient Air Quality Standards (NAAQS) objective. Two sub-objectives are most relevant to the SEF. The first is attainment of ozone standards through the cooling effect of vegetation within the SEF. Vegetation, primarily forested areas within the SEF, provides cooling through evapotranspiration and a lowering of urban heat island temperatures. This benefit also indirectly impacts the reduction of peak energy consumption during the summer months and lowers the emissions of other NAAQS gases. The second sub-objective directly related to the forested vegetation in the SEF is support of PM attainment. This is provided by the cleansing properties of the forested land within the SEF.

The SEF supports the first three objectives under Goal 2. The first objective to ensure safe drinking water and recreation waters is met through the protection of source water. The recent request for proposals noted below highlights one approach that could use the SEF:

> “The EPA is seeking proposals from organizations interested in working with communities to protect their drinking water sources from contamination through a resource- or geographic-based planning approach. Communities involved in these efforts will have completed source water assessments, and must be served by public water systems that are highly or moderately at risk of contamination. EPA funds will be used for training and technical assistance to these communities, with the goal of establishing sustainable source water protection programs.”

Through the geographic identification of public water systems at moderately or high risk within the SEF, inclusion of the SEF as priority areas for protection of ecological services could be incorporated in the communities sustainable source water protection program. Objective 2.2 focuses on the protection of watershed and aquatic communities. The second sub-objective focuses on increasing wetlands area by 100,000 acres. Through the identification of low-lying areas within the SEF, opportunities for wetland restoration can be targeted. In support of the third objective for Clean and Safe Water, the reduction of nonpoint source loadings impacting the SEF can be prioritized by croplands that are within or upstream of the SEF.

Third, the objectives for Goal 6 are met through the SEF specifically through the implementation of carbon sequestration strategies to reduce national greenhouse gas emissions.

The Fourth goal supported by the SEF is under Goal 7. The crux of the SEF applicability to meeting the second objective of providing access to tools for using environmental information falls under the development of tools to query data and to provide access to new types of data that are relevant to localities. The SEF as a decision support tool is currently being used by a number of local communities. Bartow County, Georgia has just completed their greenspace plan using the SEF as a fundamental piece of information in developing their greenspace strategy. Additional information and similar activities are listed in the next section.

The final goal of significant relevance to EPA's mission is Goal 8. This goal involves the use of innovation to address environmental problems. Four objectives are met under Goal 8. The first objective is to provide scientific understanding to measure, model, maintain and/or restore, at multiple spatial scales, the present and future integrity of highly valued ecosystems. The SEF falls in direct line with the pursuit of this objective. Although additional research needs to be conducted to accurately measure the impact the SEF has on protecting ecosystem services, the model does provide a visual queue of the potential interface between urban and natural lands. The second objective relies on the results of partnerships. The easiest method to quantify results is the placement of land within the framework into some form of conservation or easement status. Additional methods for quantifying benefits from protecting land need to be developed and are being looked at from each of the agencies involved in the Southeast Natural Resources Leaders Group. Murray County, Georgia is partnering with the SENRLG in the development of their comprehensive land use plan. The approach to greenspace protection using the SEF will be developed as a case study for supporting other partnerships in the future. The primary interest in the case study is the quantification of resource protection and resulting environmental benefits.

The third objective is specific to the integration of innovative approaches being used to support EPA programs. Examples of this integration in Region 4 include wellhead protection programs, NPDES permitting in light of Total Maximum Daily Load issues, and review processes such as those required under the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA). The final objective is the demonstration of regional capability to assist environmental decision-making. Examples of these applications are listed in the following sub-section and three specific examples are included within this Workbook.

The most significant advantages provided by the SEF are the ability to focus, prioritize and leverage existing EPA programs. This enables targeted decision-making in the daily activities of program managers. The following are brief explanations of program implementation opportunities that Region 4 is moving forward with at this time.

National Environmental Policy Act (NEPA) programs in Region 4 are working to use the framework, in the context of environmental impact statement reviews, as a tool for screening federally funded projects that adversely impact the SEF. Projects that fall within the SEF hub and corridor network can be given a higher level of review based upon project impacts to important ecological corridors or based upon the total framework acreage impacted by a single project within a given watershed. This approach is particularly useful in evaluating the potential environmental impacts resulting from proposed highway construction. The use of SEF allows the NEPA reviewer to give quick and early notification of environmental concerns regarding the Environmental Impact Statement or Environmental Assessment for transportation projects. The SEF can also provide transportation agencies with assistance in determining alignments that will avoid impacts to ecologically significant lands in the southeast at the onset of their planning process, when it is still economically feasible as opposed to the end of the planning process where it often occurs. This process is being utilized at the present time in the alignment of the I-69 corridor in the Mississippi Delta (see Map 3 for details on corridor realignment based on ecosystem integrity). See the Federal Agency Applications under Federal Highway Administration and U.S. Forest Service for additional insights to the I-69 Corridor and applications being developed around this issue.

National Pollutant Discharge Elimination System (NPDES) program is beginning to think about how to evaluate total point source; non-point source and land cover impacts to water quality within the SEF. The approach hopes to be able to calculate impervious surface and agricultural run-off in relation to the native landscapes and riparian buffers to gain some insight to the assimilative capacity of the natural areas. The approach could have significant implications in helping to quantify benefits from the SEF in meeting Total Maximum Daily Load (TMDL) limits. The hope is that communities will use natural landscapes as a tool for complying with TMDLs while also supporting other EPA.

Supplemental Environmental Projects (SEPs), as a tool for mitigating adverse environmental impacts from facilities that are out of compliance with environmental regulations, could provide a unique opportunity for EPA to protect areas in the SEF. The development of guidance on how protection of specific areas in the framework could address land, air and water issues will be important. Headquarters knowledge of the SEF and its applicability to sustaining ecosystem function is important to the overall integration of the SEF into this program area. An example of the approach is illustrated by current efforts to have the City of Mobile, Alabama meet their Consent Decree for water violations through the protection of greenspace within the SEF that supports improved water quality. The SEP guidance in this example is targeting potential locations in the SEF that meet Brownfield requirements, fall within identified Environmental Justice communities and support water quality protection through wetland protection. Region 4 attorney's recently submitted the SEP opportunity to the party in violation.

Wetlands Program Office is working to identify road development mitigation banks for wetlands that are of like type, fall within the same watershed, are within the same ecological unit and provide protection of wetlands within the SEF. Development of a methodology for identifying like wetland types is underway to meet this criterion. With the vast number of permits that the Wetlands Program Office must review, the limited staff and the amount of time required to complete an effective review of wetland disturbance impacts this processes will help to target areas that may be of greater concern to the overall function of ecological processes. As a landscape feature of convergent hydrology, wetlands require the surrounding uplands to have adequate protection in order to function. The SEF provides a way of integrating wetlands mitigation into a larger scale ecological context.

Drinking Water and Watershed Protection are areas that have potential uses for the Southeastern Ecological Framework. Integrating watershed protection with drinking water source protection, wellhead protection and wastewater treatment programs can provide a big picture view of what is happening in a watershed. This synergy of program activity provides internal co-benefits for EPA programs. It is the use of the framework as a catalyst for synergy that is the primary focus of Region 4's internal program activities.

b. Other Federal Agency Applicability

The ability to leverage programmatic funding from other agencies has been recognized by the Southeastern Natural Resource Leaders Group (SENRLG) as a key to effective natural resource management. This organization, comprised of the Regional Directors of each federal (natural resource) agency in the Southeast, has identified regional issues of concern that support individual agency missions. Although specific agencies may take the lead on certain issues based on available funds and authority, each member agency provides staff time to this collaborative project. A few examples that have evolved from the partnership are noted below.

US Forest Service (USFS), Federal Highway Administration (FHWA), and EPA agreed in August of 2000 to be the lead agencies in a cooperative information gathering effort regarding the natural resources of the Mississippi Delta. This effort was intended to serve a variety of resource protection programs in the region, but specifically to be applied to the pre-planning phases of a new highway slated to run through the Delta: I-69. EPA and the USFS have spearheaded efforts to collect all available ecological data in the Delta. These data are being fed into the SEF to be used as a pre-planning decision support model regarding impact avoidance, minimization, and mitigation. To this end, a version of the SEF is being developed for the Delta to identify areas of high ecological value and their best potential linkages. The initial analysis is focusing primarily on the conservation and potential restoration of: wetlands, bottomland hardwood forests and habitat diversity. The product was finished in October 2001.

Department of Defense (DOD), Tennessee Valley Authority (TVA), Fish and Wildlife Service (USFWS), USFS and US Army Corp of Engineers (ACE) are working together to purchase approximately 50,000 acres of silvicultural and natural lands within the Southeastern Ecological Framework that is targeted for second home development on the Kentucky/Tennessee boarder. There are currently significant holdings of existing public lands in the area that are held by each of the lead agencies. DOD is the primary lead on the land purchase because of an identified need to provide additional training grounds for helicopter maneuvers. An activity that is not conducive to the up scale development that is being planned or the ensuing encroachment of people near their existing training facilities. USFWS identified the opportunity to buffer existing wildlife refugees and TVA has electric power generating facility responsibilities in the.

Federal Highway Administration is taking the lead on a multi agency program in association with the Florida Department of Transportation (FLDOT) to streamline road planning. The project will utilize the SEF to help flag potential problems in the early phases of road planning activities. The streamlining processes targets wetland mitigation and/or restoration opportunities for impacts that cannot be avoided. Opportunities for developing land bridges to sustain critical links within the framework can also be identified with the streamlining approach. The early identification of road development issues is also being utilized in evaluating preliminary corridor routing for the I-69 corridor.

c. State and Local Agency Applicability

The SEF and components thereof can provide a critical tool for formulating state and local connectivity strategies in urban and rural areas. Inclusion of community place-based priorities provides a fundamental component to connecting a local fishing hole, neighborhoods, bike trails, schools, and local businesses into a complete picture of the landscape fabric that enhances connectivity and improves quality of life. The SEF also has the potential to significantly contribute the development of statewide conservation plans at the state and sub-state scales. Following are some examples of potential applicability.

Mississippi and Tennessee State Performance Partnership Agreements (PPA) are using the SEF to direct natural resource protection through performance standards agreed to between EPA and the respective state. Mississippi's PPA has been signed with a request to identify priority wetlands and critical ecological areas for conservation efforts. Mississippi expects to receive 85 million dollars for ecosystem protection and easement work that will also support water quality and air quality objectives agreed to by both parties. Tennessee's PPA, although not yet completed, has requested information on the interface of significant natural resources and urban sprawl. Initial work has been submitted to Tennessee on priority greenspace protection efforts and Region 4 expects to hear comments on the products developed.

North Carolina's Million Acre Initiative proposed by Governor Hunt is an attempt to identify critical lands for protection. EPA has provided the SEF to North Carolina for inclusion as a layer in their prioritization process. EPA has also provided data to North Carolina's Emergency Management Agency to identify flood prone areas for the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Program.

Georgia's Community Greenspace Program has identified the 20 fastest growing counties in the state to share an initial 30 million dollars for permanent protection of 20% of the available land in each county. Bartow County has incorporated the SEF into their greenspace planning processes. Counties that are reviewing the framework as a component of their protection efforts include: Bibb, Cherokee, Effingham, Coweta, Floyd and Fayette. The State of Georgia is also reviewing the SEF as a tool in the development of their proposal to the Natural Resource Conservation Service (NRCS) for an Enhanced Conservation Reserve Program (CRP) that will allow the state to target conservation easements within the context of the framework and allow prioritization of CRP funds. The Georgia Buffer Initiative, funded with EPA 319 dollars, is also planning to prioritize their grant dollars to local community groups that identify areas located within the framework.

d. Applicability for Nonprofit Organizations

Many non-profit groups are already utilizing the framework for strategic planning. A number are focused on specific watersheds or ecoregions with an ultimate goal of protection of streams and rivers. The majority of Southeastern Ecological Framework corridors are riparian buffers. This provides an excellent opportunity to work with many of these watershed groups within the context of water quality protection through land conservation.

Trust for Public Land, The Nature Conservancy and the Georgia Conservancy are developing a Chattahoochee Riverway corridor starting at the headwaters of the river. The goal is to purchase conservation easements or property for a stretch of 168 miles on either side of the river. The organization has completed a real time monitoring program for water quality and is evaluating a process to provide the same information for the major tributaries. EPA is providing GIS analysis of watershed characteristics as well as the SEF. This will lay the foundation for the programs second phase, which is developing a comprehensive watershed strategy for the Upper Chattahoochee watershed.

Georgia Conservancy's Blue Print for Sustainable Communities program is currently using the Southeastern Ecological Framework as the basis for watershed protection in the Middle Chattahoochee Watershed. The Blue Prints program is composed of businesses, state, local and city governments, private citizens, federal agencies, state universities and non-profit organizations primarily from Columbus, Georgia. The group is working to develop land use plans, zoning ordinances and greenspace protection efforts that will protect the quality of life in the region. Areas within the framework will be given special consideration in the development of a strategic plan for the rapidly developing Mulberry Creek sub-watershed as a pilot.

Defenders of Wildlife has included the SEF in their long-term strategic plan for the southeast. The SEF will be used to help further target their efforts in habitat and biodiversity protection for the region.

B. SPECIFIC APPLICATIONS OF THE SEF RESULTS AND MODELING PROCESS

The three following applications are provided to extend the utility of the SEF analysis and to also provide examples of how the SEF data and methods can be used in similar conservation planning applications at various scales. The first application is an extension of the SEF analysis where data used in the delineation of the SEF and additional data sets acquired since have been integrated into a regional analysis to further characterize important natural resources in EPA Region 4 and prioritize areas within the SEF. The Mississippi Delta Framework project provides an example of how additional data sets and design criteria can be used to delineate an ecological framework at a sub-regional scale. The Delta Framework project also provides considerations for delineating areas of ecological signficance and restoration priorities within a landscape dominated by agricultural uses. The Murray County, Georgia analysis considers how the SEF data and analytical methods may be relevant to conservation planning at the local scale. Together, these three application should increase the utility of the SEF data and provide insights and methods to incorporate SEF methodology into conservation planning projects at various scales.

Section IV: Regional Application: Prioritization of the Southeastern Ecological Framework

A. INTRODUCTION

Prioritization of the Southeastern Ecological Framework was conducted to identify areas that are most signficant for natural resource protection activities across EPA Region 4. Since time and funding are always limited, it is important to identify the areas of highest priority to help focus resource protection efforts. The following includes various methods and examples for assessing priorities both regionally and specifically within the SEF. These assessments may be most pertinent to region-wide and state conservation programs, but some analyses and combined results may be useful for conservation planning efforts at smaller scales as well. This assessment is a first iteration and an example of how priorities can be identified, but data and analyses that could be used to enhance future efforts will also be discussed.

B. TYPES OF PRIORITIZATIONS

The purpose of the prioritization phase of the Southeastern Ecological Framework (SEF) Project was to identify areas within the framework that are of a higher priority for conservation attention and protection. To accomplish this goal, prioritization was completed for three distinct areas: the entire eight state region (including a version clipped to the boundaries of the SEF), all hubs, and all linkages. This multi-geographic unit approach was taken because of the nature of the methodology used to create the SEF (See the methodology in the SEF report for more details). Ecological hubs are the backbone of the SEF, and are defined as contiguous priority ecological areas after the exclusion process (PEAXs) that are 5000 acres or greater. Some hubs may contain lands matching only one PEA criterion while other hubs may contain lands matching multiple PEA criteria. Also, through the process of hub optimization, gaps within hubs are filled when suitable land uses are available and the edges of the hubs are smoothed. This process can cause some variation in the amount of PEAs that comprise hubs. Prioritization identifies where the overlaps or potential "hot spots" of priority areas occur within hubs.

Linkages, if protected, provide potential opportunities for connectivity between hubs, and are designed to traverse the best quality lands available between hubs. However, optimal habitat is not always available, and some linkages must cross less than optimal lands. Since linkages are created with less stringent criteria than hubs (i.e., lands included are not required to meet PEA criteria), they are generally comprised of lands that match fewer PEA criteria or are otherwise of lower priority. As a result of these differences between hubs and linkages, it is logical to evaluate and prioritize each separately.

The prioritization of the entire region provides an opportunity to identify other areas of significance that may not be contained within the boundaries of the SEF. These analyses included data that was not available when the SEF was delineated and therefore provide additional opportunities to characterize and prioritize natural resources of significance regionwide. The regional prioritization is done cell-by-cell, which means that the entire region is broken into similar sized units (90 meter squares) and prioritized based on a number of different criteria. These results can also be “clipped” to the SEF boundaries, which then shows priorities throughout the framework for hubs and linkages combined.

For both the hub and regional prioritization analyses, four categories of prioritization were completed: Ecosystem Services, Biodiversity, Threats, and Recreation Potential. For hubs there was an additional category, Hub Structure and Function, (discussed in more detail in the Hub Prioritization Section, Part 2. A). Prioritizations were categorized in this manner because areas in the SEF have significance for various ecological criteria and it may not be suitable to combine and compare areas that have values for different categories of ecological significance. For example, it would not be useful to compare one area that has high biological diversity and another area that has high aquifer recharge, and determine one to be more important than the other. Rather it makes more sense to compare areas that have similar intrinsic values in an effort to identify high priority areas of a similar function.

Linkages were prioritized in several different categories including Internal Structure, External Context, Width Analysis, and Hub Ranks. These categories are meant to rate linkages based on both their quality to serve as functional connectors and the significance of the hubs that the linkages connect.

a. The Single & Multiple Utility Assignment Ranking System

In this prioritization phase, a ranking system involving the use of SUAs (Single Utility Assignments) and MUAs (Multiple Utility Assignments) was used to prioritize the Southeastern Ecological Framework and its components (hubs and linkages). Using this method, varying measures of priority are transformed into a common ranking system, from which multiple datasets can be compared and combined (ESRI 1996). This transformation is accomplished through reclassification of the data into a common interval scale of values, in this case, from 1 to 10.

First, individual SUAs are created for each desired prioritization criteria. A SUA is a dataset that has been reclassified into an interval scale of values and is ready for comparison and combination. In this prioritization phase, each SUA has been reclassified into values from 1 to 10, with one representing the lowest priority areas and ten representing the highest priority areas.

In most cases, the reclassification produces ten categories, and each category is assigned a priority rank from 1 to 10. In a few cases, some SUAs have been reclassified into less than ten categories, but the priority ranks assigned to each class still range from 1 to 10, with the lowest and highest ranks (1 and 10) always being represented. For example, some individual SUAs have been reclassified into only 2 categories, which generally signifies the presence or absence of a feature or phenomenon. In this case, the absence of the feature represents the low priority category and is assigned a rank of 1 and the presence of the feature represents the high priority category and is assigned a 10.

After reclassification, the individual SUAs were combined to create MUAs (Multiple Utility Assignments) dependent upon the category of the analysis. For example, all individual regional biodiversity prioritization SUAs were combined to create a regional biodiversity MUA to delineate areas of highest potential significance for biological diversity in the region and the SEF.

For the regional prioritizations, all areas in the region receive a priority rank from 1 to 10. For the hub and linkage prioritizations, all hubs and linkages receive priority ranks from 1 to 10, and all other areas receive a zero value.

b. Reclassification Methods

The process of reclassification involves dividing the data into ranges and assigning utility values from 1 to 10. The primary methods of reclassification used are equal interval, equal area, and natural breaks. Equal interval separates the data into equal intervals based on the range of the data. It is useful for reclassifying continuous data such as distance and proximity analyses. Equal area distributes the data so that each class has an equal number of cells. It is useful for creating a more equal spatial distribution of values, particularly with datasets that are not normally distributed, may be highly skewed, or have outlier values. For example, in the species hotspots dataset there are many areas that have low numbers of species and only a few areas have high numbers of species. Use of an equal interval reclassification method would result in very little area receiving a high ranking, whereas the use of equal area results in a more even spatial distribution and ranking of values where a wider range of areas with significant biodiversity values receiving high ranks. Natural Breaks is a classification method based on Jenks' Optimization Method (algorithm), which groups data into like categories. Using natural breaks, data are grouped so there is a minimum difference within each data class and a maximum difference between classes.

The classification method used for each suitability surface was chosen based upon the data distribution and how well the data would be distributed amongst the ten classes. The desired result was a range or gradient of ranked areas that represent the overall distribution of the original data.

Most SUAs were ranked using either equal interval or natural breaks. However, the MUAs were ranked using equal area in order to spatially distribute the values into ten equivalent geographic classes, in which each class is representative of 10% of the total land area in the region or one of the SEF components. The highest priority sites are then considered to be those areas that fall into the top ten percent.

C. METHODS

Due to the complexity and space required to discuss the details of the prioritization methods, the methods section with the primary body of this report are limited to basic descriptions of the types of anlyses used. For more details, two appendices are provided. Appendix D contains a summarized version of methods that provides more detail on data used and techniques. Appendix E contains the technical methods intended for use by those interested in potentially recreating or using similar methods for other projects. Only a basic description of the prioritization analyses is included here so please refer to Appendix D or Appendix E for more details.

a. Regional Prioritizations

i. REGIONAL PRIORITIZATIONS: ECOSYSTEM SERVICES

Ecosystem or ecological services are ecological processes and functions provided by natural and semi-natural areas that help sustain or enhance human life (Daily 1997). Primary ecosystem services include water and air protection and purification, flood and storm protection, functional nutrient cycling, etc. The ecosystem service prioritizations are based on available data and techniques. Other analyses including water and air purification assessments could be added in future iterations.

1. Surficial Aquifer Areas Vulnerable to Pollution

U.S. Environmental Protection Agency (USEPA) and the National Water Well Association (NWWA) developed a method to map potential aquifer vulnerability to pollution. The analysis, referred to by the acronym DRASTIC, depicts areas which are more or less sensitive to land use changes which may affect ground water quality. This prioritization identifies areas in the region that are most vulnerable to surficial aquifer pollution, and hence most important for protecting ground water. A regional DRASTIC analysis, created by EPA Region 4 Planning & Analysis Branch, was used to delineate these vulnerable areas.

2. Size & Proximity to Wetlands

Functional wetland systems are important for protecting water resources as they operate as a natural filter, trapping sediments and toxins from water before it percolates into the aquifer. Larger wetland areas are arguably more important for protecting water resources, as they retain the ability to filter larger volumes of water. Areas adjacent to wetlands are also important in moderating edge effects from neighboring intensive land uses, and offering additional filtering functions. This analysis ranks wetlands and adjacent areas based on the size of the wetland and proximity to wetlands.

3. Surface Water Source Priorities

As a basic assessment of priority areas surrounding surface water sources for potable water, surface water intake points obtained from EPA were prioritized using population numbers associated with each surface water source point. Surface water intake points were buffered by 5 miles to indicate a potential area of influence around the intake point. Although this analysis is fairly coarse and more detailed analyses of watersheds important for drinking water are needed, it does indicate immediate areas of interest around surface water intake points prioritized by the size of the population served.

4. Ground Water Source Priorities

As a coarse assessment of priority buffer areas adjacent to ground water sources, ground water intake points obtained from EPA were prioritized by a proximity analysis, where buffer zones within 1 mile of an intake point were identified.

5. Major and Wild and Scenic River Buffers

Protection of riparian zones and additional upland buffers around rivers should be a high priority. To indicate the significance of areas adjacent to rivers within Region 4, lands adjacent to all major rivers and Wild and Scenic Rivers were identified.

6. Coastal Storm Protection Areas

Intact natural and semi-natural land cover within coastal areas can be important for minimizing storm damage related to coastal storms and especially hurricanes. As a surrogate for more specific FEMA data on coastal surge and flood areas, an analysis was created which identified all natural and semi-natural landcover in coastal areas and prioritized these areas by size.

7. Shellfish Harvest Area Buffers

Approved coastal shellfish harvest areas must meet certain water quality standards to remain open to harvest. Although water quality within estuaries is dependent on all freshwater inflows, immediate buffer zones adjacent to estuaries harboring shellfish harvest waters are also important for maintaining water quality and hence were identified in this analysis.

ii. REGIONAL PRIORITIZATIONS: BIODIVERSITY

Biodiversity can be defined as the variety of life including genes, species, natural communities, and landscapes. Biodiversity is threatened by factors including habitat loss and fragmentation, negative ecological impacts associated with intensive land uses, alien or weedy species, etc. (Meffe and Carroll 1997). The following prioritizations all contain assessments relevant to identifying areas that are potentially most important for conserving biodiversity. This includes some information on areas containing the most species of conservation significance and areas that are most likely to support viable opportunities to conserve biodiversity. However, additional data on locations of species of conservation interest and natural communities and the identification of areas most important for conserving viable populations of such species will be important to enhance future iterations.

1. Conservation Lands Size Classes and Proximity

Existing public conservation lands and private preserves are focal areas for efforts to conserve biological diversity in most regions. As land transformation to agricultural, suburban, urban, and industrial uses continues on private lands, conservation lands become increasingly important for harboring intact natural communities and other components of biodiversity including listed species. Also, the theory and practice of reserve design for conserving biodiversity demonstrate that larger conservation areas will often have a better opportunity to maintain intact ecosystems with functional processes. Therefore, these areas are more likely to contain viable populations of species of conservation interest and to conserve biodiversity into the future. In addition, areas adjacent to existing public conservation lands and private preserves are very significant for effective conservation planning. Such lands can provide functional buffers for conservation lands, provide additional habitat for species of conservation interest, especially wide-ranging species, or can provide corridors or landscape linkages connecting existing conservation areas. In this analysis, existing conservation lands and adjacent areas were prioritized based on both the size of the existing conservation area and proximity to conservation areas.

2. Interior Forests

Interior forests are critical for conserving forest interior species and other forest dependent species including species that require large blocks of intact forest. Interior forests can be defined as forested lands that are sufficiently buffered from external effects or negative edge effects to provide intact forest habitat with interior conditions that are not edge-influenced. Although there are some limitations with using the National Land Cover Data set (NLCD) such as the inability to accurately identify pine plantations versus natural forests, this data can still be used to identify potential interior forests using all forest cover. In this analysis forest blocks not potentially disturbed by intensive land uses or roads were identified and then prioritized based on the size of the forest interior blocks.

3. Old Growth and Significant Longleaf Pine Forest Stands

Old growth forest and significant longleaf pine stands were identified using Forest Inventory Assessment (FIA) data as part of the Priority Ecological Area analysis for the Southeastern Ecological Framework.

4. Imperiled Species Priority Areas

As part of the book, *Precious Heritage: the Status of Biodiversity in the United States*, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). Their imperiled species analysis used the Environmental Protection Agency's EMAP hexagons (648.7 square kilometers) as a base unit to summarize the distribution of imperiled species across the United States. The prioritization analysis was created by prioritizing areas based on the potential number of imperiled species found in each area.

5. Listed Species Priority Areas

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). Their analysis of federally listed species used the Environmental Protection Agency's EMAP hexagons (648.7 square kilometers) as a base unit to summarize the occurrence of listed species across the United States. The prioritization analysis was created by prioritizing areas based on the potential number of listed species found in each area.

6. At-Risk Aquatic Species by Watersheds (HUCs)

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). The analysis of aquatic biodiversity was based on assessing the number of G1, G2, G3 aquatic species (fish and mussels only) found within watersheds represented by the U.S. Geologic Survey's eight digit Hydrologic Cataloguing Unit (HUC). The prioritization analysis was created by prioritizing areas based on the potential number of at-risk aquatic species found in each area.

7. Critical Watersheds for Aquatic Biodiversity

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). The critical watersheds analysis identified all of the watersheds (based on eight digits HUCs) needed to contain all fish and mussels species found in the natural heritage database. All such watersheds were given a high priority in this analysis.

8. Black Bear Habitat Suitability Analysis

This analysis creates a cumulative index of habitat suitability for Black Bears (*Ursus* *americanus*) in EPA's Region 4. The purpose of this analysis is to identify potentially significant habitat blocks and landscape linkages to promote long term viability of black bear within the Southeastern United States. Eleven individual analyses indicating relative significance for black bear habitat potential were created and combined into a single, cumulative index. These analyses were:

1. Potential Primary, Secondary and Tertiary Habitat
2. Potential Core Black Bear Habitat
3. Distance from Potential Core Black Bear Habitat
4. Ranking roadless areas based on size classes and percentage of primary habitat contained within
5. Diversity of Habitats
6. Land use intensity
7. Distance from intensive land uses greater than 100 acres in size
8. Distance from Primary roads
9. Conservation lands
10. Road density grid
11. Potential primary habitat in size classes

9. Size Classification of Priority Ecological Area after Exclusion

This prioritization ranked all PEAs based upon their size, where larger-sized PEAs received a higher rank. Since there is a direct relationship between patch size and species diversity (Forman and Godron 1986) and because larger patches are more likely to conserve viable populations and functional ecological processes (Meffe and Carroll 1997; Forman 1995), larger PEAs are considered higher priority.

iii. REGIONAL PRIORITIZATIONS: RECREATION POTENTIAL

The recreation potential prioritization was created to identify recreation opportunities in the region. In order to identify opportunities, the influence of urban areas, conservation lands, water based recreation and points of interest were evaluated.

1. Influence of Urban Areas

This analysis is a measure of recreational demand based on the population of urban hubs. The theory behind this analysis is that the demand for resource-based recreation services increases with increasing population.

2. Influence of Conservation Lands

This analysis relates level of resource based recreational service provided by existing conservation lands to the potential for recreation. The size of the conservation land is used as a surrogate measure of the potential level of service. The greater the level of service provided, the greater the potential to recreate.

3. Water Based Recreation

This analysis relates the association of water-based amenities and recreation potential. Water based recreational amenities are often the focal point of parks and public lands. Even when the land surrounding a water body is under private ownership, the water itself will still have recreational value. The entire economy of many coastal areas is driven by the attraction to the water. This analysis defines the level of recreational potential provided by the water-based amenities.

4. Influence of Points of Interest

Points of Interest are geographic locals that have an attraction because of their natural beauty and uniqueness, their recreational potential or their historical value and other factors. This attraction is the equivalent of recreation potential. In this analysis only those points of interests involving a natural or historical aesthetic were used.

iv. REGIONAL THREATS

The regional threats analysis incorporates two related analyses that assess the threats from intensive land uses and roads that can both negatively affect ecological integrity existing natural and semi-natural lands, and the likelihood that such natural, semi-natural and agricultural lands will be converted to residential or urban land uses.

1. Context Analysis: Landscape Viability Index

The purpose of this analysis was to create an index of threats to ecological integrity based on the intensity and proximity of potential disturbances.

2. Urban Growth Potential Model

The potential for future urban growth was modeled using a set of parameters that evaluates existing urban land uses and infrastructure (roads) as an indicator of future growth. The parameters used were: distance from roads; distance from urban areas; urban density at a small scale; and urban density at a large scale.

b. Hub Prioritizations

There are 1128 ecological hubs, which can be considered the backbone of the SEF. They are created by compiling all the PEA criteria and identifying contiguous areas of 5000 acres or greater. Hence, each hub contains one or more priority ecological areas (PEAs). Hubs were prioritized to identify hot spots of priority areas, to evaluate the types of priority areas contained within each hub, and to analyze hub shape and composition. There are five types of prioritizations used to evaluate hubs: ecosystem services, biodiversity, recreation potential, threats, and hub structure and function.

i. HUB PRIORITIZATIONS ADAPTED FROM REGIONAL PRIORITIZATIONS

Many of the ecosystem services and biodiversity prioritizations that were completed for the entire region were summarized by hub to enhance and complete hub prioritization. These prioritizations were necessary to complete at the regional scale, but also important to summarize by hub, as hubs serve as the building blocks of the ecological framework. Regional prioritizations were summarized by calculating the average rankings of each per hub.

The following regional prioritizations were summarized by hub:

Ecosystem Services:
Shellfish Harvesting Areas
Major Rivers and Wild & Scenic Rivers
Wetlands: Size and Proximity
Surficial Aquifer Pollution Vulnerability
Coastal Areas Storm Protection

Recreation Potential
Influence of Urban Areas
Influence of Conservation Lands
Water Based Recreation
Influence of Points of Interest

Biodiversity:
Critical Aquatic Biodiversity Watersheds
Threatened & Endangered Species
Imperiled Species
At-Risk Aquatic Species
Conservation Lands: Size & Proximity
Interior Forest Areas
PEA Classes
Potential Black Bear Habitat

Threats
Context Analysis
Urban Growth Potential

ii. HUB PRIORITIZATIONS: ECOSYSTEM SERVICES

Ecosystem or ecological services are ecological processes and functions provided by natural and semi-natural areas that help sustain or enhance human life (Daily 1997). Primary ecosystem services include water and air protection and purification, flood and storm protection, functional nutrient cycling, etc. These analyses ranking hubs based on their value for providing specific ecosystem services is based on data available for this first iteration. Additional data such as comprehensive watershed analyses for drinking water should be conducted in future iterations.

1. Number of Stream Start Reaches per Hub

This prioritization is used to rank hubs based on the number of stream start reaches that exist within each of the Hubs. Stream start reaches can be important for significantly influencing water quality in watersheds downstream, so hubs with high numbers of stream start reaches are more significant for protecting water quality than those with fewer start stream reaches.

2. Percent Wetlands per Hub

This prioritization is used to measure the amount of wetlands that exist within each of the hubs, and hubs with higher percentages of wetland receive higher ranks.

3. Spatial Mix of Wetlands and Uplands

This analysis identifies hubs with significant mixes of upland forests and forested or herbaceous wetlands. Hubs containing significant mixes of wetlands and uplands are more likely to have functional flooding and fire processes especially in the Southeastern Coastal Plain. Although this analysis is included within the ecosystem service section, such areas can also have important biodiversity values.

4. Surficial Aquifer Vulnerability to Pollution by Hub

For this analysis, the regional prioritization based on the EPA DRASTIC model of surficial aquifer vulnerability was summarized by hub.

5. Size of & Proximity to Wetlands by Hub

For this analysis, the regional prioritization for size and proximity to wetlands was summarized by hub.

6. Coastal Storm Protection Areas by Hub

For this analysis, the regional prioritization for coastal storm protection areas was summarized by hub.

7. Major and Wild & Scenic Rivers by Hub

For this analysis, the regional prioritization for major and wild and scenic rivers was summarized by hub.

8. Shellfish Harvesting Areas Buffer by Hub

For this analysis, the regional prioritization for shellfish harvesting areas was summarized by hub.

iii. HUB PRIORITIZATIONS: BIODIVERSITY

The following prioritizations all contain assessments relevant to identifying areas that are potentially most important for conserving biodiversity. This includes some information on areas containing the most species of conservation significance and areas that are most likely to support viable opportunities to conserve biodiversity. However, additional data on locations of species of conservation interest and natural communities and the identification of areas most important for conserving viable populations of such species will be important to enhance future iterations.

1. Topographic Diversity

This prioritization is used to rank hubs based on the topographic diversity that exists within each of the hubs. Hubs with greater topographic diversity are expected to have greater elevational gradients that may be significantly correlated with the potential to support biodiversity.

2. Size & Proximity to Conservation Lands

For this analysis, the regional prioritization for size and proximity to conservation lands was summarized by hub.

3. Black Bear Habitat Suitability Analysis

For this analysis, the regional prioritization for black bear habitat suitability was summarized by hub.

4. Interior Forests by Hub

For this analysis, the regional interior forests prioritization was summarized by hub.

5. PEA Size Classification

For this analysis, the regional PEA size classification prioritization was summarized by hub.

6. Imperiled Species Priorities by Hub

For this analysis, the regional prioritization for imperiled species was summarized by hub.

7. Listed Species Priorities by Hub

For this analysis, the regional prioritization for listed species was summarized by hub.

8. Aquatic Biodiversity

For this analysis, the regional prioritization for at-risk aquatic species was summarized by hub.

9. Critical Watersheds for Aquatic Biodiversity

For this analysis, the regional prioritization for critical aquatic biodiversity watersheds was summarized by hub.

iv. HUB PRIORITIZATIONS: RECREATION POTENTIAL

The recreation potential prioritization was created to identify recreation opportunities in the region. In order to identify opportunities, the influence of urban areas, conservation lands, water based recreation and points of interest were evaluated. These regional analyses were then summarized for hubs by calculating the average index value for each hub.

v. HUB THREATS

The regional threats analysis incorporates two related analyses that assess the threats from intensive land uses and roads that can both negatively affect ecological integrity existing natural and semi-natural lands, and the likelihood that such natural, semi-natural and agricultural lands will be converted to residential or urban land uses. These two regional analyses, the Context Analysis and Urban Growth Potential, were then summarized for hubs by calculating the average index value for each hub.

vi. HUB STRUCTURE AND FUNCTION

The goal of the hub structure and function prioritizations was to evaluate hubs based on their shape, size, and internal and external compositions. An optimal hub is one characterized by a low amount of edge habitat (low perimeter to area ratio), low internal fragmentation, high quality internal habitat, and surrounded by natural, semi-natural or generally low intensity land uses.

Principles of landscape ecology are used to evaluate patch characteristics, such as composition, size, and shape, in relation to the patch's ability to support viable ecosystems or natural communities. Patch composition, in terms of appropriate habitat and suitable land use, is important for providing adequate resources for species of conservation interest and functional ecological processes. Patch size is important because larger patches are more likely to support viable populations of species of conservation interest, functional ecological and evolutionary processes, and important ecosystem services. Patch shape is important as different shapes offer varying amounts of interior habitat. A circle is considered an optimal shape since it is the most compact shape, with the least amount of edge (perimeter) per area. The amount of edge habitat within a patch is important because the habitat composition and structure that is found in edge habitats differs significantly from the interior habitat (Forman and Godron 1986). Patches with more edge-affected habitat are more likely to have reduced ecological integrity associated with negative edge effects.

The land uses which surround hubs, or the external context (composition) of hubs, is also important because of the negative effects from high intensity land uses that can extend into the hubs. Negative effects include habitat loss and fragmentation, wildlife mortality from automobiles, runoff, soil erosion, proliferation of exotic and/or invasive plants, and noise and air pollution. Hubs surrounded by lower intensity land uses will be less influenced by these effects.

1. Internal Gaps / Hub Density

This analysis is used as measurement of the contiguity or density of each individual hub. Hubs with contiguous areas and minimum gaps or holes offer more suitable habitat areas with less opportunity for disturbance by poor land uses that may occupy areas within the overall hub.

2. Internal Context of Hubs: Percent PEA per Hub

This prioritization is used to measure the proportion of Priority Ecological Areas (after exclusion) that are contained within each hub. Hubs, by definition are PEAs after exclusion that are contiguously 5000 acres or greater. However, through the processes of hub optimization and network optimization, other areas that are not PEAs, but are of suitable land use, are added to the core hubs. This analysis gives a measure of how much area was added during the two optimization processes.

3. Internal Context of Hubs: Percent SEA per Hub

This prioritization is used to measure the proportion of Significant Ecological Areas (after exclusion) that are contained within each hub. The range of percents for SEA per hub varies more than PEAs because SEAs are not the primary component in the creation of hubs.

4. Internal Context of Hubs: Land Use Context Index

Intensive land uses are excluded from hubs during the exclusion process, however pockets of intensive land uses may be enclosed within and surrounded by hubs and exert a negative influence on hubs. This prioritization evaluates the influence of intensive land uses within hubs.

5. External Context of Hubs: Land Use Context

This prioritization is used to measure the intensity of land uses adjacent to hubs. Land use intensity is measured using the Land Use Context Index (see description above) within a 5 kilometer buffer of each hub.

6. External Context of Hubs: PEAs

This prioritization is used to measure the amount of PEAs that exist within a 5 kilometer buffer of the Hubs.

7. External Context of Hubs: SEAs

This prioritization is used to measure the amount of SEAs that exist within a 5 kilometer buffer of the hubs.

8. Hub Total Area Index

This measure ranks hubs based on their total area where larger hubs receive higher ranks.

9. Hub Core Area Index

The purpose of this prioritization is to calculate the core or interior area for each hub. Core areas are important because they are the most remote areas within the hub and are least likely subjected to negative edge effects. Core area is defined as the area of the largest circle that fits within the hub, also called the largest-circle-fit technique (Forman 1995).

10. Hub Core Roadless Area Index

The purpose of this prioritization was not to identify any roadless area, but specifically core roadless areas with compact shapes and low amounts of edge. Core roadless areas are determined by calculating the largest circle that fits within a hub that is not bisected by major roads (primary or secondary roads).

11. Perimeter of Circle to Perimeter of Patch (Hub) Ratio

The purpose of this prioritization was to analyze hub shape as it compares to a circle. As stated in the description of the Hub Function & Structure Prioritizations, a circle is considered an ideal shape because it is the most compact shape with the least amount of edge. To compare hub shape to that of a circle, the ratio of the perimeter of each hub to the perimeter of a circle having the same area as the hub was calculated.

12. Hub Corrected Perimeter to Area Ratio

The purpose of this prioritization was to compare hub perimeter to hub area. The basic premise here is that if two hubs have the same area, the one with a smaller perimeter is more compact and has less edge, and is more desirable because it has more interior habitat area and is less susceptible to negative edge effects. However, because a simple perimeter-to-area ratio is dependent on size as well as perimeter, it is necessary to use an equation that corrects for variance caused by change in hub size if such a ratio is to be a helpful indicator of hub shape.

13. Amount of Roads Per Hub

This prioritization calculated the percentage of primary and secondary road cells per hub, where hubs with a less road crossings receiving higher ranks.

c. Linkage Prioritizations

Linkages were identified to provide the opportunity for connectivity between hubs. Optimal linkages are characterized by a contiguous swath of land with adequate width and high quality habitat. Through the use of the cost surfaces and the least cost path function (in Arc/Info GRID), linkages were delineated to traverse the areas of highest quality land use between the hubs that they connect. However, the quality of linkages delineated in the SEF was variable.

To analyze the habitat quality, width, and contiguity of linkages, three main types of prioritizations were completed: Internal Context Analyses, External Context Analyses, and Width. In addition, a fourth prioritization ranks the linkages based upon the overall prioritization ranking of the hubs that they connect.

There are three types of linkages: general, upland, and riparian, based upon the type of hubs they connect. Linkages were prioritized separately for each type.

i. SEPARATING LINKAGES INTO DISCRETE SEGMENTS

The first step in prioritizing linkages was to separate them into discrete segments for evaluation. Although linkages were created to connect one hub to another, one linkage can cross through or between many hubs. For prioritization, it was decided that linkages would be separated into segments that connected at least two different hubs.

ii. LINKAGE PRIORITIZATIONS: INTERNAL CONTEXT ANALYSES

To measure the habitat quality and potential functionality of linkages, the percentage of PEAX (Priority Ecological Areas after excluding unsuitable land uses) and SEAX (Significant Ecological Areas after excluding unsuitable land uses) in each linkage were calculated. To measure the negative edge effects from roads and possible fragmentation, the percent of primary and secondary roads per linkage was calculated. Also, the overall intensity of land uses within the linkages was evaluated as a measure of land use quality within the linkages.

1. Percent Priority Ecological Areas per Linkage

The percentage of PEAX (priority ecological areas after excluding unsuitable land uses) was calculated per linkage.

2. Percent Significant Ecological Areas per Linkage

The percentage of SEAX (significant ecological areas after excluding unsuitable land uses) was calculated per linkage.

3. Percent of Primary & Secondary Roads per Linkage

The percentage of primary and secondary roads per linkage was calculated by dividing the number of primary and secondary road cells per total number of linkage cells.

4. Internal Land Use Context

This analysis prioritizes the linkages by the intensity of land uses within or surrounded by the linkage. Although intensive land uses are not included in most linkages, some linkages include agricultural land use. Furthermore pockets or nodes of agricultural or urban land uses can in some cases be surrounded by linkages.

iii. LINKAGE PRIORITIZATIONS: EXTERNAL CONTEXT ANALYSES

The purpose of the external context analyses is to obtain a measure of the landscape context surrounding the linkages. Linkages surrounded by low intensity land uses, priority or significant ecological areas are less affected by negative edge effects and offer better opportunities for functional connectivity. In all three of these analyses a one kilometer buffer was chosen as the area of potential influence directly relevant for determining the contextual quality of the linkages based on a conservative estimate of the potential for edge effects and other types of landscape interactions (Forman 1995).

1. Priority Ecological Areas Context of Linkages

This prioritization measures the amount of PEAX (priority ecological areas after excluding unsuitable land use) within a one kilometer buffer area of each linkage.

2. Significant Ecological Areas Context of Linkages

This prioritization measures the amount of SEAX (significant ecological areas after excluding unsuitable land use) within a one kilometer buffer area of each linkage.

3. Land Use Context of Linkages

This analysis prioritizes linkages by the intensity of the land use within a one kilometer buffer of the linkage. Land use intensity is measured using the Land Use Context Index methods completed for hub prioritizations.

iv. LINKAGE PRIORITIZATIONS: WIDTH ANALYSES

In addition to containing high quality habitat, an optimal linkage should also include a swath of contiguous land area with adequate width. Although there remains no exact determination of "how wide should a linkage be", it is generally accepted that "the wider, the better" (Noss 1987b; Hunter 1990; Noss 1993; Beier and Noss 1998). Functional widths will also be influenced by the context of the linkage, with the assumption that linkages surrounded by more intensive land uses will need to be wider. Length is also an important factor, and linkages should be wider as length increases, especially if the linkage is intended to support wide-ranging species such as black bear. To measure linkage contiguity and width, two analyses were completed: Density Analysis and Perimeter to Area Ratio. It should be noted that these analyses can only serve as surrogates for measuring actual widths, average widths, or variation in width of the linkages included in the SEF. Due to limitations of raster analysis in Arc-Info Grid direct measures of linkage widths, especially with so many linkages, would be difficult. However, the analyses included can serve as a means to evaluate the linkages relative to each other to determine which are more likely to have functional characteristics.

1. Density Analysis of Linkages

A density analysis was performed as a measure of contiguity or the amount of gaps/holes contained in the linkages.

2. Width Measurement: Corrected Perimeter to Area Ratio

A perimeter to area ratio was completed as another measure of contiguity. The basic premise being that if two linkages have the same area, the one with a smaller perimeter to area ratio is more compact and has less edge, and therefore possesses a better shape. However, because a simple perimeter-to-area ratio is dependent on size as well as perimeter, it is necessary to use an equation that corrects for variance caused by change in overall size if such a ratio is to be a helpful indicator of shape.

v. LINKAGE PRIORITIZATIONS: HUB RANKS

1. Ranking of Linkages by Overall Prioritization Ranking of Hubs They Connect

The purpose of this prioritization was to rank linkages based upon the priority ranking of the hubs which they connect. Linkages that provide connectivity between high priority hubs should be of higher priority themselves, as linkages can potentially enhance the hub's ability to support viable ecosystems and natural communities through exchange and movement of resources between hubs. After all hub prioritizations were completed and the overall hub ranks were calculated, the linkages were evaluated based upon the overall rank of the hubs which they connected.

d. Creation Of Multiple Utility Assignments (MUAs)

MUAs were created by taking the average of all SUAs in each prioritization category. The MUAs were ranked using equal area in order to spatially distribute the values into ten equivalent geographic classes, in which each class is representative of 10% of the total land area in the SEF. The highest priority sites can then be considered those areas that fall into the top ten percent.

Five regional MUAs, six hub MUAs, and one linkage MUA were created. Four MUAs that were clipped to the SEF boundary were also created. MUAs are listed below, with the corresponding input SUAs. Weighting of input SUAs was equal except where noted.

i. REGIONAL PRIORITIZATION MUAs

1. Regional Ecosystem Services MUA

- Surficial Aquifer Areas Vulnerable to Pollution
- Size & Proximity to Wetlands
- Surface Water Source Priorities
- Ground Water Priorities
- Major and Wild & Scenic Rivers Buffers
- Coastal Storm Protection Areas
- Proximity to Shellfish Harvesting Areas

2. Regional Biodiversity MUA

- Size & Proximity to Conservation Lands
- Interior Forests
- Old Growth and Significant Longleaf Pine Forest Stands
- Imperiled Species Priority Areas
- Listed Species Priority Areas
- At-risk Aquatic Species by Watersheds (HUCs)
- Critical Watersheds for Aquatic Biodiversity
- Black Bear Habitat Suitability Analysis
- PEA Size Classification

3. Regional Threats MUA

- Context Analysis
- Urban Growth Pressure Model

4. Regional Recreation Potential MUA

- Proximity to Urban Areas
- Proximity to Conservation Lands
- Hydrographic Features
- Points of Interest (GNIS - Geographic Names Information System)

5. Final Regional MUA

A final regional MUA was created by averaging the four regional MUAs:

Regional Ecosystem Services MUA
Regional Biodiversity MUA
Regional Threats MUA
Regional Recreation Potential MUA

ii. HUB PRIORITIZATION MUAs

1. Hub Function / Structure MUA

Total Area Index
Core Area Index
Roadless Area Index
Perimeter of a Circle to Perimeter to a Hub
Perimeter to Area Ratio
Amount of Roads per Hub
Contextual Rating
Hub Density/ Internal Gaps
External Contextual Analysis: Land Use
External Contextual Analysis: PEA
External Contextual Analysis: SEA
Internal Context of Hubs: PEA
Internal Context of Hubs: SEA

2. Hubs Ecosystem Services MUA	Weight
Stream Start Reaches by Hub	0.21
Surficial Aquifer Vulnerability to Pollution	0.21
Size & Proximity to Wetlands	0.21
Proximity to Shellfish Harvesting Areas	0.08
Coastal Storm Protection Areas	0.08
Major and Wild & Scenic Rivers	0.21

The Hub Ecosystem Services MUA was weighted in order to counteract the coastal areas bias in the MUA analysis. Two of the six ecosystem services SUAs, proximity to shellfish harvesting areas and coastal storm protection, are heavily coast-oriented. When combining these two datasets with the rest of the SUAs, the resulting MUA shows a heavy priority bias towards the coasts. Coastal areas are important for ecosystem services, however the resulting coastal bias is more an outcome of data availability, rather than an accurate depiction of priority ecosystem services areas. Hence, ecosystem services have not been comprehensively represented, but the weighting scheme used provides for the most accurate depiction of ecosystem services with the data available. Ideal future datasets would include air quality, carbon sequestration rates, areas upstream of drinking water intake points, and complete 100 and 500 year floodplain data (only parts of the region have been completed).

3. Hub Biodiversity MUA

Topographic Diversity
Size & Proximity to Conservation Lands
Black Bear Suitability Analysis
Interior Forest Areas

PEA Size Classification
Imperiled Species Priorities
Threatened and Endangered Species Priorities
At-risk Aquatic Species Priorities
Critical Aquatic Biodiversity Watersheds

<u>4. Hub Threats MUA</u>

Landscape Viability Analysis
Urban Growth Model

<u>5. Hub Recreation MUA</u>

Influence of Urban Areas
Influence of Conservation Lands
Water Based Recreation
Influence of Points of Interest

<u>6. Final Hub MUA</u>

The final Hub MUA was created by averaging the above five hub MUAs.

iii. LINKAGE PRIORITIZATION MUA

Internal Context: Percent PEA
Internal Context: Percent SEA
Internal Context: Percent of Primary and Secondary Roads
Internal Land Use Context
External Context: PEAs
External Context: SEAs
External Context: Land Use
Perimeter to Area Ratio
Density
Hub Ranks

iv. SEF PRIORITIZATION MUA

Prioritization was first completed for the entire region to evaluate all the ecological priorities and threats that occur region wide. However, the primary purpose of the prioritization phase of the SEF Project was to identify areas within the SEF that are a higher priority for protection and attention. Hence, the four regional MUAs created were clipped to the boundaries of the SEF to isolate framework areas for evaluation. They are as follows:

1. SEF Ecosystem Services MUA
2. SEF Biodiversity MUA
3. SEF Threats MUA
4. SEF Recreation Potential MUA
5. SEF Combined MUA

D. RESULTS AND DISCUSSION

a. Regional Prioritizations

Regional prioritizations are conducted for the entire area within EPA Region 4. In each individual prioritization analysis, every area in the region receives a value ranging from a low priority value of 1 to the highest value of 10. The prioritization analyses represent a variety of available data sets and analytical techniques. Some of the data sets used were also components in the process of delineating the Southeastern Ecological Framework (SEF), but other data have been acquired since the completion of the SEF. Some analyses are similar to methods used to delineate the SEF, but some new analysis and variations in techniques have also been utilized in the prioritization process. Therefore, there are two important properties of the results of regional prioritization that should be considered:

1) Since regional prioritizations are done for all areas within EPA Region 4 both within and outside the SEF, these analyses can be used to assess various natural resource conservation priorities regardless of whether an areas is found within the SEF or not. Depending on the prioritization analysis, results may be relevant to regional, state, or local planning, but the user needs to be aware of how a particular analysis was developed to help determine whether analyses are appropriate at more resolute scales. Some of these issues will be mentioned in specific discussion of the results below.
2) As suggested above in #1, because some new data, new analyses, and methods different from the delineation process for the SEF have been used in prioritization, there can be areas of high signficance for protecting specific resources or categories of resources (such as ecosystem services) that are not always within the SEF. Some of these areas might be suitable for addition to the SEF in future iterations, but they also can be relevant to other natural resource conservation planning at various scales. These issues will also be mentioned in specific discussion of the results below.

To aid planning efforts using these regional prioritizations, two versions of the analyses are included in this report: 1) the original region-wide analyses; 2) the region-wide analyses clipped to the boundaries of the SEF. Also, the following descriptions of results and included figures discuss primarily the Multiple Utility Assignments (MUAs) for each major natural resource category: ecosystem services, biodiversity, recreation potential, and threats to ecological integrity. Specific Single Utility Assignments (SUAs) are only mentioned in discussion of specific caveats or issues in a particular MUA. However, individual SUA priority analyses are also potentially very useful for conservation planning. The methods used to develop each of the individual SUAs has been included in the previous section and the data layers are included in the data library that accompanies this document.

i. ECOSYSTEM SERVICES

Ecosystem or ecological services are ecological processes and functions provided by natural and semi-natural areas that help sustain or enhance human life (Daily 1997). Primary ecosystem services include water and air protection and purification, flood and storm protection, functional nutrient cycling, etc.

Six Ecosystem Services SUAs were used to develop the regional Ecosystem Services MUA

(Fig. 1):

Surficial Aquifer Areas Vulnerable to Pollution
Size & Proximity to Wetlands
Surface Water Source Protection Priorities
Ground Water Source Protection Priorities
Major and Wild & Scenic Rivers Buffers
Coastal Storm Protection Areas
Proximity to Shellfish Harvesting Areas

The darkest colors on Figure 1 represent the areas with the highest potential significance for protecting ecosystem services. Several features stand out in the map. First the broad bands of darker blues primarily within the Southeastern Coastal Plain represent areas important for protecting surficial aquifers based on the criteria used in the DRASTIC model that identify areas vulnerable to aquifer contamination. This includes much of the Florida peninsula, a portion of southwestern Georgia, southeastern Alabama, and northern Florida, and across the Atlantic coastal plain. Large wetland areas in the Southeastern Coastal Plain also are evident. Major rivers across the region also stand out as a result of the buffer analysis of major and wild and scenic rivers. Finally, buffers around surface water intake points that serve large population or that overlap with other SUAs of moderate priority also show up as highly significant primarily outside of the Southeastern Coastal Plain.

In the Ecosystem Services MUA clipped to the SEF, the primary features that show up are again wetlands and other lands within the SEF near the coasts and various major rivers across the region.

Overall, the data and analyses not available and therefore not included in this ecosystem services prioritization must also be considered. Not all ecosystem services that may be significant and could potentially be portrayed at a regional scale are included in this analysis due to data and analytical limitations. The first example is air purification including carbon sequestration. Although such an analysis was considered, no existing data or information was found that could be used. All forests in the region may be important for these purposes, but means to prioritize forests does not appear to be available. Second, the protection of water quality for drinking water, biodiversity conservation, and other purposes is also an extremely important ecosystem service. Although the wetlands analysis, surface water source, ground water source, and surficial aquifer vulnerability analyses captured some aspects of these services, more information and analysis are needed to provide a comprehensive picture of the areas needed to protect water resources. One of the primary needs for future prioritization is a thorough analysis of watersheds upstream of surface drinking water sources. Although the surface water source analysis included here identifies immediate buffer zones around important surface water intake points, it does not include the identification of all areas upstream that may influence the water quality at the intake point. Finally, areas prone to flooding or important for storing flood waters is a related issue. Much of the floodplain around major and wild and scenic rivers is likely incorporated in the buffer analysis of these features, but specific floodplain data is not yet available for the entire region and was therefore not included in the ecosystem service prioritization. In conclusion, the area within Region 4 that is probably most underrepresented by this analysis is the forests of the Appalachians. These forests are likely important for the attenuation of air quality problems and they serve as the primary headwaters for many rivers throughout the region.

Figure IV-1. Ecosystem Services MUA for EPA Region 4.

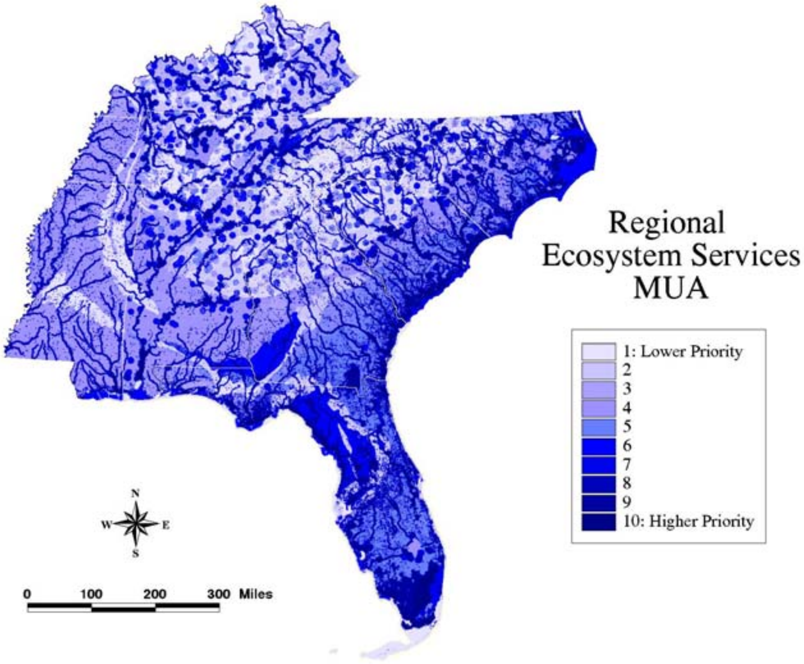
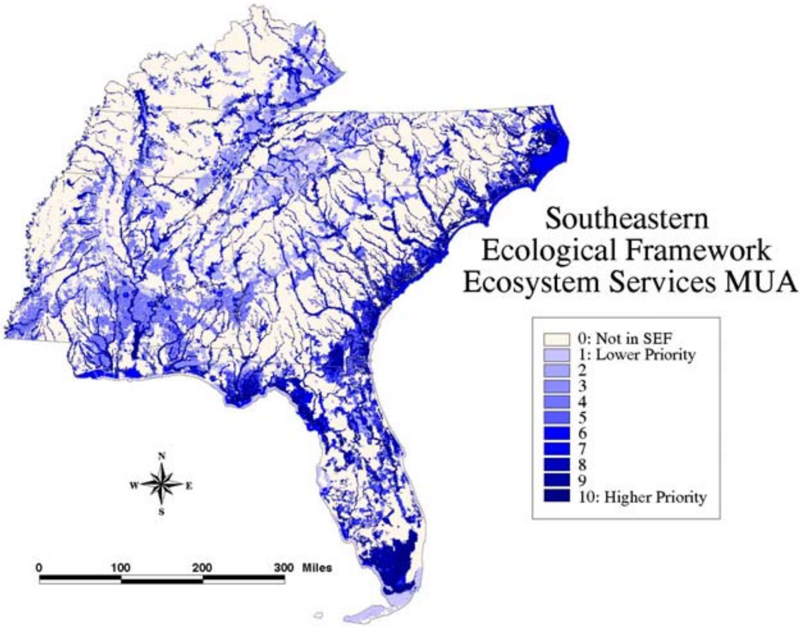


Figure IV-2. Ecosystems Services MUA clipped to the Southeastern Ecological Framework boundary.



ii. BIODIVERSITY

Biodiversity can be defined as the variety of life including genes, species, natural communities, and landscapes. Biodiversity is threatened by factors including habitat loss and fragmentation, negative ecological impacts associated with intensive land uses, alien or weedy species, etc. (Meffe and Carroll 1997).

Nine biodiversity prioritization data layers and analyses were used to create the regional biodiversity MUA:

Size & Proximity to Conservation Lands
Interior Forests
Old Growth and Significant Longleaf Pine Forest Stands
Imperiled Species Priority Areas
Listed Species Priority Areas
At-risk Aquatic Species by Watersheds (HUCs)
Critical Watersheds for Aquatic Biodiversity
Black Bear Habitat Suitability Analysis
PEA Size Classification

The darkest colors on Figure 3 represent the areas that are potentially most significant for conserving biodiversity in the region based on the available data. Most of the included SUAs contribute significantly to the patterns discernible at the regional scale including the four analyses based on ABI and TNC data (Imperiled Species, Listed Species, At-risk Aquatic Species Watersheds, and Critical Watersheds for Aquatic Biodiversity), Black bear habitat suitability, the conservation lands analysis, and the interior forest analysis. The large areas of bright green represent moderate to moderately high areas of significance and are the result of the ABI watershed analyses. These data layers represent information concerning aquatic biodiversity that are summarized by entire 8 digit HUC watersheds. The hexagon shape evident in the plateau regions of northern Alabama, Tennessee, and Kentucky represent EPA EMAP hexagons where high numbers of imperiled or listed species occur. Although there are other hexagons containing high numbers of these species found in other parts of the region, they tend to more closely overlap with other biodiversity criteria and therefore are more obscured through the combination process. Another feature that may be clear on the biodiversity MUA is the tendency for larger conservation lands tend to show as high priorities. This occurs because several analyses either include conservation lands directly or conservation lands tend to be likely candidates for including the features analyzed. The conservation lands analysis is an obvious source, where large conservation lands received a high priority. However, the black bear analysis also included conservation lands as a factor, and primary occupied bear habitat, and the largest blocks of available bear habitat tended to be on existing conservation lands. Furthermore, although blocks of interior forest were not limited to conservation lands, there was a tendency for conservation lands to support interior forest, and especially larger blocks of interior forest. The best example is Great Smoky Mountains National Park, which incorporates the two largest blocks of interior forest in the region.

In the Biodiversity MUA clipped to the SEF, larger conservation areas tend to show up as having primary significance with some surrounding areas included. The largest areas include conservation lands and supporting areas within the Appalachians, Eglin Air Force base to the Apalachicola National Forest in the Florida panhandle, the Everglades, and Okefenokee National Wildlife Refuge in southern Georgia south to the Ocala National Forest in central Florida.

There are several issues regarding the available data and analyses that need to be addressed when using this assessment of areas potentially significant for biodiversity conservation. First, identifying areas important for biodiversity and designing reserve networks to conserve biodiversity should include several data sources and analyses that could not be included in this assessment (Noss 1996). Additional data on locations of species of conservation interest and natural communities and the identification of areas most important for conserving viable populations of such species will be important to enhance future iterations. Although information on imperiled and listed species from ABI and TNC was used, this information came in a generalized, summarized form based on two types of mapping units: EPA EMAP hexagons and eight digit HUC watersheds. EMAP hexagons are 160,000 acres and most of the eight digit HUC watersheds are even larger. Therefore, since these units have been used for the general identification of areas containing many imperiled or listed species, it is likely that some areas within them actually have no species of conservation interest and more resolute data may be necessary for biodiversity assessment and planning at the local level. More specific information on locations of species and natural communities of conservation interest would be helpful for regional and state planning and necessary for local conservation planning. State natural heritage programs (and ABI as their "parent" association) have such information (and such data was incorporated into the SEF for Florida, Georgia, and Alabama and was obtained later for Mississippi), but it is often difficult to obtain for a variety of reasons.

Another program that will provide additional data useful for comprehensive biodiversity assessments and planning is the federal GAP Analysis project. GAP analysis is being conducted in every state and many of the state analyses in EPA Region 4 are very close to being completed. These projects will produce habitat or natural community vegetation maps for each state and potential habitat models for native vertebrate species. The vegetation maps are more resolute than the NLCD (National Land Cover Dataset) vegetation classes and could be used to conduct representation analyses to determine which vegetation types are not currently well represented within existing conservation lands. Also the habitat models can be used to identify specific areas that potentially support species of conservation interest, and they will be used in the GAP program to identify biodiversity hotspots that are not currently protected.

Finally, viability assessments for species of conservation interest are also an important element of reserve design. This is especially true for wide-ranging species that need large areas to support viable populations such as the black bear. Viability analyses are based on the life history parameters of the particular species (birth rates, death rates, longevity, etc.) and help assess population size, land areas, and other conditions necessary to support viable populations. Such an assessment has been conducted in Florida for a host of selected vertebrate species (Cox et al. 1994; Cox and Kautz 2000; Kautz and Cox 2001). The Florida analysis strived to identify areas needed to protect viable populations of each of the selected species and determined if more habitat needed to be protected to meet viability goals. Although viability assessments are not possible for species that lack information on essential life history parameters and can be time consuming when they are possible, these analyses can greatly enhance the specific identification of areas important for conserving a region's native biodiversity. Therefore, the regional assessment of biodiversity and EPA Region 4 could be greatly improved if similar assessments as completed in Florida were conducted in other states within the region.

Figure IV-3. Biodiversity MUA for EPA Region 4.

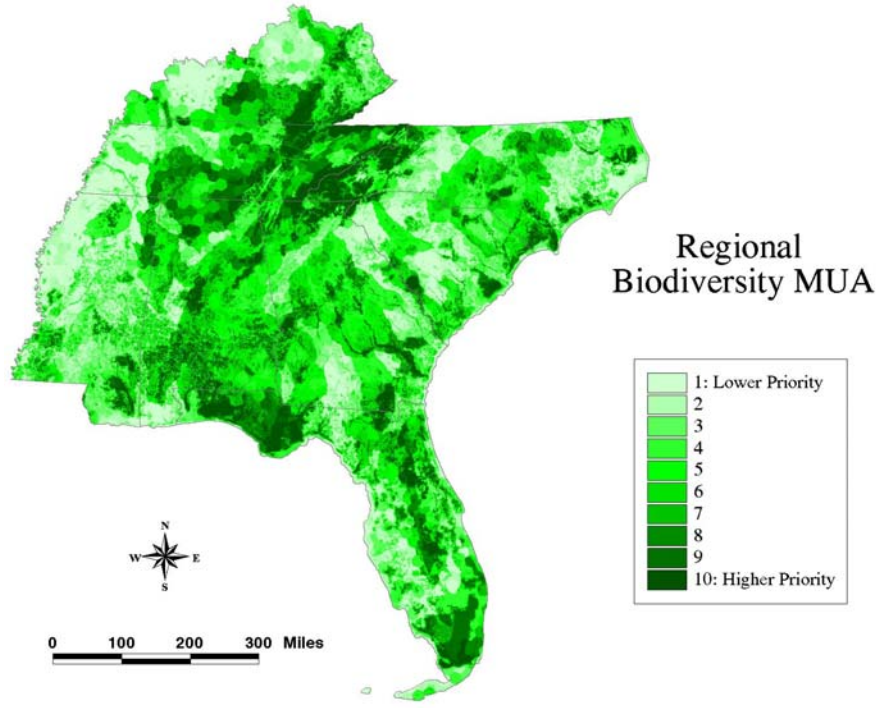
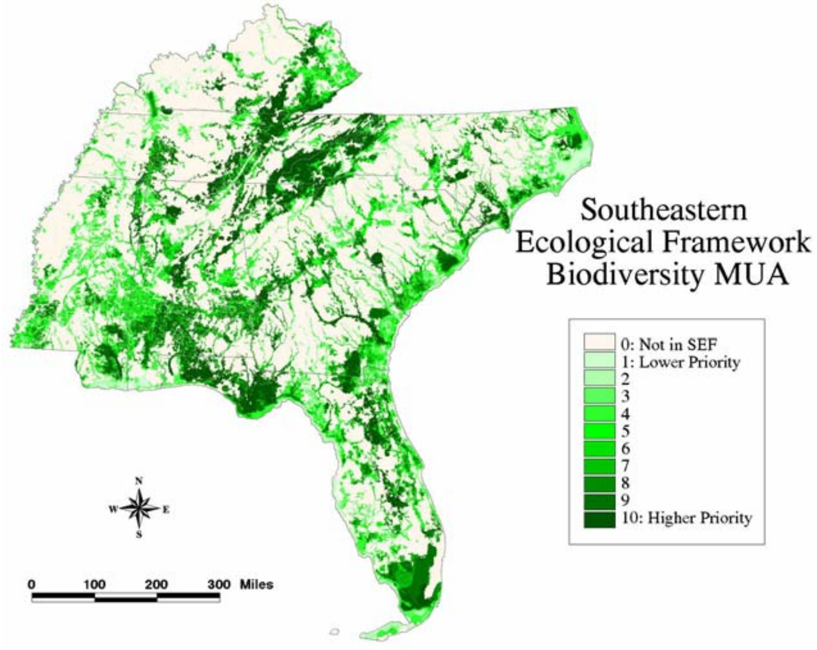


Figure IV-4. Biodiversity MUA clipped to the Southeastern Ecological Framework.



iii. RECREATION POTENTIAL

Recreation potential can of course be considered a double-edged sword. The resource-based recreation potential of conservation areas and other natural and semi-natural lands can be considered an important ecological service or at least an important amenity. However, recreational demand on land can also have significant negative impacts on natural resources. This analysis of recreation potential is primarily focused on the former instead of the later, but the assessment presented here can still be used for various types of planning. Where there is high potential recreational demand, this demand can serve as a key incentive for protecting additional conservation lands that will be open for various compatible recreational activities. This analysis can also be used to determine, from a regional perspective, where natural resources have the most potential to be impacted by recreational use and therefore where more attention is needed to make sure conservation objectives are met while allowing appropriate, compatible recreational uses.

This analysis of recreation potential is predicated on two complementary assumptions. First, areas in close proximity to larger human populations are more likely to have greater demand for recreational services. Second, features that have higher interest potential or have more capability to support recreational uses are more likely to have a higher demand for recreational services. Where these factors tend to converge is where there will be the highest potential recreation demand. The results of the regional analysis tend to show a combination of areas with the best potential for supporting resource-based recreation and areas with larger human population nearby (Fig. 5). The most prominently feature of high recreation potential is the southern Appalachians (or Blue Ridge/Great Smoky Mountains) in eastern Tennessee, western North Carolina, and northern Georgia. This area contains large conservation areas, many river systems, and many points of interest. In addition, it is greatly influenced in this analysis by the size of the Atlanta metropolitan area but also population centers in central North Carolina and eastern Tennessee. Another prominent area showing high recreational significance is the Ocala National Forest/Merritt National Wildlife Refuge/Canaveral National Seashore and surrounding lands in central Florida. These areas are greatly influenced in their recreation potential the Orlando metropolitan area and other growing urban centers nearby. Several river systems are prominent at the regional scale including the Tennessee River from its source to its confluence with the Ohio River, much of the Savannah River on the border of Georgia and South Carolina, and the Santee and Cooper River system in South Carolina. Various coastal lands also receive higher recreation potential ranking, especially larger coastal conservation lands, due to influence of the coast in the aquatic proximity component of the model and the tendency for more concentrated human populations along the coast.

The regional recreation potential analysis clipped to the SEF shows the same patterns of areas that show most prominently as having high recreation potential at the regional scale (Fig. 6).

There are at least a couple important assumptions made in this analysis that could affect the results. The conservation lands component to this analysis assumes that areas with or near larger aggregations of existing conservation lands will have the highest recreation potential. This assumption is clearly valid in many cases but there are at least two significant contradictions. First, all conservation lands are treated the same except for size. However, there is a diverse range of conservation land types ranging from national and state parks to Department of Defense (DOD) lands. Clearly some lands included in our existing conservation lands data, such as military reservations, are not as accessible nor support the range or recreational activities as some others. Though DOD lands are frequently open to various forms of public use, they clearly are not as accessible as state parks or similar public conservation areas. In addition, smaller conservation lands may support key resources, such as a springs, sinks, falls, or other unique natural features, that may be highly attractive. The representation of these areas may be partially ameliorated by the inclusion of points of interest in this assessment.. A more resolute and comprehensive analysis of recreation potential would include a more thorough consideration of the variability in attractiveness of various types of conservation lands and specific conservation lands with specific features of interest.

Figure IV-5. Recreation Potential MUA for EPA Region 4.

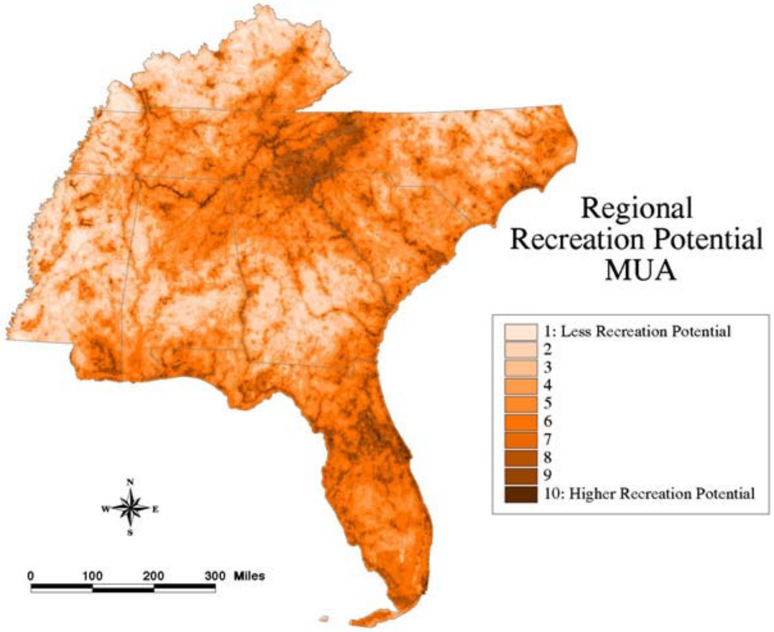
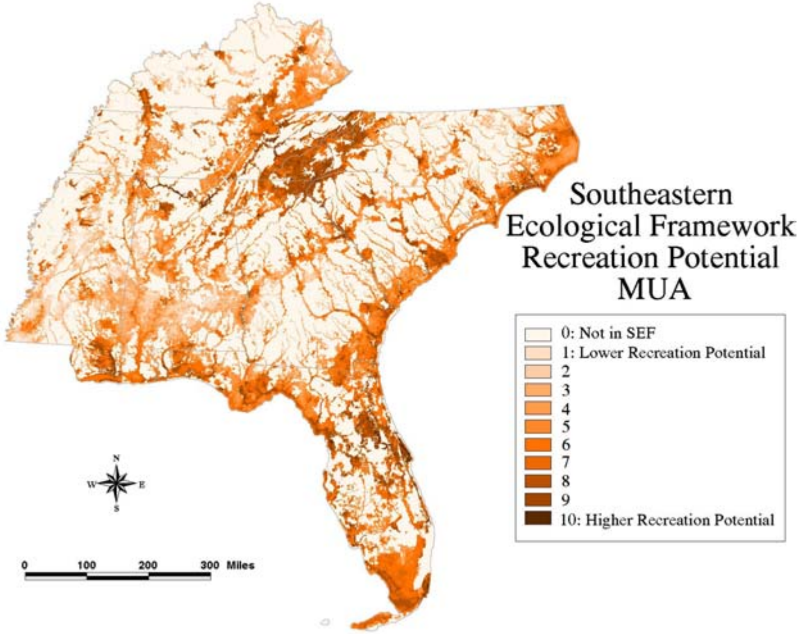


Figure IV-6. Recreation Potential MUA clipped to the Southeastern Ecological Framework.



iv. THREATS TO ECOLOGICAL INTEGRITY

Lands important for conserving natural resources or providing ecological services can be impacted by a variety of negative influences associated intensive land uses including residential development, urban areas, industrial land uses, and roads. However, the ultimate threat to natural resource lands is their conversion to intensive land uses. The two analyses used to evaluate threats serve as general regional scale assessments of these factors that threaten important natural and semi-natural lands throughout EPA Region 4. Although these models include some potentially redundant factors including proximity to major roads and proximity to existing urban areas, together they serve as a sound, general basis to evaluate regional level threats of intensive land uses in the region. The threats posed by residential and urban land uses and major roads and road networks are varied and well documented from in many studies (Forman 1995; Meffe and Carroll 1997).

In the regional MUA for the threats analysis (Fig. 7), the darker colors represent areas with the higher potential of threats associated with intensive development and road networks. Prominent areas at the regional scale with a high level of potential threats include the urbanizing corridor from Atlanta to the northeast all they way to Raleigh in north-central North Carolina and central Tennessee and Kentucky. With only a few exceptions, most of the Florida peninsula also shows up as having a high probability of threats to ecological integrity because of increasing urbanization and residential growth. In the version of the regional threats MUA clipped to the SEF (Fig. 8), the areas that within the SEF that appear to be most threatened include most coastal areas and many rivers systems throughout the SEF but especially in the Piedmont, Plateau, and parts of the Appalachian ecoregions.

Although this assessment provides a useful basis for assessing potential threats at the regional and state scales, there are a couple of potentially important components that are not incorporated. The primary factor involves specific use of pollution information. Pollution threats can range from specific discharge points, non-point watershed and landscape influences, to regional air pollution issues. Though these issues would be difficult to accurately characterize, a more comprehensive future version of a threats assessment would be significantly improved by incorporating various pollution threats. In the results of the current analysis there are two examples that are relevant. First, although the Everglades show up as being relatively free of threats directly associated with urbanization and roads, the Everglades landscape is impacted by regional water management problems including both disruption of hydrological cycles and water pollution inputs from agricultural land uses upstream in the watershed. Second, Great Smoky Mountains National Park and some surrounding National Forest lands show up has having low threats from urban areas and roads, but forests (especially high elevation forests) in the areas are threatened by regional air pollution problems. Another important issue that is not represented in the threats analysis is the damming and channelization of many rivers across the region, which has serious and adverse affects on aquatic biodiversity.

Figure IV-7. Threats to Ecological Integrity MUA.

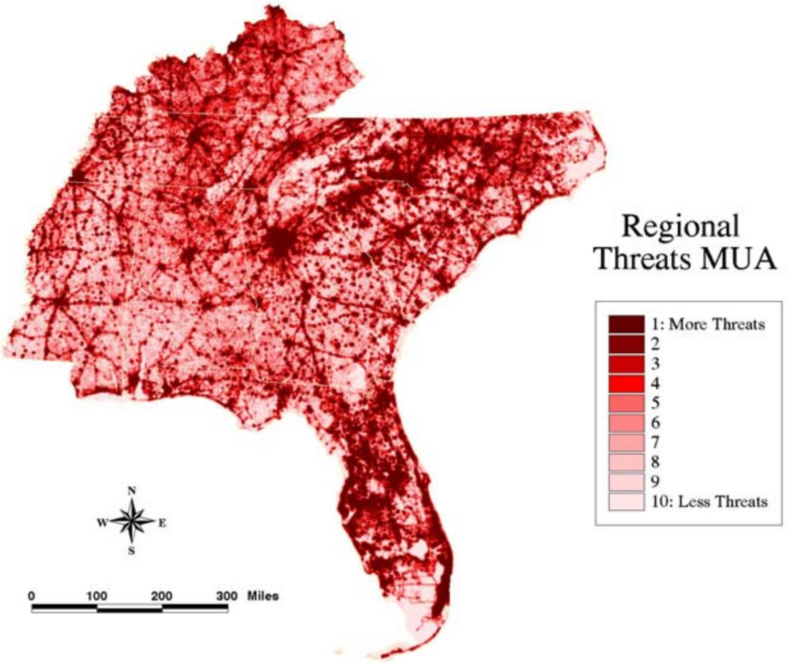
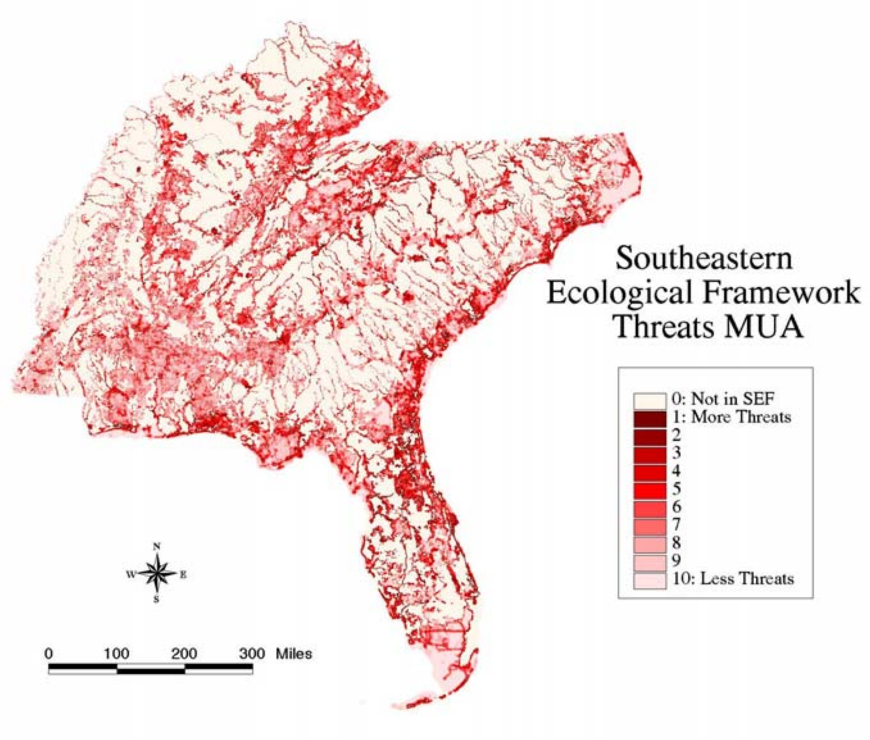


Figure IV-8. Threats to Ecological Integrity MUA clipped to the SEF.



v. <u>REGIONAL MUAS COMBINED</u>

Although we do not recommend reliance on a combination "final" version of all MUAs as the basis for making conservation planning decisions, such a combination is provided here to serve as indication of how various factors and priorities overlay with each other among the four different major categories: ecosystem services, biodiversity, recreation potential, and threats to ecological integrity. The primary concern with combining these four categories is that they can represent related, though still significantly different factors that all can be important. By the nature of how a combination is created, there will tend to be averaging affects that will obscure areas that may be very important for one of the criteria but not others. Therefore, the MUAs for all four categories and the SUAs used to create the four MUAs are more suitable tools for assessing priorities, especially for specific resources. However the combined maps of all MUAs will show where there are areas that are important for several of the categories discussed previously (Fig 9; Fig. 10).

Figure IV-9. All MUAs combined for EPA Region 4.

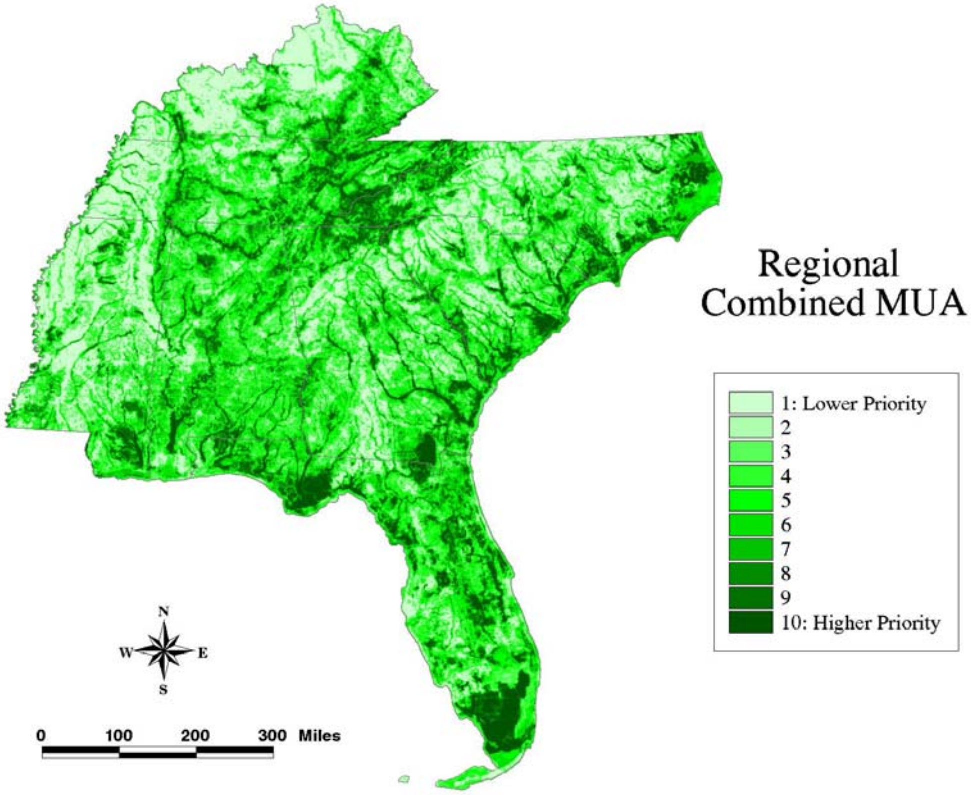
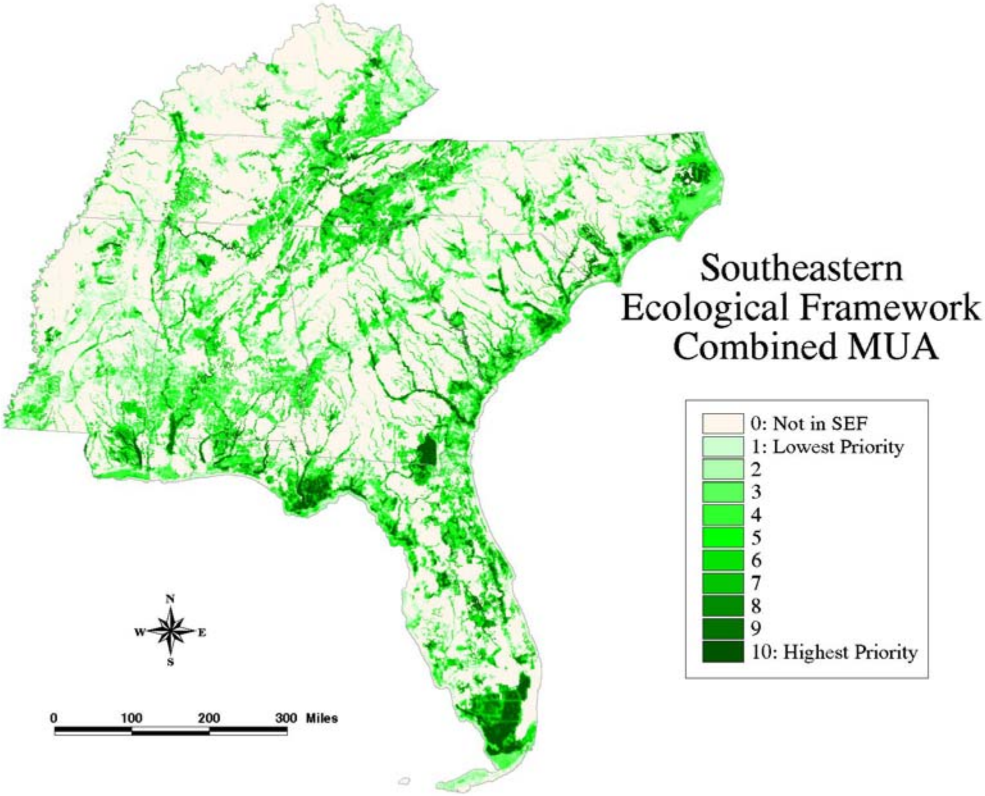


Figure IV-10. All MUAs combined clipped to the SEF.



b. Hub Prioritizations

There are 1128 ecological hubs, which are the backbone of the SEF. They are created by compiling all the PEA criterion and identifying contiguous areas of 5000 acres or greater. Hence, each hub contains one or more priority ecological areas (PEAs). Hubs were prioritized to identify hot spots of priority areas, to evaluate the types of priority areas contained within each hub, and to analyze hub shape and composition. Hubs were prioritized using five different categories of analysis: hub structure and function, ecosystem services, biodiversity, threats, and recreation potential. Some of these analyses are completely independent of analyses done in the regional prioritization discussed previously. However, other Hub prioritizations represent summaries of the regional prioritizations where the value or priority of the Hub is determined by averaging the values of all areas (or cells) found within the Hub. In both cases, it is important to mention the averaging effect due to size in the hub prioritizations. In some of the mapped results that follow, there will be examples where smaller or medium-sized Hubs may receive higher values than larger Hubs that potentially have higher significance for that particular resource. This result can occur because of averaging affects, where there is a high probability of variation in values as the area increases with size. Therefore, very large Hubs may have many areas within them that receive high values for a particular factor, but there may also be areas within the hub with significantly lower values that result in the Hub receiving only a moderately high or average overall value. For this reason in particular, we consider the Hub prioritizations as secondary to the regional analyses presented previously. We especially think that the regional prioritization clipped to the Southeastern Ecological Framework provide the most thorough and accurate portrayal of potential priority areas specifically within the SEF. Nevertheless, Hubs are the primary component of the SEF and represent the areas most likely to contain natural resources of high significance. The following characterizations of the Hub may still prove useful for various conservation planning activities.

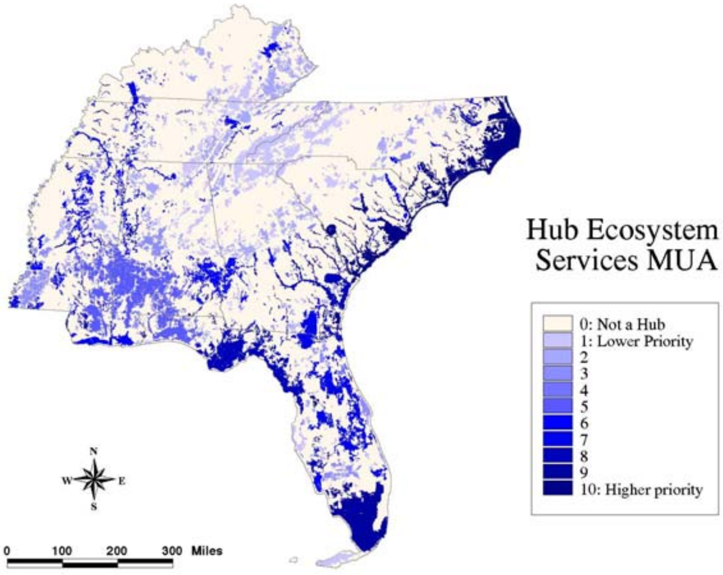
i. ECOSYSTEM SERVICES

The Hub ecosystem services analysis was a combination of eight analyses including five summarized regional prioritizations and three new analyses. The ecosystem service from the regional prioritization that were used included:

Shellfish Harvesting Areas
Major Rivers and Wild & Scenic Rivers
Wetlands: Size and Proximity
Surficial Aquifer Pollution Vulnerability
Coastal Areas Storm Protection

The additional analyses included a characterization of stream start reach densities, calculation of the percentage of wetlands per hub, and identification of hubs with a good mix of wetland and upland habitat. The results of this analysis are very biased to hubs that occur within the Southeastern Coastal Plain (Fig. 12). Various reasons were responsible for this result. As discussed in the regional ecosystem services analysis several of the analyses included were biased towards coastal resources and wetlands, which also tend to be more prominent in the broad, meandering basins in the coastal plain. In addition, two of the new ecosystem service analyses for this Hub-based prioritization included wetlands as a primary component. Finally, several characterizations, like the importance of Appalachian forests for water quality and quantity in many of the region's rivers or their potential significance for ameliorating air quality problems (such as carbon sequestration) are either not captured or thoroughly captured in the analyses included here.

Figure IV-11. Hub Ecosystem Services Prioritization.



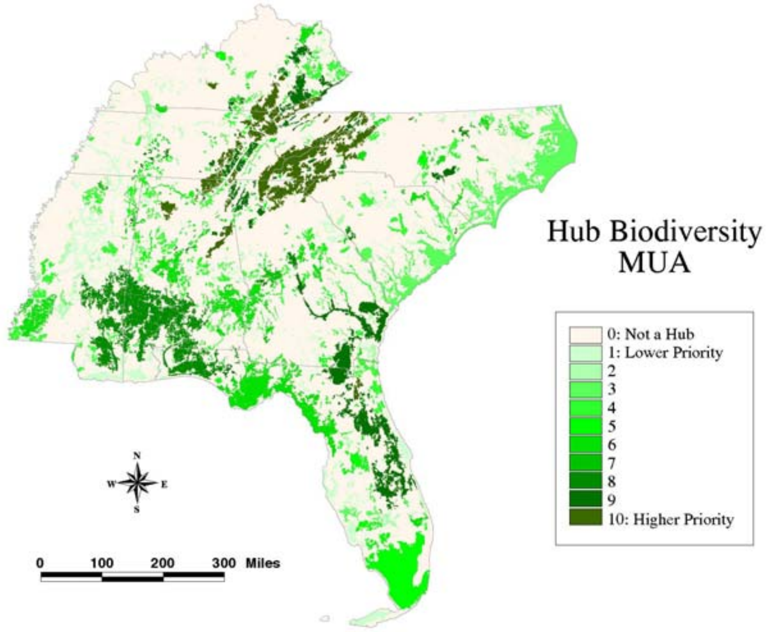
ii. BIODIVERSITY

All of the regional biodiversity prioritizations were used in the Hub biodiversity prioritization analysis except the old growth and longleaf pine forest analysis, which did not fit well with the process needed to create summary values for Hubs. One additional analysis, a measure of topographic diversity within Hubs done for each ecoregion with EPA Region 4, was added.

The map of the results (Fig. 13) indicate several large areas of Hubs with higher potential biodiversity significance including: most of the Hubs within the Appalachian ecoregions; a large region of private forest lands and public conservation lands ranging from the western Florida panhandle through southwestern Alabama and southeastern Mississippi; the Altamaha River basin and Fort Stewart in southeastern Georgia; the Okefenokee National Wildlife Refuge and Osceola National Forest conservation complex in southern Georgia and north Florida; and the Kissimmee River-lower St. Johns River-and Ocala National Forest region in central Florida. Smaller areas that also stand out has highly significant include: Mammoth Cave National Park in central Kentucky; the William B. Bankhead National Forest in northwestern Alabama; the Talladega National Forest in eastern Alabama; Fort Bragg and the Lumber River basin in central North Carolina; and a landscape including Hanging Rock State Park north of Winston-Salem, North Carolina.

Although this analysis can be considered a sound preliminary basis of which Hubs are potentially more significant for biodiversity conservation in EPA Region 4, there are additional data and analyses currently not available for the entire region that would strengthen future iterations of regional biodiversity assessments. For more details, see the section above on the region-based biodiversity analysis discussed previously in this document or the Southeastern Ecological Framework final report.

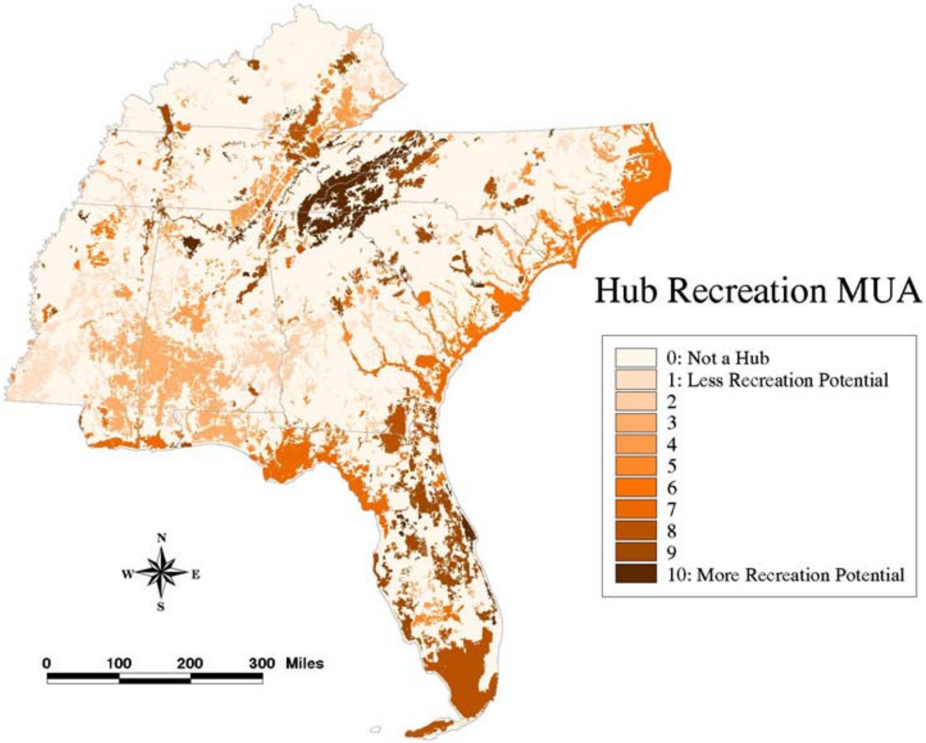
Figure IV-12. Hub Biodiversity Prioritization.



iii. RECREATION POTENTIAL ANALYSIS

The Hub recreation potential analysis summarizes the final regional recreation potential MUA discussed above. This analysis considers both the qualities of areas that may be best suited for serving resource-based recreation while also assessing potential demand based on nearby human population. The results (Fig. 14) indicate that a variety of Hubs across the region can be considered to have higher recreation potential. The Appalachian Hubs in eastern Tennessee, western North Carolina, and northern Georgia appear to be the most important resource-based recreation resource in EPA Region 4. Others Hubs that show up at the regional scale with the highest level of significance include parts of the upper Tennessee River, the William B. Bankhead National Forest in northwestern Alabama, and several Hubs in central Florida. Larger Hubs or areas with Hubs showing a high level of signficance for recreation potential include many of the Hubs in the Florida peninsula, various Hubs in the Piedmont in Georgia through North Carolina, the Talledega National Forest in eastern Alabama, several Hubs on the western ridge of the Appalachian in north-central Tennessee and eastern Kentucky, the lower Tennessee River basin in Tennessee, Kentucky, Alabama, and northeastern Mississippi, and Mammoth Cave National Park in Kentucky.

Figure IV-13. Hub recreation potential analysis.

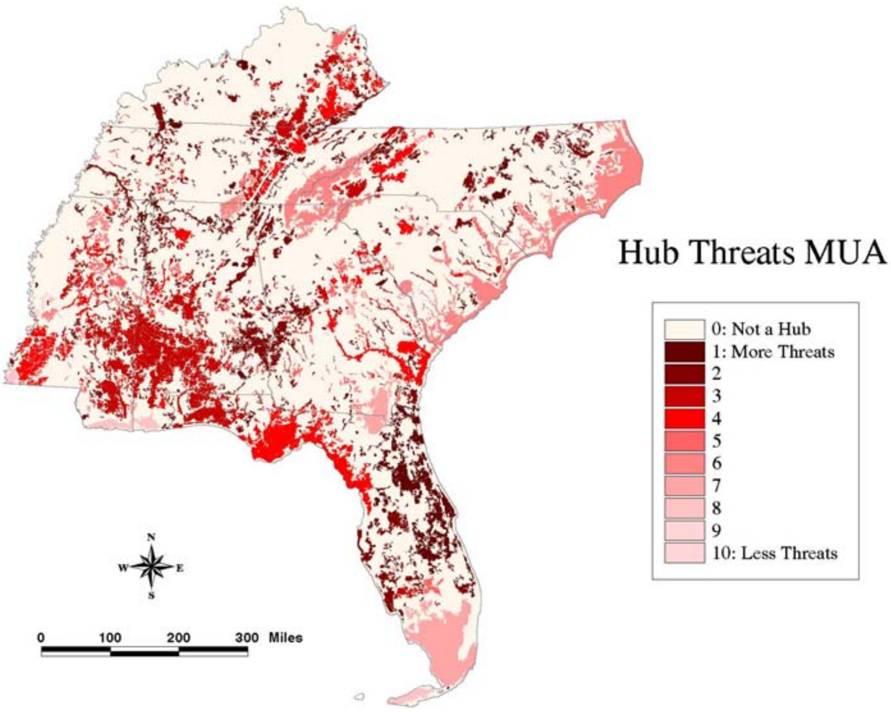


iv. THREATS ANALYSIS

The threats assessment for Hubs is based on the regional threats analysis discussed above. This analysis covers threats related primarily to urban development, major roads, and intensive road networks. It only provides an indirect assessment of pollution threats and does not include specific evaluation of point, non-point, or regional air quality pollution.

Based on this analysis (Fig. 15), almost all Hubs have at least moderate to high level of threats across the region. Some of the Hubs that do show up as having lower threat potential due to urbanization and roads include several examples of areas where other threats still apply such as the Everglades landscape and parts of the Keys National Marine Sanctuary in south Florida. Both of these areas are threatened by water quality or water management issues. Several other Hubs, one along the Alabama and Mississippi coast and along the Georgia through North Carolina coast are predominantly large water bodies and therefore not thoroughly assessed in this analysis, which is more suitable for assessing impacts on land areas and associated riparian networks.

Figure IV-14. Threats analysis summarized by Hubs.

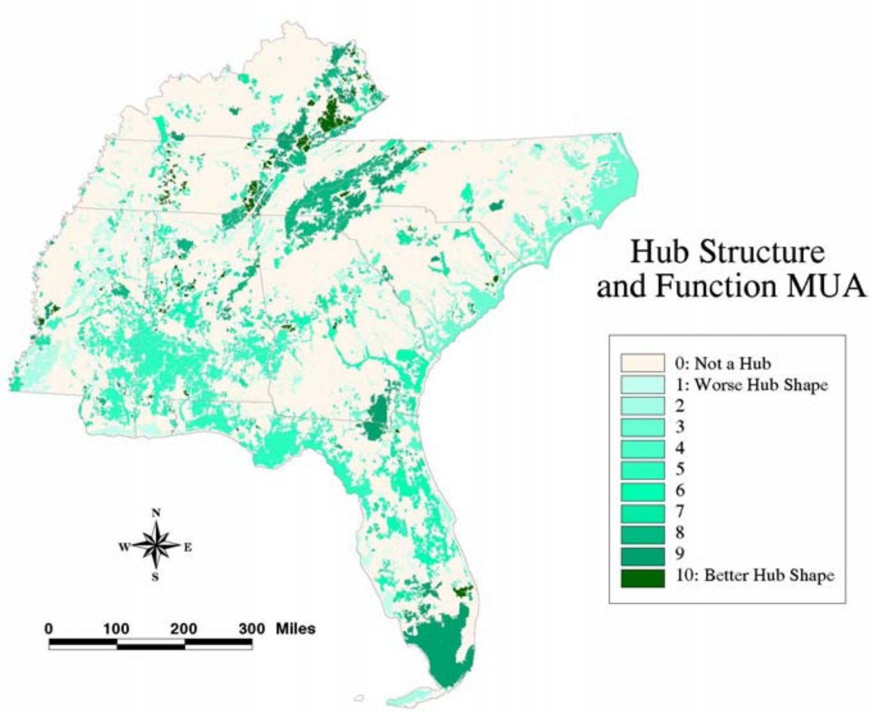


v. STRUCTURE AND FUNCTION

The goal of the hub structure and function prioritizations was to evaluate hubs based on their shape, size, and internal and external compositions. An optimal hub is one characterized by a low amount of edge habitat (low perimeter to area ratio), low internal fragmentation, high quality internal habitat, and surrounded by natural, semi-natural or generally low intensity land uses. The land uses which surround hubs, or the external context (composition) of hubs, is also important because of the negative effects from high intensity land uses that can extend into the hubs. Negative effects include habitat loss and fragmentation, wildlife mortality from automobiles, runoff, soil erosion, proliferation of exotic and/or invasive plants, and noise and air pollution. Hubs surrounded by lower intensity land uses will be less influenced by these effects.

Based on the various prioritization analyses assessing Hub size, Hub composition, and external context, Hubs in several areas have the potential for intact structure, size, and context to be most likely to support functional ecological services and biodiversity (Fig. 11). These areas include Great Smoky Mountains National Park and surrounding National Forest lands within the Appalachians, Okefenokee National Wildlife Refuge and Osceola National Forest in southern Georgia and northern Florida, and the Everglades/Big Cypress landscape. However, as discussed above in the regional prioritization threats analysis section, some of these areas are not completely insulated from significant impacts. The Everglades suffers from water management and water waulity issues and the high elevation forests in the Appalachians are impacted by regional air quality problems. However, these areas do represent large landscapes with the size and overall internal integrity to potentially support viable ecologial systems.

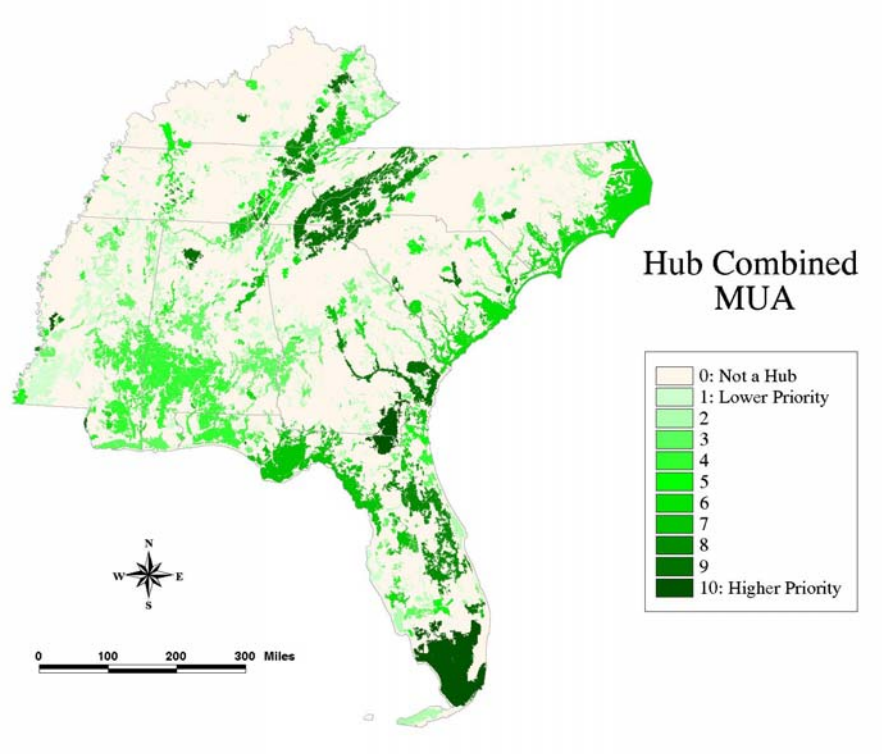
Figure IV-15. Hub Structure and Function Prioritization.



vi. HUB MUAS COMBINED

Although we do not recommend reliance on a combination “final” version of all MUAs as the basis for making conservation planning decisions, such a combination is provided here to serve as indication of how various factors and priorities overlay with each other among the four different major categories: ecosystem services, biodiversity, recreation potential, and threats to ecological integrity. The primary concern with combining these four categories is that they can represent related, though still significantly different factors that all can be important. By the nature of how a combination is created, there will tend to be averaging affects that will obscure areas that may be very important for one of the criteria but not others. However the combined maps of all MUAs for the Hubs will show where there are areas that are important for several of the categories discussed previously (Fig 16).

Figure IV-16. All Hub MUAs combined.



c. Linkage Prioritizations

Linkage prioritizations were developed to help assess priorities among the landscape linkages identified in the Southeastern Ecological Framework process. Linkages were prioritized by assessing their stucture, width, context, and the relative priority of the Hubs that the linkages connected. Though there are some issues which make assessing linkage width and other structural elements difficult, the linkage assessments can serve as a starting point for identifying corridors that might warrant conservation attention first. However, the regional prioritization presented in previous sections can also serve to identify priorities across all components within the SEF (Hubs, linkages, and areas added through optimization). Based on the results we recommend that users focus on the regional prioritizations clipped to the SEF as the primary source of SEF priorities, and then the specific linkage priorites can be used as additional information. Because of the scale of most of the linkages, the results of their prioritization are not presented here but are included in the data library included with this report.

E. CONCLUSIONS

Based on the discussions of methods and results above, there are several conclusions relevant to using the prioritization data for planning purposes. First, although some prioritizations that combine priorities for various categories incuding ecosystem services, biodiversity, recreation potential, etc. are included, we recommend that users should focus on the individual prioritization analyses or the combined prioritization MUAs for each particular prioritization category that are most relevant to their planning efforts. Furthermore, although the primary purpose of these analyses was to prioritize components of the SEF, regional prioritizations for the entire southeastern United States were also created as part of the process. These regional prioritzations can be useful for conservation planning efforts outside of the SEF. Users interested in such information should also be reminded that delineation of the SEF includes several data layers such as PEAs and SEAs that include areas of natural resource signficance outside the SEF.

Some datasets (such as the biodiversity analyses based on ABI and TNC data) are generalized to the extent that they should be used only for regional and state applications. More resolute data will be necessary in most cases for local planning efforts. However, many of the datasets used in or created by these analyses are resolute enough for local applications. The user should refer to the methods section and detailed methods in Appendix D or Appendix E to assess the suitability of any particular analysis to their planning applications.

This is a first iteration prioritization that should be enhanced as new data and analyses become available in the future. As discussed in the results and discussion section, there are data gaps that affect the thoroughness of the results in some of these analyses. This includes needing more specific information on biodiversity, various ecological service data and analyses, and indicators of pollution-related threats. However, this prioritization provides a useful starting point and resource for assessing areas of natural resource significance in all eight states within Region 4 EPA.

Section V: Multi—State Scale Application: The Mississippi Delta Ecological Framework

A. INTRODUCTION

In August 2000, at the request of the SE Natural Resource Leaders Group (SENRLG), the Federal Highway Administration (FHWA), US Environmental Protection Agency (EPA) and the US Forest Service (USFS) agreed to be the lead agencies in a cooperative effort to gather information regarding the natural resources of the Delta. This effort was intended to serve a variety of resource protection programs in the Delta, but specifically to be applied to the pre-planning phases of a new highway slated to run through the Delta: I-69. Because EPA Region 4's Planning and Analysis Branch already had a model for identifying such areas (the SEF), it was chosen as the data repository and analytical center.

This then was a test using the methodology developed by the University of Florida to develop an ecological framework at a scale in between the Florida Ecological Network and the Southeastern Ecological Framework. The product would have a very specific use by federal agencies, States, county programs and private conservation agencies in preparing for the I-69 project. The final product of the data was delivered to EPA, FHWA programs and all the agencies that contributed to this effort (approximately 40 CDs) for use regarding the I-69 project. It is available and free to the public. The product was finalized in October 2001. The DEF work is also included here as part of the Southeastern Ecological Framework final report applications section. The data gathering phase lasted about 7 months and the analysis phase lasted about 6 months. One person (Stacy Fehlenberg) worked on the project on a full time basis for this period. One other person (John Richardson) spent about a month and a half working on some of the final analyses, developing some of the protocols that were different than those in the SEF and the final distribution of the data CD's. During the entire process, researchers at the University of Florida were consulted on the methodology to ensure that the process was as similar to that developed for the SEF as possible.

B. BACKGROUND

The natural environment and the processes that support it are our life support system. Every thing that the environment provides to us for free usually comes at a very high price if we have to replace it or maintain it. In that regard, preservation of existing natural systems and their inherent processes is essential for our survival. Landscape ecologists have known for a long time that piece-meal protection of the environment often leads to degradation of the parts being protected. The resulting fragmentation prevents the operation of many large-scale processes from adequately functioning. Preservation of natural areas that are contiguous with other natural areas is an important guiding principle for conservation planning.

Recognizing that successful protection of natural resources requires more than "spot" conservation of isolated areas, this framework attempts to identify not only highly valuable and sensitive ecological areas, but the best potential links between them. One of the biggest threats to the environment is loss of functionality due to fragmentation. Roads, agriculture and other development often lead to cutting natural systems into smaller pieces. Large, contiguous tracts of natural land are required not only for species habitat range, such as migratory birds or black bears, but for ecosystem function. Many ecological processes, like water filtration and functional evolution, require large areas of land, often crossing more than one land cover type. Viable landscape linkages are needed to connect these different land types, or the processes are disrupted and their capabilities to function healthily are compromised. For these reasons, conservation must take on the new challenge of not only protecting small pristine areas, but ecological connectivity in an effort to protect larger, integrated landscapes containing a mosaic of public and private lands and a variety of compatible uses that functions together to protect important ecosystem services and biodiversity.

C. OBJECTIVE AND GOALS

The SENRLG requested a watershed analysis of the Mississippi Delta intended to produce a planning resource for a variety of natural resource programs, both federal and non-federal. The objective of this effort was a compilation database that would highlight ecological priorities in the Delta, and thereby demonstrate potential cross-agency program collaboration.

The goal of this database creation and pre-emptive assistance in terms of I-69 was to mitigate the ecological impacts of this new highway's construction via early exchange of data, and thereby streamline the statutory process for all concerned agencies. From a resource standpoint, identifying sensitive and/or valuable ecological resources in the Delta could not only highlight what areas for the highway to avoid, but also to delineate potential areas that could be considered for conservation, enhancement or restoration. It was hoped that, by identifying these areas early on, permitting, mitigation, and funding procedures (such as NEPA and TEA-21) related to the building on I-69 may be greatly expedited.

Other benefits of this effort will be the database itself and its potential for use by other natural resource agencies. For example, Ducks Unlimited has developed several GIS layers in the Lower Mississippi Alluvial Valley (LMAV), such as a Soil Wetness Index, indicating soils appropriate for wetland restoration. This and other information like it from the various partners involved in this initiative could provide a wealth of planning resources to serve a wide variety of conservation and restoration programs in the Delta.

D. METHODOLOGY

The methodology for the DEF model was based on the SEF methods used in EPA's eight-state region (described previously in this document) and modified slightly to customize it for the ecological data sets that were available for the Lower Mississippi Delta. Since the methods were taken from the SEF project, detailed information on the methodology is not repeated in this section. Where major differences occur in the methodology, they are noted (See Appendix F for detailed methods).

Data was collected from a wide variety of natural resource agencies. These included State, Federal, local and non-governmental organizations, but the majority of regional databases came from US Geologic Survey, U.S. CensusTiger95, the US Forest Service and its contractor, Ducks Unlimited, and the Lower MS Joint Venture Office's Mississippi Alluvial Valley Conservation Planning Atlas, 2001 (led by the US Fish and Wildlife Service).

All data was received in digital format, and varied in scope greatly, but often covered at least a state, if not the whole watershed, for consistency. Data was compiled and reprojected into the EPA Region IV's customized Albers projection.

In comparing the methodology to the SEF project, hub size (5000 acres or greater), PEA definition, and SEA designations remained unchanged, with public lands, wetlands and roadless areas serving as the main PEA criteria (see Table 1). Many riparian-based SEAs (except Significant Riparian Areas itself) were not included in the DEF due to extreme lack of intact riparian areas in most of the central Delta. The PEA exclusion process for Hubs also used the same criteria as the SEF (areas close to urban, agricultural areas, and areas with high road density being excluded).

There were two main indicator species used for the habitat analysis for the DEF that more specific from the analyses used in the SEF: migratory birds that use the Lower MS Alluvial Valley as a flyway (as a whole), and the Louisiana Black Bear (*Ursus americanus*). Their feeding and breeding requirements (10,000 acres on contiguous land in natural cover, plus distance tolerances to roads, urban areas and agricultural lands) served as a guide for the Bird Conservation Areas and Black Bear Habitat PEAs.

Table V-1. PEA data layer descriptions for the delineation of the DEF.

PEA LAYER	**GIS coverage**	**Description**	**Source**	**Coverage**
PEA layer for black bear habitat	pea_bbhab	Known black bear habitat	State of Louisiana	Louisiana
PEA layer for potential black bear habitat	pea_potbbhab	Modeled black bear habitat	DEF Modeling	Delta
PEA layer for roadless areas	pea_rdless	Areas with greater than 5000 acres without roads	DEF Modeling	Delta
PEA layer for priority migratory bird conservation areas	pea_bca2	Modeled for priority bird conservation areas	US Fish and Wildlife Service	LMAV
PEA layer for public lands	pea_publands	Existing lands in public management	USGS, States	Delta
PEA layer for wetland reserve	pea_wrps	Wetland reserve areas from NRCS	NRCS	Delta (- TN)
PEA layer for reforestation	pea_refortrk	Reforestation efforts on public lands	Modeled from USFWS information	LMAV
PEA layer for habitat diversity	pea_habdiv	30 meter habitat diversity	Modeled from NLCD/MRLC land cover	Delta
PEA layer for wetlands	pea_wetland	Wetlands from NLCD	Modeled from NLCD/MRLC land cover	Delta
Combined database for all PEA layers	pea_combine	Final PEA layer	Modeled	Delta
PEA after exclusions	PEAX	PEA with areas excluded for roads and urban	Modeled	Delta

The PEA layers were combined so that any pixel that had any one of the PEA input layers present was included in the final PEA layer. The exclusionary process was the same as with the SEF, excluding areas containing intensive agricultural or urban land uses or close to major roads and urban areas. The PEAX (PEA with exclusions) layer was then filtered to remove all pieces and fragments less than 5000 acres. This filtered PEAX was then the basic HUB layer. The Hubs were optimized with the same methodology as the SEF analysis, filling in areas of natural land cover and smoothing the edges in areas of natural land cover.

Linkages were then delineated using ArcView, the Hub layer and the cost surface generated for the Delta region. The process was essentially the same as that done in the SEF delineation, but utilizing ArcView instead of the ArcInfo AML. Initially, connectivity was delineated using riparian corridors as a guide, as with the SEF. Connectivity between the hubs was dictated by a similar cost surface criteria used in the SEF, with slight modifications to allow for the extensive agricultural land cover of the Delta. These modifications allowed agricultural lands to have a slightly higher suitability than in the SEF, to allow proximity to and crossover through the agricultural areas that dominate the Delta landscape when necessary. The linkage process delineates a single cell path between the endpoints defined in the linkage process. Many links were made between the various hubs, some of which were through areas with a high amount of agriculture.

It was necessary to allow as many potentially feasible linkages (that would require restoration in some cases) in the Delta as possible while also focusing on the linkages with the highest existing ecological integrity. Some links were formed along riparian areas, and most in the outlying wooded areas outside the alluvial valley, but the cost surface used to delineate linkages allowed some, admittedly tentative or speculative, "jumps" between these areas to explore areas potentially important for connectivity for wildlife and opportunities to restore connectivity.

Therefore, the next step involved an analysis conducted to compare all of the links and to determine the land cover make up of them. After the analysis was done, many links that were very high in agricultural land use and very thin were deleted from the linkage coverage. These deleted links represented an effort to connect hubs through long stretches of agricultural areas. The link information for these was saved for an analysis of potential ecological restoration/mitigation areas.

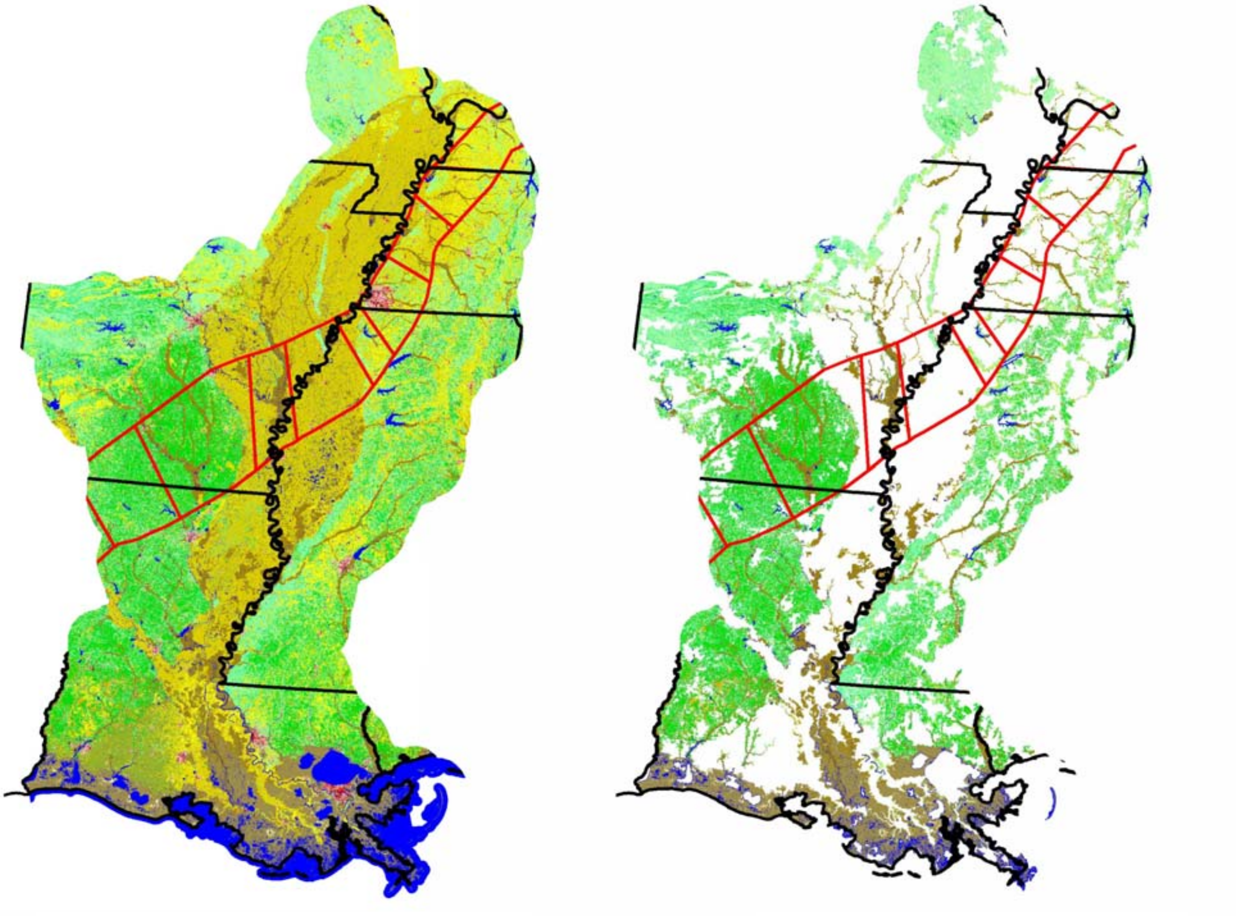
The development of the corridors along the single cell linkage connection delineated through the least cost path function was done in a slightly different manner than in the SEF project. The linkages in the DEF were expanded by allowing the single cell connection to expand out along the path to a distance of 5000 meters through natural areas and to a distance of 100 meters through agriculture areas. A cost distance algorithm was run using ArcView Spatial Analyst with natural areas assigned a cost of 1 and agriculture areas assigned a cost of 50. Any combination of agriculture and natural that added up to 5000 was included in the linkage. Other areas were assigned an infinite cost. This allowed corridor expansion to occur to a much larger width through natural areas but limited the width through mixed and exclusively agricultural areas.

A process of "expand and contract" then allowed these single cell links to "bleed" into any contiguous compatible landscape, as was done in the SEF, to fill out the corridors. The hubs and linkages were combined and optimized to fill gaps containing suitable land uses to create the final DEF.

E. RESULTS

The DEF model produced a series of interconnected hubs and corridors comprised of large tracts of ecologically significant land in the Lower MS Delta. The resulting framework represents some of the best remaining ecological areas in the MS Alluvial Valley, covering areas in the States of: Louisiana, Mississippi, Arkansas, west Tennessee, the boot heel of Missouri and the southern tip of Indiana. In total, over 44% of the 89+ million acres in the study area were identified as part of the Framework, but it is important to note that the vast majority of these areas lie outside the alluvial valley itself. Of the whole study area, roughly 40% of the land acreage is agricultural and 41% is forest, but this distribution is not even (Fig. 1). Most of the alluvial valley is agricultural, while the vast majority of the forested areas lie outside it, beyond the ridge lines. The alluvial valley is low and flat, and was historically frequently flooded by the Mississippi River, making it an ideal landscape for the farming that has taken place there for hundreds, if not thousands (including native activity), of years. This dominance of landcover conversion for human use left little of the native landscapes, and therefore, little of its original ecological functionality, in the valley; hence, the "great divide" in ecosystems (and therefore the Framework) between the inside and outside of the alluvial plain.

Figure V-1. Study Area Land Cover and Land Cover within the Delta Ecological Framework.



Study Area Land Cover
See Table V-2 for legend

DEF Land Cover
See Table V-2 for legend

I-69 Corridor Segment 🟥

But despite this dominance of converted landscapes inside the valley, there remain some significant riparian corridors along the Mississippi River itself and its tributaries. If preserved, these could provide sufficient (if not ample) habitat corridors and water filtration functionality. There are also a few sizable national forests and wildlife refuges that, if connected with restored native landcover, could further provide significant landscapes for wildlife and ecological function. Significant areas within the valley include the Lower Yazoo Basin, from the Delta National Forest to the Tensas River National Wildlife Refuge (NWR); the middle Yazoo between the Tahomey and White River NWRs (as well upstream of the White River NWR); the Coldwater, Little Tallahatchie and Hatchie river corridors, among others. Outside the alluvial plain, much of Louisiana, SW Arkansas, and many of the riparian corridors in Tennessee and eastern Mississippi contain vast areas of ecological and natural resource conservation significance.

A summary of the land cover types (NLCD) shows that the Delta study area encompasses approximately 89 million acres. The Delta ecological framework is about 39.5 million acres or about 44% of the study area. Currently about 8.8 million acres is in some form of public management. This represents about 22% of the DEF. The DEF contains most of the wetlands in the study area (Table 2, 10.9 million acres, 85% of the existing wetlands) and 73% of all of the forested areas in the study area. The linkages generated in the modeling process allowed for inclusion of agricultural areas and the final total is about 1.32 million acres (out of 39.5 million acres) of which .87 million acres is in grassland or pasture.

F. CONCLUSIONS

The Mississippi Delta Ecological Framework is currently being used by the Federal Highway Administration in the process to delineate feasible route alternatives for the proposed Interstate 69 through the region. In addition, the DEF and data created during the delineation process has received interest from other agencies responsible for natural resource conservation efforts within the region.

The Mississippi Delta Ecological Framework, despite being completed under a tight time schedule, demonstrated that the natural resource analysis methodology developed within the Florida Ecological Network and Southeastern Ecological Framework was applicable to the objectives and scale of multi-state regional resource assessment in a landscape dominated by agricultural land uses.

For more information on the delineation of the DEF and the use of the data in regional applications, contact Stacy Fehlenberg (404-562-8309) or John Richardson (404-562-8290) from EPA, Region 4.

Table V-2. Summary of land cover types in the Delta study area and in the Delta Ecological Framework.

NLCD Land Cover	Acres in Study Area	Percent in Study Area	Acres in DEF	Percent in DEF	Percent of Land cover type in DEF
Open Water	7,560,044	8.48	2,426,107	6.13	32.09
Low Intensity Residential	920,097	1.03	9,007	0.02	0.98
High Intensity Residential	212,957	0.24	350	0.00	0.16
Commerical/Industrial/Transportation	426,665	0.48	7,592	0.02	1.78
Bare Rock/Sand/Clay	56,956	0.06	23,497	0.06	41.26
Quarries	36,934	0.04	4,385	0.01	11.87
Transitional	693,452	0.78	482,525	1.22	69.58
Deciduous Forest	14,553,897	16.33	10,345,734	26.15	71.09
Evergreen Forest	10,866,448	12.19	9,052,115	22.88	83.30
Mixed Forest	7,980,768	8.96	4,960,562	12.54	62.16
Shrubland	575	0.00	138	0.00	24.02
Grassland/Herbaceous	225,685	0.25	130,046	0.33	57.62
Pasture / Hay	10,422,338	11.69	749,980	1.90	7.20
Row Crops	19,298,414	21.65	423,834	1.07	2.20
Small Grains	2,881,909	3.23	21,550	0.05	0.75
Urban Recreational Grasses	227,508	0.26	10,322	0.03	4.54
Woody Wetlands	8,075,020	9.06	6,511,095	16.46	80.63
Emergent Herbaceous Wetlands	4,679,113	5.25	4,407,473	11.14	94.19

Section VI: Local Scale Application: Delineation of an Ecological Network in Murray County, Georiga

A. INTRODUCTION

a. The Intent of the Local Application

The Southeastern Ecological Framework (SEF), a region-wide, eight state model identifying linked ecologically significant areas, can be a powerful tool for county planners and other local agencies interested in conservation planning. However, the results can appear potentially abstract and intimidating, as there is no clear cut formula for how local entities can translate these model results into a meaningful contributor for delineation of specific conservation goals at the local level. The areas identified in the SEF are vast, crossing county, state, and conservation lands boundaries. Exactly how these areas are relevant at the county level needs further exploration. The SEF provides a relevant "backbone" and an important context for local conservation planning that identifies the larger areas of conservation significance within a region or landscape. However, local conservation initiatives should also focus on identifying resources at finer scales and in more detail than possible in a regional level model such as the SEF.

This local application serves to explore and provide an example of how the Southeastern Ecological Framework can be utilized at the local or county level. The first portion of this section discusses potential applications of the SEF at the local level, the second portion describes the methods used in the Murray County, Georgia case study, the third section presents the results, the fourth section discusses the results and in the fifth section, conclusions are drawn.

b. Why should the SEF be utilized at the local level?

i. THE IMPORTANCE OF CONSERVATION SCALES: THE NEED FOR INTEGRATION BETWEEN DIFFERENT SCALE CONSERVATION PROJECTS

Successful, comprehensive conservation planning involves the consideration (and incorporation) of the larger ecological context (Forman 1995). A county level ecological network should primarily focus on areas of local ecological significance, such as habitats, communities, and conservation areas that support species of conservation interest, and areas supporting functional ecological processes. However, these local ecosystems are not confined, independent systems, but rather are dependent upon neighboring ecosystems for inputs of resources and energy (Noss and Harris 1986). As neighboring habitats, ecosystems, and landscapes function together and interactively, there is a continuing need to evaluate the relationship between one another. Resources and energy are exchanged both within and between ecosystems and landscapes, and the health of interacting systems is contingent upon one another. Furthermore, some native species require larger areas that can exceed the bounds of a county or other local area to support viable populations.

The SEF is one of the only current conservation initiatives to address such an expansive geographic scale. The SEF project allows for integration of various conservation scales by offering a common regional conservation framework that can be used to both guide projects and evaluate how smaller geographic areas fit into the larger conservation context.

ii. COORDINATION OF PROTECTION EFFORTS

Coordination of various scale protection efforts is important for maximum efficiency and protection of ecologically significant areas. Federal, state, and local entities, as well as private conservation organizations can work together towards a common goal, and consequently achieve that goal in a quicker and more comprehensive manner. With limited financial and human resources, it is important to streamline efforts in order to yield the most efficient results. The SEF can provide the "bigger picture" or framework that can help guide various multi-scale conservation efforts towards a common goal.

Currently, there are plans to use the SEF to focus and prioritize existing EPA programs to streamline the decision-making process of Region 4 program managers (Durbrow et al 2001). Participating agency programs include National Environmental Policy Act (NEPA) programs, National Pollutant Discharge Elimination System (NPDES) programs, Supplemental Environmental Projects (SEPs), and programs through the Wetlands Program Office.

iii. UTILIZATION OF SEF PRODUCTS, INFORMATION, DATA, AND ANALYSES

During the course of the SEF's 4-year project history, great amounts of energy, research and thought has been contributed from various sources. The first stage of this project was to collect regional GIS data necessary to complete the desired analyses. However, the availability of uniform regional data was lacking as many GIS mapping projects have focused on smaller geographic areas (such as states, counties, or watersheds). Consequently, regional datasets were often created by compiling individual state datasets.

The format and projection in which GIS data are stored is dependent upon the geographic scale and location of the area mapped. Consequently, while collecting GIS data from various sources and geographic areas, time-intensive data processing was necessary in order to get the data in a common format and projection. The result is a database of regional GIS layers that are physically housed in one location and in the same projection (hence ready for overlay and analysis). Furthermore, this database includes not only input data sources, but also a unique set of analyses produced from these sources. Having this rich source of data can save others time in data collection and processing.

We advocate and welcome the use of our data, analyses and products. This project is meant to act as a resource to others who aspire to perform sound conservation planning and conservation-related projects. The goal here was not only to create analytical products for others to utilize, but also to establish a *process* that others could follow.

iv. ADDRESSING LOCAL CONSERVATION CONCERNS NOT ADDRESSED IN THE SEF

The SEF is a regional model covering eight states and was designed to address regional conservation needs for the southeastern United States. Since the scale of the project is so large, the results do not comprehensively include each and every ecologically significant area in the southeast. This is due to both the limited availability of data (ecological data not available or not in digital or GIS format) and the SEF parameter that set a size threshold of 5000 acres for ecological hubs.

Collecting detailed knowledge concerning the significant ecological areas of each locality (county, city, region) in the southeastern United States is an immense task that could take years to complete because of the variability in data type and recording protocols. Many areas already have comprehensive ecological data, others areas are in the process of conducting studies and analyses, and still other areas have been neglected altogether for lack of financial, technical or intellectual resources. For areas where data do exist, they often only exist in hard-copy (paper) format. The conversion of these data into a digital mapable format is time consuming and often expensive. Hence, the data collected for the SEF model only covers the major areas of ecological significance in the Southeastern U.S. that have been studied, analyzed, and mapped, and may not include smaller areas of ecological significance.

Since the SEF was not intended to comprehensively serve local conservation needs, it is necessary for counties and localities to continue with more refined conservation work at the local level to augment the analyses in the SEF. To apply the SEF process at the local scale, it is imperative to incorporate locally collected and relevant information concerning areas of ecological significance. Examples include, specific watersheds or subwatersheds important for protecting drinking water sources, or known local habitat areas for species of conservation concern.

c. How Can the SEF Products & Regional Data be Utilized at the Local Level?

i. EVALUATING SEF DATA TO UTILIZE IN THE LOCAL CONSERVATION PLANNING PROCESS

The SEF data can potentially be used to supplement local data sources needed in the creation of a local conservation plan. After formulating conservation goals and collecting local data, the SEF products can be compared to the sources of local data to determine the usefulness of any SEF data products. As stated in the previous section, the SEF has collected a wealth of information and digital geographic data that is ready to be utilized by others. Conservation lands, hydrographic features, wetlands, land cover, potential black bear habitat, shellfish harvesting areas and 100-year floodplain are just some examples of the datasets that have been collected. After reviewing the SEF datasets available, an assessment can be made about the appropriateness of using the SEF data for local planning.

ii. IDENTIFICATION OF LOCAL PRIORITY ECOLOGICAL AREAS

Although the SEF identified larger blocks of ecologically significant lands, the data used in the project can still be helpful for local analyses. In the SEF modeling process, priority ecological areas are first identified, then hubs are created from those priority areas that are 5000 acres or greater. (For more information concerning the SEF modeling methods, please refer to the accompanying SEF Final Report). Hence, not all Priority Ecological Areas (PEAs) identified in the SEF project are included in the actual Southeastern Ecological Framework. These areas are still extremely important and significant, but because some of them are small and isolated from other PEAs, they are not included in the framework. These PEAs can be helpful for the identification of significant ecological areas at the local level, and can also augment local data sources. Furthermore, the SEF identification process also included the identification of Significant Ecological Areas (SEAs) that can also be relevant to local conservation planning. SEAs are considered to be of secondary significance to PEAs, but they also identify areas that can be important to local conservation goals.

iii. REGIONAL ECOLOGICAL CONTEXT: EVALUATION AND PRIORITIZATION OF LOCAL ECOLOGICALLY SIGNIFICANT AREAS IN THE REGIONAL CONTEXT

As discussed in Part 1, Section B, a sound conservation plan involves consideration of the larger ecological context, and the SEF provides the means in which local areas can be evaluated. It is important to analyze how local ecologically significant areas fit into the SEF since local pieces may provide added significance at the regional level. For example, locally significant habitat patches may serve as "stepping stones" to larger conservation areas, and riparian corridors may connect larger blocks of ecologically significant lands. Recognition of regional significance can offer additional justification to protect these local areas, while also preserving the ecological integrity of the larger system by enhancing connectivity. These local areas can be "bumped" up in their priority status, as they exhibit ecological importance at a variety of scales.

iv. USING THE SEF METHODOLOGY TO CREATE A LOCAL ECOLOGICAL NETWORK

The SEF project methodology is based on the principles of landscape ecology, conservation biology, and reserve design. These principles stress conservation of biodiversity through protection of critical habitats to support viable populations of species, the facilitation of biotic movement and dispersal through the identification and protection of landscape linkages, and protection of functioning ecosystems and the ecological services that they provide. Using these principles can lead to a holistic, integrated conservation approach that protects landscapes, biological diversity and ecological services by accounting for the interaction between and within ecosystems and the urban environment. These principles are applicable at various scales of conservation, and are discussed in detail in the companion report to this document: The Southeastern Ecological Framework Report.

The methodology used in the SEF project is a four-step process: 1. Identification of Priority Ecological Areas (and Significant Ecological Areas), 2. Selection of Ecological Hubs, 3. Identification of Landscape Linkages, and 3. Combination of Hubs and Linkages to create the final network. Any or all of the methods used in these steps can be used at the county planning level. The local application of the methods is discussed in more detail in the following section of this report: The Murray County Case Study.

d. Data Issues

Since the county example explores the use of regional analyses and the combination of regional and local data for conservation planning, it is important to discuss potential data issues that may arise in this process. Following is a discussion of issues concerning data availability, map scale, and combining data of different scales.

i. DATA AVAILABILITY

Depending on the geographic area and the subject of interest, data can be in abundance or scarce. Data can be found from various sources, including state and federal agencies, research institutions, and Data Clearing House websites. These websites compile and organize data for easily accessible distribution. For example, in the local case study of

Murray County, many data was received from the Georgia GIS Data Clearinghouse (http://gis.state.ga.us/Clearinghouse/clearinghouse.html) and the North Georgia Regional Development Council.

In any GIS-based project or analysis, the first step is to develop goals and create a list of necessary data. The next step involves taking an inventory of existing available data. Thereafter, data gaps can be evaluated and decisions can be made as to whether there is time or resources to create primary data necessary, or whether there is a surrogate data source available. Data availability is often the limiting factor in GIS based research projects and sometimes less than ideal data must be used in order to complete an analysis. However, the availability of GIS data is increasing, as GIS has quickly become a popular tool for various planning and management applications.

ii. MAP SCALE

Map scale is the relationship between distance on a map and distance on the ground (USGS 2000). If features on the ground were mapped at their actual size, maps would obviously be too large and cumbersome for practical use. Hence, to represent areas at a convenient size for use, the actual size of all features must be reduced proportionately. This proportion is the scale of the map.

Scale is usually represented by a graphic scale on the map, or a numeric scale called the "representative fraction" (RF). The RF shows the numeric relationship between distance units on the map and distance units on the ground. The first number of the fraction is always one and represents the distance units on the map. The second number varies depending upon the scale of the map and refers to the distance units on the ground.

An example representative fraction is 1:24,000, where one unit on the map equals 24,000 units on the ground. The smaller the second number of the RF, the larger the map scale is considered. Large-scale maps cover less area, but show more detail and features than small-scale maps. Small-scale maps cover larger areas, but show less detail. An example of a large-scale map would be a 1:24,000 scale map. Small-scale maps are generally 1:250,000 and smaller (USGS 2000).

The scale of the data is an issue that needs careful consideration depending upon the geographic extent of the area of interest and the amount of detail that needs to be represented on the map. If the area of interest is small and great detail is needed, then a large map scale should be chosen. However, if a larger area of interest is being mapped, then detail should be sacrificed and a small map scale should be chosen. For county level analyses, 1:24,000 is a commonly used map scale.

iii. COMBINING DATA OF DIFFERENT SCALES

Since geographic data is mapped at varying scales, it is often necessary to combine data of varying scales for desired analyses. In these cases, it is important to determine whether the combination of data scales is appropriate and how it will affect the results of the analyses.

Determining appropriateness depends upon the goal of the analysis. For example, if the area of interest is small (e.g. county), and only regional scale (e.g. state or multi-state) datasets exist for a particular feature of interest, it is important to consider whether the features represented in the regional data are resolute and accurate enough for county level analysis. For the opposite example, when the area of interest is large and only county data exists, it is important to consider whether it is appropriate to use the data if it is not complete for the entire study area. If it is complete, it is important to consider how detailed the features are and if they will slow down computer processing time when performing an analysis at the regional scale. In the local workbook example, the appropriateness of combining regional scale (lower resolution) and local scale (higher resolution) data for local conservation planning is discussed.

When combining data of different scales, it is also important to note that the scale of the resulting data set or map is only as resolute as the coarsest input data. For instance, if combining two vector data layers, one with a scale of 1:24,000 and the other with a scale of 1:100,000, the resulting layer should only be considered at a scale of 1:100,000. If combining two raster data layers, one with a resolution (cell size) of 10 meters and the other with a resolution (cell size) of 50 meters, the resulting data layer should only be considered a resolution of 50 meters, although the cell size can be 10 meters. The cell size can be 10 meters, but the features represented will only be at a resolution of 50 meters, since one of the inputs was at a resolution of 50 meters.

B: MURRAY COUNTY, GEORGIA CASE STUDY

a. Introduction

Murray County, Georgia has been chosen as a representative county model to demonstrate how the methods and products completed in the Southeastern Ecological Framework can be used at the county level for conservation or natural resource planning. Currently, it is a unique time for Murray County, as the political and ecological climate offer ample opportunities for successful natural resource protection. In January 2001, a new county commissioner was elected, and one of his primary agendas involves implementing county measures to protect natural resources. Furthermore, the State of Georgia recently adopted the Georgia Greenspace Program, which offers high growth counties financial assistance for permanent protection of greenspace.

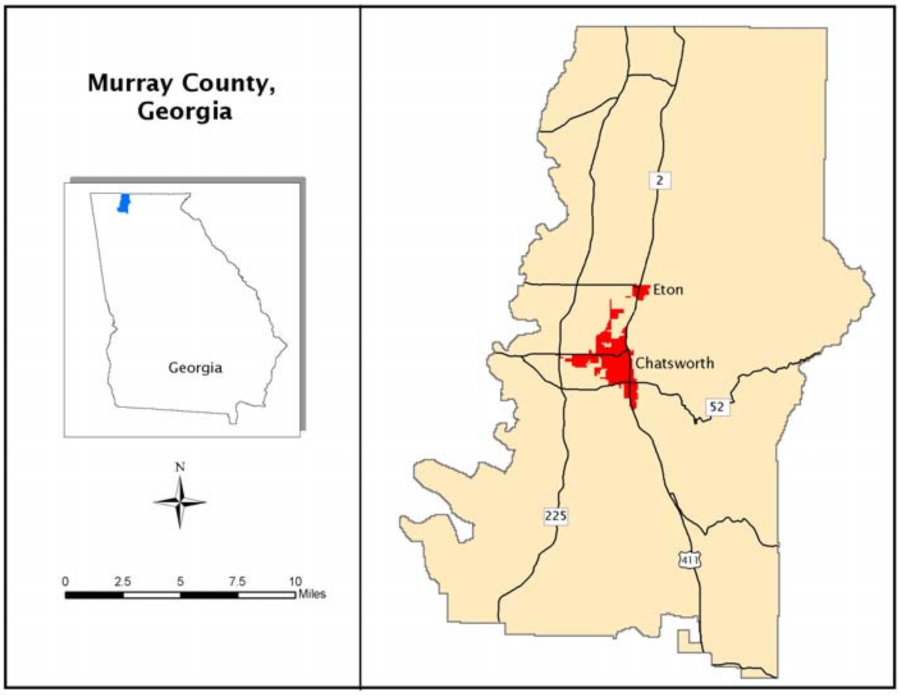
For this particular example, SEF-based methods will be used to show: 1) How GIS and conservation planning principles can be used to identify prominent areas of ecological significance in the county; 2) The importance of the integration of regional-scale conservation planning efforts with county level conservation and natural resource planning; and 3) How the SEF methods can aid in the creation of a comprehensive strategy for conservation and natural resource protection.

i. MURRAY COUNTY BACKGROUND

1. Geographic location

Murray County is located in NW Georgia, along the border between Georgia and Tennessee. The county is approximately 344 square miles, or 220,160 acres (United States Census Bureau 2000). The county has only two incorporated cities: Chatsworth and Eton.

Figure VI-1. Location of Murray County, Georgia.



Murray County straddles three ecoregions. The west side of the county is in the Central Appalachian Ridges and Valleys Ecoregion. The topography of this area is relatively flat and open with a few scattered ridges and hills. Elevations range from 700-800 feet above sea level, with slopes ranging from 0 to 8%.

The northeastern portion of the county is in the Blue Ridge Mountains Ecoregion. The topography of this area is characterized by rugged mountains and valleys that contain headwater tributaries of southwestward and northward flowing streams. Elevations range from 3000-4000 feet above sea level, with most slopes of 25% or greater.

The extreme southeastern portion of the county is located within the Piedmont Ecoregion. The Piedmont region transitions between the Appalachian Mountain regions and the Southeastern Coastal Plain. The topography is characterized by rough, hilly surfaces, with elevations ranging from 1,300 to 1,500 feet in the northern portion, and gradually decreasing to 1000 feet in the southern portion. Slopes vary from 8% in valley areas to 25% or greater near mountainous areas. (Clark & Zisa 1976)

2. Demographics

According to the 2000 census, the Murray County population was 36,506, a 39.6% increase since 1990 (United States Census Bureau 2000). The county population rate increase was higher than the State of Georgia's population rate increase since 1990, which was 26.4%. Population density is approximately 106.1 persons per square mile, with the highest concentrations of people in the cities of Eton and Chatsworth. The county is currently experiencing growth pressure from Chattanooga, TN, which is approximately 40 miles northwest of the county. The City of Eton is also growing rapidly.

3. Industry / Economic Activities & Employment

Primary economic activities in the county include manufacturing, wholesale trade and retail trade, much of which is associated with the carpet and carpet related industries (United States Census Bureau 1997). The carpet industry requires large inputs of water, and hence relies heavily upon the Conasauga River and local watersheds. Other industries include accommodations and food services, health care and social assistance, and transportation.

4. Land Cover / Land Use

The county is predominantly rural and sparsely populated. The majority of the land cover is forest (approximately 178,004 acres or 81% of county's total area), under varying ownership. The forest is an important resource, as timber production is the major economic natural resource use in the county. Approximately 36,000 acres (16% of the county) are in agricultural land uses. Approximately 15,000 acres or 7% of the county's total land area are in residential land uses. Forest ownership is shown in Table VI-1.

Table VI-1. Murray County Forest Acreage by Ownership Class.

	Total	*Federal*	*State, City, County*	*Forest Industry*	*Farm*	*Corporate*	*Private Individual*
1989	178,004	73,135	80	392	43,957	5,495	54,945

*source: United States Dept of Agriculture, 1989

5. Significant Natural Resources

Murray County is rich in natural resources and already has approximately 52,854 acres, or 24 % of the total county area, in conservation. This acreage does not include the Wildlife Management Areas because they are leased under annual contracts and are not under permanent protection.

Existing Conservation Lands

National Forest

- Chatahoochee National Forest: Approximately 51,360 of the total 749,689 acres of the Chatahoochee National Forest are contained within Murray County (USFS 2000). This is approximately 23% of Murray County's total land area (including the Cohutta Wilderness Area, listed below). A large part of the forest is managed for multiple uses, including timber production, general recreation, preservation, and other public uses. It is an extremely important regional resource for timber, recreation and wildlife. Chattahoochee is the primary provider of quality hardwood timber in Georgia (USFS 2000). In terms of wildlife, Chattahoochee offers quality habitat for a variety of wildlife species, including many endangered fish and mussel species, the black bear, and various neo-tropical migrant birds.

Wilderness Areas

- Cohutta Wilderness Area: Cohuttta Wilderness Area, located within the Chattahoochee National Forest, is the largest federally designated wilderness area in a national forest system in the southeastern United States. It was established for protection of roadless areas, public recreation, and controlled hunting. Cohutta is a total of approximately 32,268 acres in Georgia, 5,158 of which are located in Murray County (USFS 2000). Elevations range from 950 to 4,200 feet.

State Parks

- Fort Mountain State Park: Fort Mountain State Park is approximately 1920 acres and offers hiking, biking, and horse trails. It is located about 2-3 miles east of Chatsworth.

Wildlife Management Areas

The Georgia Department of Natural Resources (GADNR) manages two Wildlife Management Areas (WMA). GADNR enters annual contracts with landowners to make the land available for public use recreation such as hunting and hiking. These areas are not permanently protected since they are leased on an annual basis.

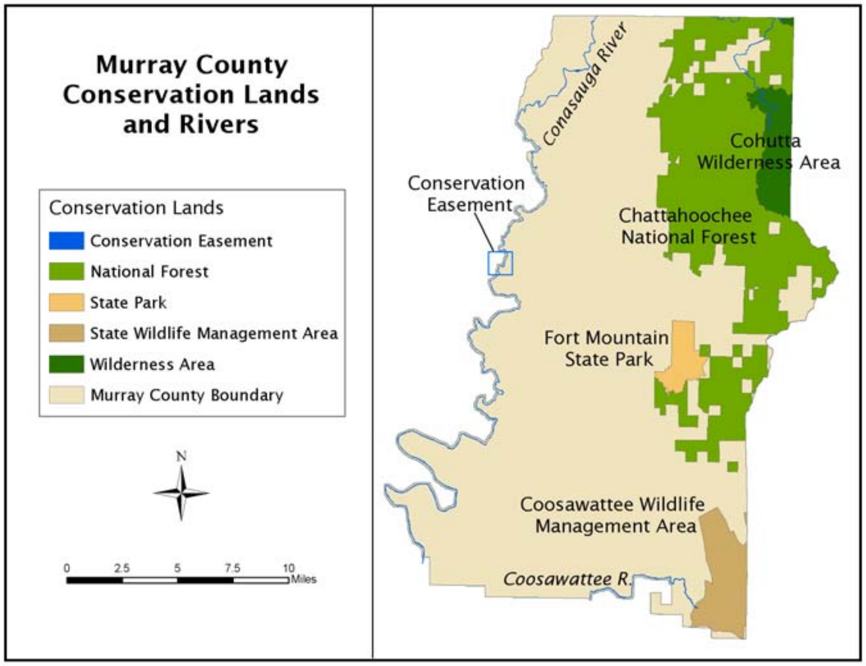
- Cohutta Wildlife Management Area - The Cohutta WMA is located in the Chattahoochee National Forest. It encompasses a total of 95,265 acres, and spans both Murray and Gilmer counties. It is under ownership of U.S. Forest Service and one private landowner.

- Coosawattee Wildlife Management Area: Coosawattee WMA spans Murray and Gilmer counties, and surrounds Carter's Reservoir in the southeastern portion of Murray County. Approximately 6,345 acres of the total 10,515 acres are within the county.

Protected Rivers

The Georgia Department of Natural Resources adopted the Rules for Environmental Planning Criteria, which defines Protected Rivers as any perennial river or water course with an average annual flow of at least 400 cubic feet per second (pursuant to Section 12-2-8 of Article I, Chapter 2, Title 12 of the Official Code of Georgia Annotated). GADNR considers rivers of such size as important resources for wildlife habitat, recreation facilities, and clean drinking water. Both the Conasauga River and the Coosawattee River meet the size requirement to be considered a protected river.

Figure VI-2. Murray County Conservation Lands and Rivers.



The Conasauga River

The Conasauga River originates in the Blue Ridge Mountains of the Cohutta Wilderness Area and is approximately 100 miles long. It flows north-northwesterly into Tennessee, then flows south along the western border of Murray County, and finally merges with the Coosawattee River to form the Oostanaula River in south Whitfield County.

An important resource for aquatic biodiversity, the Conasauga is home to more than 90 species of fish and 25 species of mussels, 12 of which are federally listed as threatened or endangered. Several types of snails, crayfish, insects, and other aquatic animals have been reported from the Conasauga and its tributaries (Southeast Aquatic Research Institute 1996). Historically, there were 42 species of freshwater mussels, which has dwindled to 25 due to poor water quality. Eighteen miles of the Conasauga and 54 miles of its tributaries are on Georgia's 303D list of impaired waters. The three primary factors threatening water quality and habitat in the Conasauga River system are accelerated erosion, toxic chemicals, and excessive nutrients (Southeast Aquatic Research Institute 1996).

The Coosawattee River

The Coosawattee River forms from the confluence of the Ellijay and Cartecay Rivers in Gilmer County, which borders Murray County to the southeast. The river is the primary tributary to Carter's Lake, a man made reservoir which serves as a popular recreation area and public water resource for Murray and adjacent counties.

ii. LOCAL ENVIRONMENTAL CONCERNS

Meetings with the Murray County Commissioner, county planning staff, local ecologists, and regional planning staff have yielded the following main areas of environmental concern in the county: protection of water quality, soil erosion and sediment control, floodplain protection, and wetlands delineation and protection.

1. Soil Erosion and Sediment Control

Soil erosion and resultant sedimentation in streams and rivers are of primary concern to the county. The steep slopes that occur in the Blue Ridge Mountains of the eastern portion of the county are sensitive areas that if disturbed, can contribute to increased sedimentation in proximal streams and rivers. Land disturbing activities, such as clearing for development or logging, expose lower soil layers to wind, rain, and gravity, which would otherwise be protected, and stay relatively intact through retention by the surface vegetation. The increased soil that is eroded from these areas can end up in nearby streams, thus altering the natural flow, structure, temperature and other important ecological characteristics of streams.

Excess soil erosion and sedimentation can be controlled through stream buffers that can catch and filter sediment before it reaches the stream bed and through zoning ordinances which limit development on areas such as steep slopes that are more prone to erosion.

2. Protection of Water Quality

In Murray County, protection of water quality is important for drinking water sources, preservation of aquatic biodiversity, and for supplying water to local industries. Currently, many of the major streams in the county are in on Georgia's 303D list, which is the list of the state's impaired waters. The Clean Water Act requires all states to submit a list every two years to EPA of waters that are not meeting water quality standards. The listed rivers and streams in Murray County have not been meeting the standards for fecal coliform bacteria levels and sedimentation. The high fecal coliform bacteria levels are due to fecal materials from cattle and septic tank failures. Listed rivers and streams include the Conasauga River, Perry Creek, Sumac Creek, and Mill Creek. The listed creeks are all main tributaries of the Conasauga River, an important and unique area for aquatic biodiversity. The county should first focus on these streams as part of their strategy for protecting water quality.

The county commission is interested in the protection of water quality through the addition of stream buffers. Furthermore, a local organization, the Conasauga River Alliance (in affiliation with The Nature Conservancy), has been actively working with the community and landowners to secure stream buffers on the main tributaries of the Conasauga for protection of water quality and aquatic habitats. The continuation of the Alliance's efforts, along with county action, will prove beneficial for the improvement of water quality in the impaired waters and the preservation of water quality in healthy waters as well. Also, protection of areas surrounding the local reservoir, Carter's Lake, and the waterways which feed it (mainly the Coosawattee and tributaries) are important for safeguarding drinking water.

3. Floodplain Protection

There are several rivers and streams that are designated within the 100-year flood zones by the Federal Emergency Management Agency (FEMA) including the Conasauga

River, Holly Creek, Mill Creek and the Coosawattee River. It is important to limit development in these areas, as functional floodplains can help mitigate floods through their water storage capabilities, can help protect water quality through their filtering capabilities, and can provide important habitat to a host of native aquatic, wetland, and upland species (WNDNR 1999). Furthermore, the limiting of development in these areas can help save taxpayer dollars that would otherwise be spent rebuilding or compensating flood damaged structures. Recently, the city of Chatsworth experienced some flooding from Mill Creek, which runs through the northern portion of the city. The county is concerned with future flooding and resultant property damage.

4. Wetlands - Delineation and Protection

The protection of wetlands is important for water quality through filtration of contaminants and sediments, flood control by storage capacity, and biodiversity, as many wetlands provide habitat for a variety of native species (USEPA 1999). Wetlands are protected under Section 404 of the Clean Water Act, which regulates the discharge of dredge and fill materials into U.S. waters, including wetlands. As such, it is essential for county planners and government employees to be aware of wetland areas in the county. However, the county has a lack of detailed maps of wetland areas.

Observing a wetlands map from NWI (National Wetlands Inventory) shows that much of the wetlands in Murray County occur along major streams and rivers and within the adjacent floodplains. Many of the local wetlands are located along the Conasauga River, the Coosawattee River and their tributaries. Using NWI maps can serve as a baseline assessment for wetland identification, from which further ground surveys can be conducted for more refined delineation of wetland areas.

iii. GEORGIA'S GREENSPACE PROGRAM

During the 2000 legislative session, the Georgia General Assembly created the Georgia Greenspace Program through enactment of Senate Bill 399. The Greenspace Program is a statewide program that aims at preserving at least 20% of Georgia's land area for greenspace. Through the program legislation, a permanent land preservation trust fund was established to assist counties in acquiring greenspace. The Georgia Department of Natural Resources (GADNR) is responsible for administering the program and the trust fund. Counties receive grants dependent upon their share of property taxes levied on residential property and returned to the state during the prior fiscal year. The program focuses on high growth counties who are experiencing rapid development (eligibility for participation in the program is discussed in detail in the third paragraph of this section).

Greenspace, as defined by the legislation, is "permanently protected land and water including agricultural and forestry land whose development rights have been severed from the property, that is in its undeveloped, natural state or that has been developed only to the extent consistent with, or is restored to be consistent with: (1) Water quality protection for rivers, streams, and lakes; (2) Flood protection; (3) Wetlands protection; (4) Reduction of erosion through protection of steep slopes, areas with erodible soils, and stream banks; (5) Protection of riparian buffers and other areas such as marsh hammocks that serve as natural habitat and corridors for native plant and animal species; (6) Scenic protection; (7) Protection of archeological and historic resources; (8) Provision of recreation in the form of boating, hiking, camping, fishing, hunting, running, jogging, biking, walking, skating, birding, riding horses, observing or photographing nature, picnicking, playing non-organized sports, or engaging in free play; and (9) Connection of existing or planned areas contributing to the goals set out in this paragraph".

A county is eligible to participate in the Greenspace Program Counties if it has a population of at least 60,000 according to the U.S. decennial census of 1990 or later; or if the county has experienced an average population growth of at least 800 persons per year between the 1990 or later decennial census and the most recent U.S. estimate of the county's population. According to the 2000 Census, Murray County's population increased a total of 2,584 persons since 1990, hence meeting the eligibility requirement for the Greenspace Program.

In 2000, which was the first fiscal year (FY-01) for the program, 40 counties, including Murray, were eligible for funds from CGP. Murray County was allotted $94,491 for FY-01, but chose not to participate in the program due to lack of readiness. Those funds were since distributed proportionately to the other participating 39 counties. For FY-02, Murray County has been allotted $78,182. The trust funds can only be used to purchase or defray the costs of acquisition or easements that permanently protect greenspace.

Before the county can receive funds, each must complete and submit a Greenspace Plan, which must be submitted and approved by the Georgia Greenspace Commission. The Greenspace Plan has varied requirements that demonstrate the county's preparedness and dedication to greenspace protection. The plan must identify all existing protected greenspace, specify prospective parcels of land or water for protection, show changes that have been made to the county's comprehensive plan which are consistent with the greenspace program, assign a subdivision of the county government responsibility for protecting greenspace, certify that the county has a Community Greenspace Trust Fund and has identified sources of funding for greenspace other than the state greenspace grant funds.

iv. STATUS OF MURRAY COUNTY (as of 12/01)

The North Georgia Regional Development Council (NGRDC) has recently (December 2001) prepared Murray County's Greenspace Plan and submitted it to the Commission for review. The NGRDC has already completed the greenspace plan for the western adjacent county, Whitfield, which shares the Conasauga River, an important water and biological resource for the region.

b. Delineating a Local Ecological Network for Murray County, Georgia

i. CONSERVATION GOALS & OBJECTIVES

The overall goal of this local example is to delineate an ecological network for Murray County that incorporates key environmentally sensitive areas and emphasizes connectivity to effectively protect natural resources including important ecosystems services and biodiversity. The delineation of a Murray County ecological network also creates the opportunity to explore the relationship between the regional Southeastern Ecological Framework methods and data with a similar process accomplished at the local scale. The creation of the local ecological network follows the concepts and methods utilized in the Southeastern Ecological Framework Project. A comprehensive local ecological network should address the protection of water resources, biodiversity, ecological processes, or any other environmental concerns or threats to the local environment as discussed in Part 2, while also addressing the regional ecological context of the particular locality. Based on these inputs, following are an outline of the goals and objectives necessary for the Murray County Local Ecological Network:

1. Goal 1. Protection of Water Resources

The ecological network should incorporate significant water resources in Murray County, including areas important for

Objective 1.1. Protection of drinking water resources
Objective 1.2. Protection of surficial aquifer areas vulnerable to pollution
Objective 1.3. Protection of areas with high groundwater recharge
Objective 1.4. Soil erosion and sediment control through protection of steep slopes

2. Goal 2. Protection of Ecological Processes

The ecological network should incorporate areas supporting important ecological processes that provide services such as flood control, filtration of contaminants and runoff, erosion control, and key nutrient cycles.

Objective 2.1. Protection of wetlands
Objective 2.2. Protection of floodplains

Goal 3. Protection of Biodiversity

The ecological network should incorporate locations and habitats of species representative of local and regional biodiversity and natural communities needed to effectively conserve biodiversity.

Objective 3.1. Protection of rare, threatened, endangered, and endemic species occurring within the county, and their associated habitats.
Objective 3.2. Protection of areas important for aquatic biodiversity
Objective 3.3. Protection of black bear habitat
Objective 3.4. Protection of habitat for neotropical migrant birds.
Objective 3.5. Protection of areas immediately surrounding conservation lands
Objective 3.6. Protection of Roadless Areas

Lands important for protection to achieve the above stated goals and objectives will be identified using GIS as the primary mapping and analysis tool, in particular, Environmental Research Institute's ArcInfo GRID, versions 7.2.1 Patch 2 and 8.1.

ii. GENERAL MODELING METHODOLOGY

1. PEA-Hub-Linkage Methodology

To identify areas that achieve the above stated conservation goals, the same general modeling process used in the Southeastern Ecological Framework was utilized. The methodology is a four-step process: 1. Identification of priority ecological areas, 2. Creation of ecological hubs, 3. Identification of landscape linkages, and 4. Creation of the ecological network. Priority ecological areas are areas of highest ecological significance that are most important for accomplishing the natural resource conservation goals. Ecological hubs are created from contiguous priority ecological areas and are larger areas of ecological significance that offer the best opportunities for conserving biodiversity and functional ecological processes. Landscape linkages provide connectivity between ecological hubs and enhance opportunities for conserving biodiversity and functional ecological processes. Each step is discussed in detail in section VI.b.iii.

2. Options for Incorporating the Regional Ecological Model Results

Incorporation of the regional ecological context is an essential component to identifying a comprehensive ecological network. If regional studies such as the SEF exist, then smaller planning entities, such as states, counties, or cities, can take advantage of the perspective created through regional analysis to aid in the delineation of a local ecological network. Two primary ways in which the SEF can be used are explored in this project. The first option involves the potential use of regional SEF model results (primarily the priority ecological areas datasets) as inputs into the local model. The second option involves the use of these analyses as an evaluative tool after completion of the local model.

Using the SEF as a Component in Modeling Process

The SEF components (primarily PEAs) created in the SEF project can be incorporated during the modeling process as components to the local model. If applicable to the county scale and the stated conservation goals, then the SEF PEAs can potentially be used as local priority ecological areas for the Murray County network. To determine the appropriateness of this option, regional PEAs were individually evaluated and compared to the goals of the county network to assess whether these regional PEAs could sufficiently identify priority areas within the county (This is further discussed in the results section).

Using the SEF as an Evaluative Tool

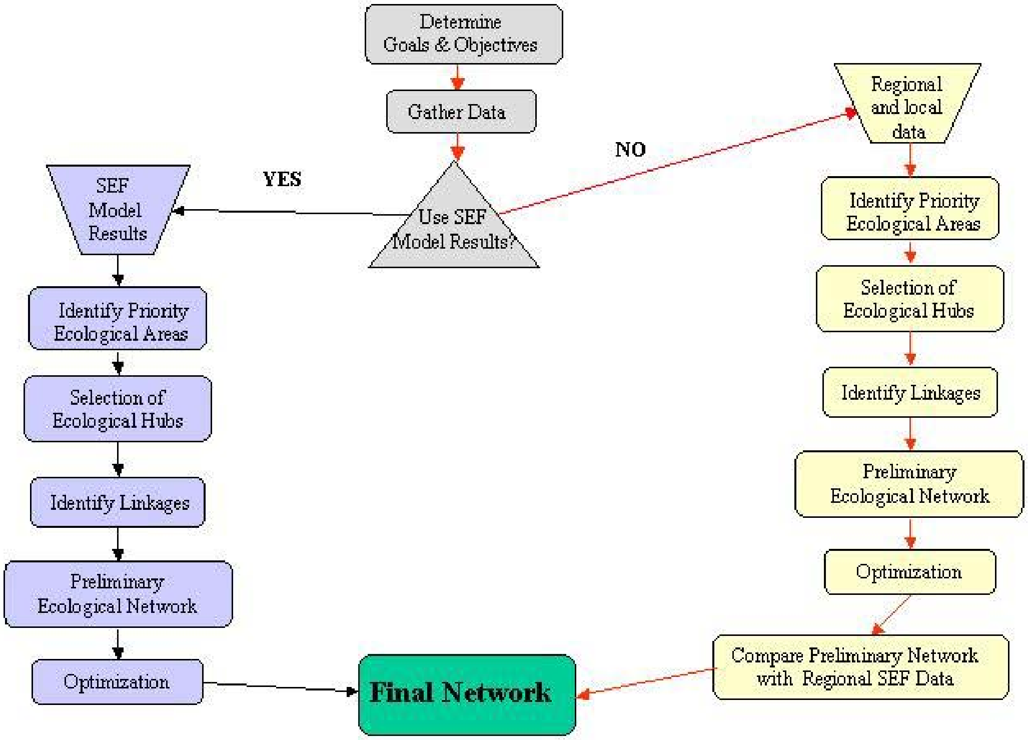
After a local network is identified, the SEF can be used as an evaluative tool to modify the network or to set conservation priorities. After comparing the local and regional model results, decisions can be made as to whether additional areas identified in the regional model should be included in the local network. Ideally, some overlap should exist between the local and regional model results. Furthermore, the SEF can be used to set priorities based upon the overlap of locally and regionally significant areas. If an area is identified as significant at both scales, then its priority for protection could potentially be increased.

When evaluating the two models, issues such as the following are important to consider:

- What regional ecologically significant areas have not been identified as significant at the local level and why?
- What areas are identified as significant at both the local and regional level?
- What is the multi-county context?
- Are there ecologically significant areas just outside the county boundary, and if so, are there any opportunities for connectivity between areas within the county and those areas outside the county?

iii. SPECIFIC MODELING METHODOLOGY

Figure VI-3 Diagram of Modeling Process.



1. Data Assessment

After setting the goals and objectives for the Murray County ecological network, data were gathered in order to spatially identify areas that, if protected, could help meet the stated goals and objectives. Gathering GIS data involves collection of data from various sources and of varying scales, including county, state, and regional level data. In many cases, data from a variety of scales must be used to complete the desires analyses. In all cases, the most resolute data available was used to identify areas to meet the ecological network goals and objectives.

County specific data were available for some goals and objectives, while only regional data were available for others. In cases where county specific data were not available, the appropriateness of using SEF model results was evaluated and if deemed appropriate, then used. If SEF model results were not deemed appropriate and county specific data were also not available, then regional data collected in the SEF project were used and re-analyzed to meet the particular goals and objectives. For example, the SEF PEA for species' locations (PEA Buffered Element Occurrences) was not deemed appropriate to use to identify locations of species of conservation interest in the county. Hence, the raw dataset of species locations (a dataset collected for the SEF project) was used to identify locations in a more resolute manner for the county ecological network. GIS data were collected from the North Georgia Regional Development Council (NGRDC), the Georgia GIS Data Clearinghouse online (http://www.gis.state.ga.us/Clearinghouse/clearinghouse.html), and the National Wetlands Inventory. Non-digital data concerning areas of environmental significance in the county were collected from meetings with the county commission, county planners, and local ecologists.

The following table outlines the data assessment process. For each goal and objective for the ecological network, available local and regional data, and regional model results were assessed for their appropriateness in meeting the stated goals and objectives. Local data refers to data that were collected specifically for the Murray County ecological network, including county and state datasets. Regional data refers to raw data that were collected and used in the SEF modeling process, including state and multi-state datasets. Regional model results refer to the PEAs delineated for the SEF project.

Table VI-2. Data Assessment

Goal 1. Protection of Water Resources				
Objective	**Available Local Data**	**Available Regional Data**	**Available Regional Model Results**	**Data Used**
1.1. Areas Important for Drinking Water	Surface Water Intake Points (GADNR)	N/A	PEA: Areas of high stream start reach density	Surface Water Intake Points (GADNR)
1.2. Surficial Aquifer Vulnerability to Pollution	Pollution Susceptibility Dataset (GADNR)	EPA Region 4 DRASTIC dataset (pollution susceptibility)	N/A	Pollution Susceptibility Dataset (GADNR)
1.3. Groundwater Recharge Areas	Most Significant Groundwater Recharge Areas (GGS & GADNR)	N/A	N/A	Most Significant Groundwater Recharge Areas (GGS & GADNR)
1.4. Protection of Water Quality Through Soil Erosion & Sediment Control	USGS Slope Dataset, USGS Hydrologic Features	Digital Elevation Model (DEM)	N/A	Slope Dataset, USGS Hydrologic Features
Goal 2. Protection of Ecological Processes				
Objective	**Available Local Data**	**Available Regional Data**	**Available Regional Model Results**	**Data Used**
2.1. Protection of Floodplains	Murray County 100 & 500-Year Flood Zones (NGRDC)	N/A	N/A	100 & 500-Year Flood Zones

Objective	**Available Local Data**	**Available Regional Data**	**Available Regional Model Results**	**Data Used**
2.2. Protection of Wetlands	NWI Wetlands	NLCD Wetlands 30m x 30m cell size; USGS Hydrology Wetlands; EPA Landuse/Landcover	N/A	NWI Wetlands
Goal 3. Protection of Biodiversity				
Objective	**Available Local Data**	**Available Regional Data**	**Available Regional Model Results**	**Data Used**
3.1. Protection of threatened, endangered, rare, and endemic species of flora and fauna of local interest	N/A	Georgia Heritage Program's Species' Locations	PEA Buffered Species Locations	Georgia Heritage Program's Species' Locations
3.2.Areas important for aquatic biodiversity	Personal Communication with local ecologist	N/A	N/A	Personal Communication with local ecologist
Objective 3.3. Black Bear Habitat	N/A	TVA's Multi-Resolution Land Cover dataset (MRLC)	PEA Potential Black Bear Habitat	TVA's Multi-Resolution Land Cover dataset (MRLC)
Objective 3.4. Habitat for Neotropical Migratory Birds (Interior Forest Habitat)	N/A	TVA's Multi-Resolution Land Cover dataset (MRLC)	Interior Forest Prioritization dataset	TVA's Multi-Resolution Land Cover dataset (MRLC)
Objective 3.5. Protection of Areas Surrounding Existing Conservation Lands	N/A	GA GAP Project Conservation Lands, USGS Public Lands	PEA Conservation Lands (buffered by 1000 meters)	GA GAP Project Conservation Lands, USGS Public Lands
Objective 3.6. Protection of Roadless Areas	1:12,000 Roads (GADOT)	1:100,000 Tiger Roads (Census Bureau)	PEA Roadless Areas	1:12,000 Roads (GADOT)

2. Step 1: Identification of Priority Ecological Areas

The first step of the modeling process is the identification of priority ecological areas (PEAs), which involves an inventory of local natural resources. First, information and data concerning significant ecological areas must be collected, reviewed, and compiled. Consultation with local scientists and researchers, as well as planners and concerned citizens is necessary to complete a comprehensive inventory. Any available local ecological studies conducted in the area should be included.

PEAs will be different for each locality and region; there is no one size fits all identification process. However, there are general guidelines that can aid in the comprehensive delineation of priority ecological areas in any locality. At a minimum, PEAs should focus on the three goals stated above: protection of water resources, functional ecological processes, and biodiversity. Protection of water resources should focus on significant aquifer recharge areas, and areas important for drinking water, such as stream headwaters and riparian corridors. Maintaining ecological processes includes such functions as protecting intact riparian corridors, floodplains, wetlands, fire-maintained communities, and hydrological cycles (Harris et al. 1996). Conserving biodiversity should focus on species and communities of conservation interest, including any that are state or federally listed or endemic, as well as their existing and potential habitats; wide-ranging or area sensitive species; and areas that support multiple species or are hot spots for biodiversity (Noss and Cooperrider 1994; Noss 1996).

The methods used to identify areas to meet each of the three Murray County conservation goals and objectives are listed below. Each objective is considered a priority ecological area, and is used in building hubs and the resulting ecological network.

Goal 1. Protection of Water Resources

The ecological network should incorporate significant water resources in Murray County.

Objective 1.1. Protection of drinking water resources: Protection of Major Streams, Reservoirs, and Watersheds Important for Drinking Water

The purpose of this analysis was to identify the major hydrologic features (rivers, streams, reservoirs) important for drinking water. These features either are direct intake points for drinking water, or are areas upstream, which flow directly into the intake points. Keeping such waters clean, free of contaminants such as fecal coliform bacteria and free of excess sedimentation, is essential to protect drinking water.

There are two main types of features for the focus of protection efforts in Murray County: (1) reservoirs, and the rivers and streams which supply them, and (2) water supply watersheds, which are defined by the Georgia DNR as areas upstream of governmentally-owned public drinking water intakes or water supply reservoirs. In Murray County, there is one man-made reservoir, Carter's Lake, and four water supply watersheds.

a. Carter's Lake and Coosawattee River

Completed in 1977 by the Army Corp of Engineers, Carter's Lake is approximately 3,500 acres. It not only provides drinking water, but also recreation opportunities. For protection of the reservoir, GADNR recommends a buffer zone of 150 feet around reservoirs, and a buffer zone of 100 feet of both sides of streams feeding into the reservoir. These recommendations were followed, and buffered areas were considered priority ecological areas.

b. Watershed Protection: Water Supply Watersheds

Identification and protection of streams upstream from intake points is essential for providing clean drinking water. Three water supply watersheds, SW Murray County, Holly Creek, and Carter's Lake, are considered small by GADNR, which means that they are less than 100 square miles. The recommended protection measures from

GADNR for small water supply watersheds include a buffer zone of 100 feet on both sides of streams within a seven-mile radius upstream of the intake point.

The fourth water supply watershed, the Conasauga, is considered large by GADNR, which means that it is greater than 100 square miles. No protection measures are listed from GADNR. However, protection measures are very important and should focus on the main tributaries of the Conasauga, restoring streamside vegetation and maintaining intact natural land cover through the implementation of stream buffers. To address protection for the Conasauga's water supply watershed, its tributaries are the main focus in the riparian linkage step of the modeling process. Furthermore, there are protection measures being undertaken by The Nature Conservancy's Conasauga River Alliance to secure stream buffers along the river and its main tributaries.

Objective 1.2. Protection of surficial aquifer areas vulnerable to pollution

The Georgia Geologic Survey (GGS) mapped out shallow water table areas with their relative susceptibility to pollution using the DRASTIC method developed by U.S. E.P.A. (Aller et. al. 1987). This method uses an index of seven hydrogeologic parameters to determine pollution susceptibility. These seven parameters comprise the acronym "DRASTIC" and are as follows: depth to water (D), net recharge(R), aquifer media (A), soil media (S), topography (T), impact of the vadose zone (I), and hydraulic conductivity(C) of the aquifer. The seven parameters are combined to create the DRASTIC index, where a higher index value corresponds to a higher susceptibility to ground water pollution.

The GGS also divided the DRASTIC index scores into categories of low, average, and high susceptibility to pollution. For this analysis, aquifer areas with high susceptibility to pollution as determined by GGS, are first selected out. Then, only those high susceptibility areas that also have natural land cover (water, forests, or wetlands) are identified as priority ecological areas. Since areas with natural cover are undeveloped, hydrological cycles are less likely to be disturbed, can function more effectively, and ultimately yield higher benefits for watershed protection. Therefore, protection of such areas from conversion to more intensive land uses that could result in contamination should be avoided.

Objective 1.3. Protection of areas with high groundwater recharge

In 1989, the Georgia Geologic Survey and GADNR published a map depicting areas in Georgia where the most significant groundwater recharge occurs (appears in Georgia Geologic Survey Hydrologic Atlas 18: "Most Significant Ground-Water Recharge Areas of Georgia"). This map was based on outcrop area, lithology, soil type and thickness, slope, density of lithologic contacts, geologic structure, the presence of karst geology, and potentiometric surfaces. The purpose of this database was to identify high recharge areas where the State of Georgia should focus groundwater protection efforts. Those areas delineated in the map that are also natural land cover (water, forests, or wetlands) are considered priority ecological areas that are more likely to maintain functional groundwater recharge.

Objective 1.4. Soil erosion and sediment control through protection of steep slopes

As discussed in Part A. Section 2, soil erosion from steep slopes can cause excess sedimentation in nearby streams, threatening aquatic habitats and water quality. The purpose of this analysis was to identify streams in danger of receiving excess sedimentation due to their proximity to steep slopes. It is important to limit development on steep slopes to prevent excess soil erosion and resultant sedimentation. In addition, stream buffers should be maintained along streams in close proximity to steep slopes so that potential sediment can be caught and filtered before reaching the streambed.

To determine a numeric value for what constitutes a "steep slope", existing and model ordinances and regulations concerning soil erosion on steep slopes were researched (Baltimore Co., City of Bloomington 1999, Brookhaven Borough 2000, Bucks Co. 1996, Newton Co. 1999, N.J. 2001, USEPA 1999, Worchester Co. 2000). These ordinances stipulated regulations for the density of development (if any) to be allowed on particular slopes, and required buffer zones around streams that fall within a particular distance of the steep slopes. From the sources, slopes from 10 to 25% and greater were considered steep. Stream proximities, the distance from steep slopes in which streams are considered to be affected or in danger of sedimentation, ranged from 200 to 500 feet. Stream buffer zones ranged from 75 to 200 feet.

To determine proper slope, proximity, and buffer amounts from the sources researched, the precautionary principle was followed, which advocates greater protection when faced with uncertainty (Noss et al 1997). Taking the conservative estimates from the available ordinances and regulations may insure more comprehensive inclusion of sensitive areas. Hence, 10% slope was considered "steep", streams within 200 feet of steep slopes were identified, and those streams were buffered by 100 feet. In order to identify steep slopes, a slope dataset created by USGS was used. The slope dataset was derived directly from a Digital Elevation Model (DEM) also produced by USGS. Both the steep slopes and the buffered stream segments were included as priority ecological areas.

Goal 2. **Protection of Ecological Processes**

Protection of Ecological Processes: The ecological network should incorporate areas supporting important ecological processes that provide services such as flood control, filtration of contaminants and runoff, erosion control, and key nutrient cycles.

Objective 2.1. Protection of Wetlands

The protection of wetlands is important for both water quality and biodiversity, as they function as a filter, offer water storage capacities, and provide important wildlife habitat. Wetlands filter nutrients and sediments before water percolates to the aquifer, control floods by storing water, and enhance and protect biodiversity (USEPA 1999). Wetlands are also protected under Section 404 of the Clean Water Act, which regulates the discharge of dredge and fill materials into U.S. waters, including wetlands. In addition to the protection of wetland areas, the protections of buffer zones surrounding wetlands have demonstrated benefits for water quality and biodiversity. Wetland buffer zones can enhance and protect wetland functions by separating the wetland from human disturbance, and filtering and storing nutrients, sediments, and runoff before reaching the wetland.

The width of the buffer zone is dependent on wetland characteristics such as existing wetland functions, values and sensitivity to disturbance; buffer characteristics such as vegetation and slope; land use intensity surrounding the wetland; and the goal of the buffer, such as protecting water quality or wildlife habitat (Castelle et al 1992). Generally, buffers with dense vegetative cover and low slope have a better ability to capture and filter sediments and nutrients from runoff (Castelle et al 1992). The more intense the surrounding land uses, the wider the buffer should be to counteract the impact.

In order to determine an appropriate buffer zone for wetlands, existing and model ordinances were researched. A source of particular importance was a study conducted for the determination of buffer zone widths for wetlands in St. John's County, Florida (JEA et al 1999). Results from the study determined that a 300-foot buffer was necessary to protect a viably functioning wetland ecosystem, while also protecting 50 percent of wetland-dependent wildlife species in freshwater wetlands, and protecting water quality by mitigating erosion from coarse and fine sands (JEA et al 1999). Results also stated that buffer zones less than 300 feet in width would still yield some benefits to the wetland but could significantly reduce wildlife populations and degrade water quality due to erosion of fine sediments (JEA et al 1999).

To identify wetlands in the county, a dataset of wetland areas were obtained from the National Wetlands Inventory. Wetlands that were greater than five acres were buffered by 300 feet, and smaller wetland areas were buffered by 100 feet. The rationale is that larger wetland areas store and filter larger amounts of water, hence requiring a larger buffer to protect and enhance storage and filtering. All wetland areas and respective buffers were included as priority ecological areas.

Objective 2.2. Protection of Floodplains

The purpose of this analysis was to identify areas of 100 and 500-year flood hazard as delineated by FEMA (Federal Emergency Management Agency). Areas delineated in the 100-year flood zones are subject to a one percent or greater chance of inundation in any given year. Areas delineated in the 500-year flood zones are subject to a 0.2 percent or greater chance of inundation in any given year (FEMA 2002). Limiting land uses in the flood zone is important since undeveloped floodplains have water storage capabilities, which offer natural flood and erosion control. Buildings constructed in the floodplain reduce the storage capacity, which causes the next flood of similar intensity to rise higher than the last (WNDNR 1999). Floodplains are also important for water quality and ground water recharge, as they filter nutrients and sediments from runoff, moderate water temperatures, and promote infiltration and aquifer recharge (WNDNR 1999). Floodplains also provide critical resources for wildlife due to processes associated with flooding and drying cycles and harbor aquatic, wetland, and upland species.

In Murray County, FEMA delineated flood zones include areas adjacent to the Conasauga River and the Coosawattee River. Also, some areas along Holly Creek, Mill Creek, and Sumac Creek are included in the flood zones, especially where each tributary converges with the Conasauga River. All flood zones were identified as priority ecological areas.

Goal 3. Protection of Biodiversity

The ecological network should incorporate locations and habitats of species representative of local and regional biodiversity and natural communities needed to effectively conserve biodiversity.

Since aquatic biodiversity is primary concern in Murray County, preservation of aquatic habitats and water quality were a main focus. Primary threats to water quality and aquatic habitats include excessive inputs of sediments and nutrients from adjacent lands (Binford and Buchenau 1993). The implementation of stream buffers with intact surrounding vegetation yields numerous benefits for aquatic habitats and water quality. These benefits include filtering of sediments, nutrients, and contaminants before reaching the streambed; regulating water temperatures; and contributing to habitat diversity (Binford and Buchenau 1993). Furthermore, forested stream buffers are particularly important as the forest provides a primary food resource for aquatic organisms (Binford and Buchenau 1993).

Objective 3.1. Protection of Rare, Threatened, Endangered and Endemic Species Occurring Within the County, and Their Associated Habitats

The purpose of this analysis was to identify locations and habitats of species of local conservation interest. To accomplish this, a dataset of species' locations created by the Georgia Natural Heritage Program was used. Species included in this analysis were federally and state listed species, and species that ranked high according to the Heritage Rarity Ranks and Conservation Status, which indicate relative rarity of species statewide and range-wide.

Aquatic dependent species dominate the list, as the Conasauga River and its tributaries are a unique resource for aquatic biodiversity. Over 90 species of fish and 42 kinds of freshwater mussels have been reported from the entire Conasauga and its tributaries (Southeast Aquatic Research Institute, 1996). With almost 70 miles of the Conasauga's total 100 bordering Murray County, the county is home to a majority of these species. There are a total of 14 federally listed flora and fauna species in Murray County, for only 7 of which data was available. The only known endemic species for which data was available is the Conasauga Logperch (*percina jenkinsi*), which is endemic to the Conasauga and its' tributaries. A total of 11 fish species, 4 mussel species, 1 reptile species (a turtle), and 12 plant species were included in the analysis. See Table 1 for a list of all species included in this analysis, and corresponding Tables 2 and 3 for explanation of the state, global, and federal ranks for each species.

For this analysis, a filtering process was used to determine which species occurrences in the Natural Heritage Program database were current and of highest priority. All species observed 1975 or after were chosen to represent current observations of species. All species that ranked S1, S2, G1, G2, or G3 according to the Heritage ranks were included to represent the highest priority species. Species that met both the date and rank criterion were included in this analysis.

The Natural Heritage species occurrence databases frequently also include information about the precision of each occurrence, which is a location confidence measure. Second precision is the finest, which indicates that an element could be observed within an area with a radius of approximately 90 meters around the recorded occurrence location, or about three seconds in the geographic coordinate system. Minute precision indicates that an element could be observed within an area with a radius of approximately 1850 meters, or about one minute in the geographic coordinate system. General precision indicates that an element could be observed within an area with a radius of approximately 8km or 5 miles. Since the Georgia Natural Heritage Program dataset did not include information concerning the precision of the species location, it was assumed that the locations were observed in minute precision. Hence, plant occurrences were originally buffered 1850 meters, later reduced to 1000 meters to more accurately represent the potential plant range. To more accurately represent the potential range of the plant species, only areas within the buffer zone that were also with natural land cover (water; woody, herbaceous, emergent, scrub/shrub, and forested wetlands; deciduous, evergreen, and mixed forests) were included as priority ecological areas. Animal species are discussed below.

All animal occurrences in the database that met the date and rank criterion were aquatic species, including fish, invertebrates, and reptiles. To represent habitat areas for these species, the stream or river segment where the species was observed was selected. The segments were then buffered by 300 feet, following the St. Johns County Study (J.E.A. et al 1999) and those areas were included as priority ecological areas.

Table VI-3. Murray County Species of Conservation Interest (for which sufficient data was available).

Scientific Name	Common Name	State Status	Federal Status	State Rank	Global Rank
Fish					
Cyprinella caerulea	Blue Shiner	Endangered	Threatened	S1S2	G2
Etheostoma brevirostrum	Holiday Darter	Threatened	None	S2	G2
Etheostoma ditrema	Coldwater Darter	Threatened	None	S1	G1G2
Etheostoma jordani	Greenbreast Darter	None	None	S2S3	G4
Etheostoma rupestre	Rock Darter	None	None	S2S3	G4
Etheostoma trisella	Trispot Darter	Threatened	None	S1	G1
Extrarius aestivalis	Speckled Chub	None	None	S1/S2	G5
Percina antesella	Amber Darter	Endangered	Endangered	S1	G1G2
Percina jenkinsi	Conasauga Logperch	Endangered	Endangered	S1	G1
Percina lenticula	Freckled Darter	Endangered	None	S1	G2
Percina maculata	Blackside Darter	None	None	S1	G5
Invertebrates					
Lampsilis altilis	Finelined Pocketbook	Threatened	Threatened	S2	G2
Medionidus parvulus	Coosa Moccasinshell	Endangered	Endangered	S1	G1
Pleurobema georgianum	Southern Pigtoe	Endangered	Endangered	S1	G1
Ptychobranchus greeni	Triangular Kidneyshell	Endangered	Endangered	S1	G1
Reptiles					
Graptemys pulchra	Alabama Map Turtle	Rare	None	S1	G4
Plants					
Aureolaria patula	Spreading Yellow Foxglove	None	None	S1	G3
Carex platyphylla	Broadleaf Sedge	None	None	S1	G5
Carex purpurifera	Purple Sedge	Threatened	None	S2	G4
Chrysosplenium americanum	Golden Saxifrage	None	None	S1	G5
Coreopsis latifolia	Broadleaf Tickseed	None	None	S1	G3

Scientific Name	Common Name	State Status	Federal Status	State Rank	Global Rank
Cypripedium calceolus var. *parviflorum*	Small-flowered Yellow Ladyslipper	Unusual	None	S2	G5
Dryopteris celsa	Log Fern	None	None	S2	G4
Hydrophyllum macrophyllum	Largeleaf Waterleaf	None	None	S1	G5
Hydrastis canadensis	Goldenseal	Endangered	None	S2	G4
Phlox amplifolia	Broadleaf Phlox	None	None	S1	G3G5
Polymnia laevigata	Tennessee Leafcup	None	None	S1	G3
Scutellaria montana	Large-flower Skullcap, Mountain Skullcap	Endangered	LE, PT	S2	G2

Table VI-4. Murray County Species of Conservation Interest (for which insufficient data was available). For these species, there was either no geographic data available or the information did not meet the date and rarity rank thresholds.

Scientific Name	Common Name	State Status	Federal Status	State Rank	Federal Rank
Fish					
Moxostoma carinatum	River Redhorse	Rare	None	S2	G4
Noturus munitus	Frecklebelly Madtom	Endangered	None	S1	G3
Percina aurolineata	Goldline Darter	Threatened	LT	S1	G2
Percina shumardi	River Darter	Endangered	None	S1	G5
Percina sp. cf. *macrocephala*	Muscadine Darter	Rare	None	S2	G2Q
Invertebrates					
Epioblasma metastriata	Upland Combshell	Endangered	LE	S1	GH
Epioblasma othcaloogensis	Southern Acornshell	Endangered	LE	S1	GHQ
Medionidus acutissimus	Alabama Moccasinshell	Threatened	LT	S1	G1
Pleurobema decisum	Southern Clubshell	Endangered	LE	SH	G1G2
Pleurobema perovatum	Ovate Clubshell	Endangered	LE	SH	G1
Reptile					
Graptemys geographica	Common Map Turtle	Rare	None	S1	G5
Plants					
Cypripedium acaule	Moccasin Flower, Pink Ladyslipper	Unusual	None	S4	G5
Xerophyllum asphodeloides	Eastern Turkeybeard, Beargrass, Mountain Asphodel	Rare	None	S1	G4
Birds					
Aimophila aestivalis	Bachman's Sparrow	Rare	None	S3	G3
Elanoides forticatus	Swallow-tailed Kite	Rare	None	S2	G5
Haliaeetus leucocephalus	Bald Eagle	Endangered	LT	S2	G4
Mammals					
Corynorhinus rafinesquii	Rafinesque's Big-Eared Bat	Rare	None	S3?	G3G4

Table VI-5. State and Global Rarity Rankings[1]

State [Global] Rank	Relative Rarity Statewide and Range-wide
S1 [G1]	The species is critically imperiled in the state [globally] because of extreme rarity (5 or fewer occurrences of the species).
S2 [G2]	The species is imperiled in the state [globally] because of rarity (6 to 20 occurrences of the species).
S3 [G3]	The species is rare or uncommon in the state [rare and local throughout its' range or in a special habitat or narrowly endemic] (between 21 and 100 occurrences).
S4 [G4]	Apparently secure in state [or globally] (of no immediate conservation concern)
S5 [G5]	Demonstrably secure in state [globally]
SH [GH]	Of historical occurrence in the state [throughout its range], perhaps not verified in the past 20 years, but suspected to be still extant.
Q	Denotes a taxonomic question - either the taxon is not generally recognized as valid, or there is reasonable concern about its validity or identity globally or at the state level.
?	Denotes a questionable rank; best guess given whenever possible (e.g. S3?)

[1]Source GA Natural Heritage Program 2001

Table VI-6. Federal Status Explanations[1]

Federal Status	Explanation
LE	Listed as endangered. The most critically imperiled species. A species may become extinct or disappear from a significant part of its range if not immediately protected.
LT	Listed as threatened. The next most critical level of threatened species. A species that may become endangered if not protected.
PE or PT	Candidate species currently proposed for listing as endangered or threatened.
C	Candidate species presently under status review for federal listing for which adequate information exists on biological vulnerability and threats to list the taxa as endangered or threatened.

[1]Source GA Natural Heritage Program 2001

Objective 3.2. Protection of Areas Important for Aquatic Biodiversity

To supplement the element occurrence data for listed species and species of conservation concern, rivers and streams important for aquatic biodiversity were also included as priority ecological areas. Rivers and streams that were included as most significant had high water quality, supported a high number of species, or supported a high diversity of species. Included were the Conasauga River, Holly Creek, Mill Creek, and Sumac Creek (Rick Guffey, personal communication). As discussed in the analysis above, stream buffers with intact vegetation are extremely important for aquatic biodiversity and water quality. Hence, all connected intact vegetation within a 300-foot buffer of the streams was included as priority ecological areas.

Objective 3.3. Protection of Black Bear Habitat

As a complement to the highly aquatic biased element occurrence data, the black bear (*Ursus americanus)* was also chosen as a focal species. For the Southeastern United

States, the black bear is considered an umbrella species in which protection of its' habitat may translate into protection of habitat for many other species. Focal, or umbrella species, which are generally wide-ranging species with larger habitat area requirements or species that serve as good indicators of high quality natural communities, are frequently chosen for protection focus, since analysis of all species is nearly impossible. Protection of habitats for these species is considered a way to potentially protect the habitats of many other species that require smaller areas or the same natural community or habitat types (Soule and Terborgh 1999, Noss and Cooperrider 1994). The Chattahoochee National Forest offers important habitat for black bears. The Chattahoochee bear population has increased from 106 bears in 1970 to more than 650 bears in 1996 (Chattahoochee-Oconee National Forests 1996).

The purpose of this analysis was to identify potentially significant habitat blocks and corridors to promote the long-term viability of black bears. First, land cover classes were selected to represent primary, secondary, and tertiary habitats based on black bear presence and use of habitat (Cox et al 1994). Primary habitat consists of evergreen, deciduous, and mixed forests, and woody wetlands classes from the National Land Cover Dataset (NLCD). Secondary habitat consists of shrubland and transitional classes, and tertiary habitat consists of grassland/herbaceous and emergent/herbaceous wetlands classes. Primary roads were then excluded from the delineated primary habitat, and the remaining contiguous habitat areas that were at least 37 acres were identified as "core habitat" (per Mykytka and Pelton 1989). Any adjacent secondary or tertiary habitat within one kilometer of the core habitat areas was added to the core habitat, and resulting areas were grouped into size classes. Areas greater than 5,000 acres were then combined with a black bear habitat suitability index created in the SEF prioritization process. The purpose of the suitability index was to identify significant habitat blocks and landscape linkages to promote long term viability of the black bear. The index was combined with this analysis because it is a more refined habitat model that incorporates both suitable habitat areas and potential threats to habitat areas from intensive land uses and roads. The index values range from 1 to 10, where a one represents low habitat suitability and a ten represents high habitat suitability. For more detailed methods, see the accompanying SEF Prioritization Report.

Areas greater than 5,000 acres that also had high suitability index ranking (greater than 6) were considered as priority ecological areas. Areas greater than 5,000 acres that also had a suitability index ranking of 5 were considered significant ecological areas.

Objective 3.4. Protection of Habitat for Neotropical Migrant Birds.

Neotropical migratory birds are those that breed in the United States and Canada, and then travel south to Central and South America, and the Caribbean for the winter season. Some of these bird species are area sensitive, interior forest-dwelling birds that require large blocks of contiguous forest for successful breeding, foraging, and nesting (von Sacken 1998). Fragmentation of forest patches decreases interior habitat patch size, increases edge habitat, and attracts generalist species, predators and nest parasites such as raccoons, cats, blue jays, crows, and cowbirds (USGS 1999, von Sacken 1998). These generalists and predators penetrate the forest patches, compete with interior species, eat eggs or nestlings, or increase incidences of nest parasitism, and ultimately decrease breeding populations (USGS 1999, von Sacken 1998).

The Chattahoochee National Forest, containing the largest federally designated wilderness area in the National Forest System in the southeast, offers large patches of contiguous forest habitat significant for neotropical migrants. The southern Appalachian forests are particularly important breeding and nesting grounds for over 180 neotropical songbird species, such as tanagers, warblers, vireos, and thrushes (Sierra Club 1998). The purpose of this analysis was to identify large blocks of unfragmented interior forests that can serve as breeding and nesting grounds for neotropical migrants. Interior forests can be defined as forest areas that are sufficiently buffered from negative edge effects, such as predation, nest parasitism, proliferation of exotic and/or invasive species, runoff, and noise and air pollution.

To identify interior forest areas, first edge effected areas were identified, then blocks of forest not affected by edge areas were identified. Intensive land uses, such as urban, residential and commercial, which generate negative edge effects, were first identified. Then, contiguous areas of these intensive land uses were separated into three size classes to approximate their zone of negative influence, based on the premise that the larger the area of intensive land use, the further the negative effects extend. The size classes were buffered by 100, 300, or 1000 meters, with the largest class of intensive land use receiving the largest buffer. Roads were also identified as a source of negative edge effects. Primary, secondary, and tertiary roads were buffered by 300, 200, and 100 meters respectively, based on the assumption that the wider the road, the further the negative edge effects extend.

These buffered areas, considered as the zones of influence from which negative edge effects extend, were then subtracted from all forest areas. Remaining forest areas were then grouped into nine size classes, and areas that were at least 1000 acres were selected as priority areas.

Objective 3.5. Protection of Areas Immediately Surrounding Conservation Lands

Existing conservation lands have historically offered the best opportunities for conserving biological diversity (Noss 2000), as they are already under protection and generally not subject to the threat of intensive land uses, development or conversion to non-natural land uses. Consequently, high densities of flora and fauna species are typically found in conservation lands.

Maintaining the ecological integrity of conservation lands involves consideration of the effects of adjacent land uses on the actual reserve. Edge effects can extend into habitat patches, disturbing species and causing species to move towards the interior (Schonewald-Cox 1988). Edge effects vary depending upon the orientation of the sun in relation to the edge, prevailing winds and wind direction, vegetation composition and density at the edge, width of edge habitat, and intensity and type of adjacent land uses (Forman 1986).

The purpose of this analysis was to identify areas adjacent to conservation lands to serve as a buffer to protect and enhance the ecological integrity of existing protected areas. Existing conservation lands were identified, including the Chattahoochee National Forest, Cohutta Wilderness Area, Fort Mountain State Park, and Coosawattee Wildlife Management Area. These areas were buffered by 300 meters and inclusive areas were identified as priority ecological areas.

Objective 3.6. Protection of Roadless Areas

Habitat fragmentation is considered to be one of the primary threats to biological diversity (Harris 1984). Fragmentation involves both the loss of habitat and the division of larger habitat areas into smaller, more isolated pieces (Noss and Cooperrider 1994). Fragmentation can result from development or conversion of natural areas to human uses, such as residential, commercial, agriculture, and transportation.

Roads are especially detrimental to biological diversity, as they cause fragmentation of the landscape (habitats), and form physical barriers between habitats, preventing movement of small animal species, and increasing mortality rates from collisions (Noss and Cooperrider 1994). In addition, roads offer hunters access to natural areas, which can increase both poaching and legal hunting (Noss and Cooperrider 1994). Furthermore, numerous edge effects from roads, such as air and noise pollution, runoff, soil erosion, sedimentation, and the proliferation of exotic and/or invasive species, can penetrate adjacent habitat areas, significantly degrade the existing habitat, and ultimately threaten biological diversity (Noss and Cooperrider 1994).

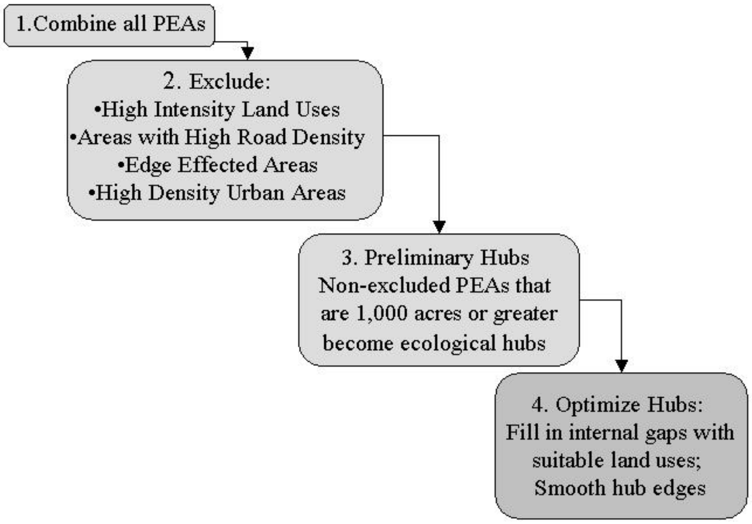
Roadless areas are important for protecting biological diversity as they offer unfragmented habitat patches in which species can thrive without the threat of human disturbance. The purpose of this analysis was to identify large blocks of roadless areas with suitable land uses that have the potential to offer undisturbed habitat. First, all roadless areas with suitable land uses, including natural or semi-natural cover such as forests, wetlands, water, shrub, and grasslands, were identified. Next, unsuitable land uses or edge effected areas, such as areas of high road densities, areas of high urban land use densities, and areas in close proximity to urban areas, were excluded from the roadless areas. Finally, all remaining contiguous blocks of roadless areas that were at least 5,000 acres were first identified as priority ecological areas, and areas that were at least 1,000 acres were identified as significant ecological areas.

3. Step 2: Selection of Ecological Hubs

After priority ecological areas have been identified, areas with unsuitable and high intensity land uses are excluded. Excluded areas include: buffered primary roads; areas with high road densities; high intensity land uses such as urban (commercial, residential, industrial) and intensive agriculture; areas in close proximity to urban land uses; and areas with high urban land use density. After these areas are excluded from the priority ecological areas, the remaining contiguous PEAs are evaluated by size. Contiguous PEAs that were 1000 acres or greater were considered ecological hubs. These larger areas of ecological significance form the backbone of the network.

After ecological hubs are identified, they are optimized to reduce internal fragmentation and potential negative effects associated with nearby incompatible land uses. The optimization process includes filling internal gaps and smoothing outside edges when suitable land use is available. Gaps less than 1,000 acres and linear holes were filled with natural land cover (deciduous, coniferous, and mixed forests, wetlands, or water). The outside edges of the hubs were smoothed to reduce uneven edges.

Figure VI-4. Selection and Optimization of Ecological Hubs Process Diagram.



4. Step 3: Identification of Landscape Linkages

The third step in the process, involves identification of existing and potential areas that protect existing connectivity between hubs or provide the best opportunities to restore connectivity. Landscape linkages, also referred to as corridors or wildlife corridors, provide and enhance opportunities for conserving biodiversity and ecological processes. Types of linkages for Murray County include riparian and upland. Riparian linkages maintain connectivity and sufficient buffers along rivers and streams, focusing on natural land cover and vegetation along streams and rivers. Upland linkages focus on providing connectivity between upland areas, primarily in mountainous and forested regions or steep slopes and other areas supporting larger blocks of upland ecosystems.

Riparian areas were the main focus of the linkage step, since protection of water resources is a primary concern in the county. In particular, the Conasauga River and its primary tributaries were identified as riparian linkages. However, agricultural land uses surround much of these streams and hence, there often is no intact vegetation needed for functional riparian corridors. Consequently, riparian linkages are shown in two colors, one for intact natural vegetation surrounding the streams, and one for agricultural land uses. These areas are highlighted and included in the network since they are areas necessary for protecting water quality and should be the targets of streamside restoration projects. (The Nature Conservancy is carrying out Stream buffer projects. Additional areas should be supplemented with stream buffer ordinances or voluntary buffers).

The primary Conasauga tributaries in Murray County (Mill Creek, Holly Creek, Sumac Creek, Perry Creek) were buffered by 300 feet. Unsuitable land uses, such as urban, residential, commercial, and roads were excluded from the stream buffer. Then natural land cover was given a value of 1 and agricultural land uses given a value of 2. Most of the tributaries originate in the national forest, and flow generally westward to converge with the Conasauga, offering connectivity between the east and west sides of the county.

For the Conasauga and Coosawattee Rivers linkages, the widths of the linkages were determined by the adjacent floodplain for each respective river. All areas adjacent to each river that were identified by FEMA (Federal Emergency Management Agency) as 100 or 500 year flood zones were included as the riparian corridor. Natural land cover received a value of 1, while agricultural land uses received a value of 2.

After the riparian linkages were completed, hubs were evaluated for any additional necessary connectivity. Two additional upland linkages were identified. The first upland linkage was added to offer connectivity between two hubs in the southern portion of the county, hubs 9 and 10. To delineate this linkage, land cover was evaluated to identify natural upland cover in the county (deciduous, coniferous, and mixed forests) that could serve as a connector between the two hubs. The second upland linkage was added to create connectivity between the eastern and western sides of the county along the ridge that runs north to south through the north-central portion of the county. Hub 3 runs along the western side of the ridge. The linkage was created using a cost surface and the cost path function in ArcInfo GRID.

Cost surfaces help to identify linkages that traverse the highest quality areas between the hubs that they connect. A cost surface is a dataset that ranks areas depending on the "cost" to move through that area. Cost can be defined or thought of as impedance. Areas that are more likely to provide connectivity for wildlife and ecological processes have no or low impedance and areas that are barriers to connectivity have high impedance. In terms of linkages, cost can be correlated to the quality of land cover or habitat. Areas with natural land cover or high quality habitat will have a low cost. Urban or residential areas, which do not offer habitat or resources, will have a high cost. After specifying source and destination locations, the least cost path function will identify the path traversing the lowest cost areas. For example, the least cost path would traverse the highest quality land cover and habitat, in an attempt to avoid urban areas.

The upland cost surface used ranks areas based on the land cover type and the context of the area (whether the area is surrounded by natural cover or by intensive land uses). Upland land cover (deciduous, evergreen, and mixed forests) surrounded by large, intact natural cover receives the lowest values, or the highest suitability for a linkage. Wetlands, water bodies, and intensive land uses such as urban receive the highest values, or the lowest suitability. The actual cost surface values are in Appendix G.

Constructing a cost surface can be a difficult process. It can be considered both an art and a science, which involves the combination of ecological and reserve design principles to accurately model and represent functional and appropriate landscape linkages. Constructing cost surfaces depends on the goal and type of linkage that is being created. When creating riparian linkages, emphasis for low cost values in the cost surface should focus on intact vegetation along riparian corridors and intact floodplains and contained or adjacent wetlands. When creating upland linkages, ideal low cost areas would include larger areas of intact upland habitat that are relatively buffered from intensive land uses. In all cases, linkages should avoid unnatural land uses, such as urban, commercial, residential, and high intensity agriculture.

5. Step 4: Creation of the Ecological Network

The final step in the process is the combination of hubs and linkages to create the network, and optimization of the network. The purpose of the optimization process is to reduce internal fragmentation and create a network that is spatially functional, following the principles of landscape ecology and reserve design. Optimization includes smoothing the edges and boundaries of the identified network, filling in some internal holes and linear gaps with suitable land uses, and adding in any priority ecological areas after exclusion that are connected to the network.

C. RESULTS

a. The Murray County Ecological Network

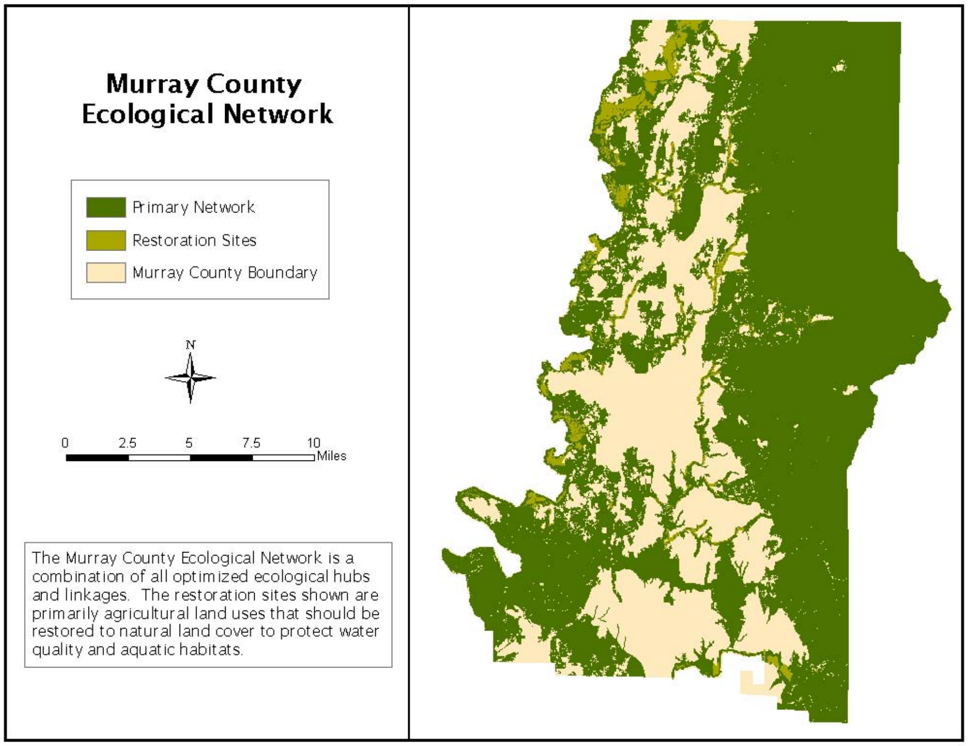
After combining the optimized hubs and linkages, the preliminary network was approximately 149,990 acres, or 68% of the county. After the optimization process, approximately 8,369 acres were added, increasing the final network to 158,356 acres, or 72% of the county. However, much of the network is already in conservation or non-developable land cover such as wetlands, flood zones, or steep slopes. Approximately 34% of the network is in permanent conservation (national forest, state park), and another 4% is under annual lease as a wildlife management area. Beyond the conservation lands, approximately 2% of the network is wetlands, 11% is flood zones, and 13% is steep slopes. The remaining portion of the network (34%) is primarily deciduous, coniferous, and mixed forest types, along with 1% agricultural land uses, which are mainly along riparian corridors, but outside of flood plains.

Optimized ecological hubs comprise the majority of the network, approximately 88%, while linkages comprise approximately 8% of the network. Approximately 6,800 acres, or 4% of the total network are agricultural areas that should be targeted for restoration of streamside vegetation. A majority of these agricultural land uses are located within flood plains, which are particularly important areas for protecting water quality. Streamside vegetation restoration projects in agricultural areas should strive to preserve adequate agricultural lands while protecting areas immediately adjacent to streams and rivers. The local government and local organizations, such as the Conasauga River Alliance, should work together with landowners to protect water quality.

Table VI-7. Breakdown of land use types within Murray County Ecological Network

Land Use Type	Percent of Network	Percent of County
Permanent Conservation Lands	34.00%	24.40%
Leased Conservation Lands (Wildlife Management Areas)	4.00%	3.00%
Wetlands (outside conservation lands)	2.00%	1.20%
Floodplains (outside conservation lands)	11.00%	8.20%
Steep Slopes (outside conservation lands)	13.00%	9.4%
Forests (outside conservation lands)	34.00%	24.40%
Agriculture	1.00%	1.00%
Total	100%	71.60%

Figure VI-5. Murray County Ecological Network.



The Murray County Ecological Network is a combination of all optimized ecological hubs and linkages. The restoration sites shown are primarily agricultural land uses that should be restored to natural land cover to protect water quality and aquatic habitats.

The identified ecological network, if protected and restored, offers a comprehensive strategy for protecting the county's natural resources. This includes protecting water resources, ensuring the viability of species of conservation interest, protecting the county's natural and rural heritage, and potentially providing additional opportunities for resource-based activities.

b. Priority Ecological Areas

The analyses of priority ecological areas in Murray County identified a large portion of the county as significant for protecting natural resources. This can be attributed to the wealth of natural land cover in the county, the large amount of National Forest lands that dominate the eastern half of the county, and the county's unique aquatic habitats.

Comprehensively, PEAs encompass 74% of the land area in the county, and SEAs incorporate 20%. Combined, these areas encompass 82% of the county (since there is some overlap of PEAS and SEAs). However, after the exclusion process, PEAs decrease to 66% of the county, and SEAs decrease to 19%, totaling 74% of the county (see Map 2 and Map 3 below). Agricultural land uses, including pasture/hay and row crops account for almost 55% of the areas deleted in the exclusion process, while proximity to major roads and high road densities account for approximately 42%. Priority ecological areas most affected by these agricultural land uses and roads include flood plains, aquifer areas susceptible to pollution, and aquifer recharge areas, each of which are important for protecting water quality.

Figure VI-6. Murray County Priority Ecological Areas.

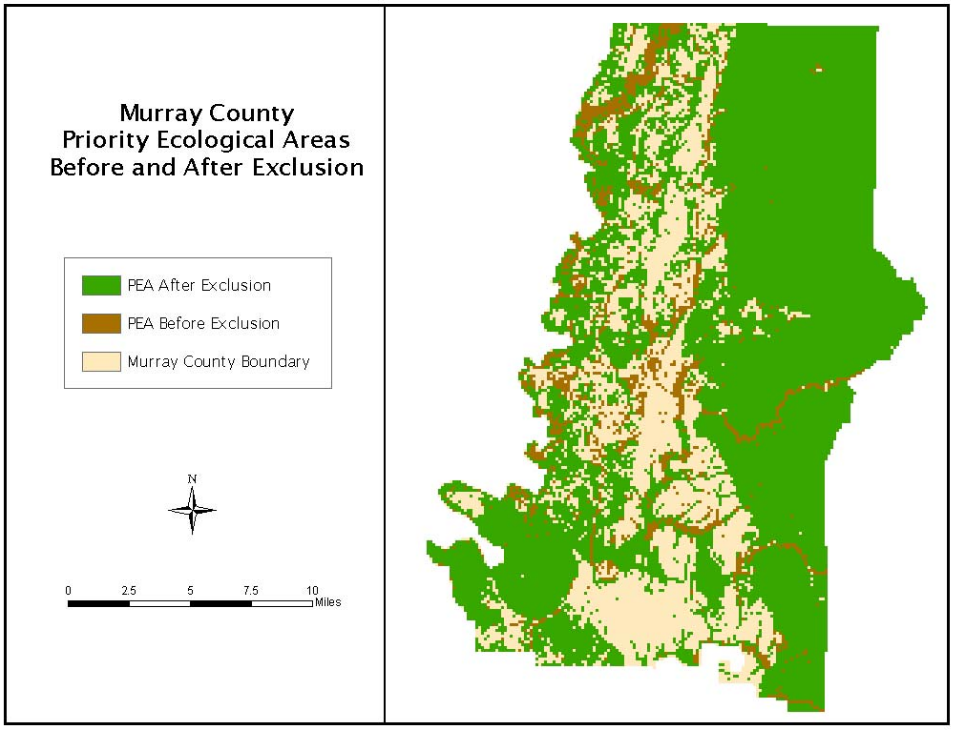
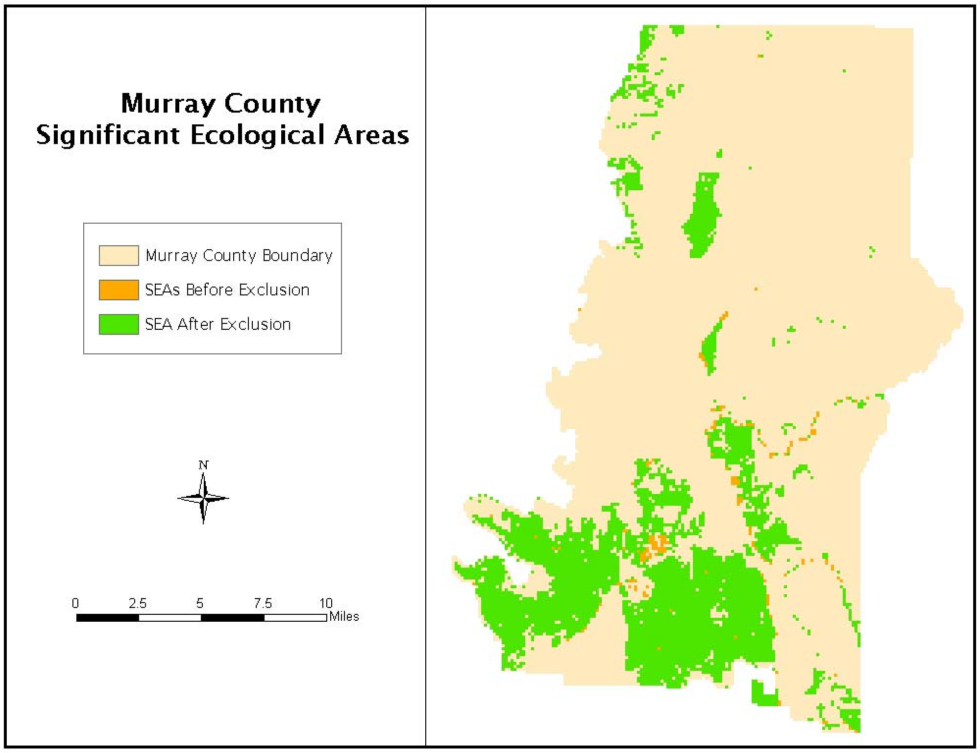


Figure VI-7. Murray County Significant Ecological Areas.



Although PEAs and SEAs after exclusion comprise 74% of the county, approximately 32% of those areas are already in permanent conservation and another 3.6% is in temporary (leased annually) conservation (see Table 1. below).

Table VI-8. Priority and Significant Ecological Areas in Murray County and Current Percent of Each Protected.

Significant Area	Percent of County[1]	Percent of Significant Area in Conservation (permanent)	Percent of Significant Area in Conservation[2] (including WMAs)
Priority Ecological Areas	74.00%	32.30%	36.07%
Significant Ecological Areas	20.00%	2.13%	2.75%
PEAs and SEAs combined	82.00%	29.17%	32.57%
Priority Ecological Areas After Exclusion	66.00%	35.80%	39.81%
Significant Ecological Areas After Exclusion	19.00%	2.08%	2.45%
PEAX and SEAX combined	74.00%	32.12%	35.72%

[1] *A note concerning the statistics*: The county boundary grid used in these analyses was approximately 351 square miles or 224,940 acres. This is 2.17% larger than the county area listed by the Census Bureau, which is 344 square miles, or 220,160 acres. This can be primarily attributed to the conversion of the county boundary to a raster format for analysis, and a modification of the boundary grid to comprehensively include both sides of the Conasauga River. The county percentages listed in the tables were calculated by using the Census Bureau's figure for total acreage; hence the numbers are slightly inflated. However, the purpose of this section is not to delineate exact acreages necessary for protection of natural resources. Rather, it is intended to provide an assessment of approximate areas necessary to comprehensively protect natural resources.

[2] The second conservation figure includes the Coosawattee Wildlife Management Area, which is not established under permanent protection.

The following table is a breakdown of PEAs significant for protecting water quality and their respective percentages in the county. Approximately 47% of PEAs and SEAs after exclusion were identified as significant for water resources, which corresponds to 35% of the county. Only 15% of these water resource areas are under some type of conservation protection, leaving 85% of the areas (or 30% of the county), without any type of protection. Overall, of the identified PEAs, almost 36% are already in conservation, and another approximately 40% are significant for protecting water resources.

Table VI-9. Areas Significant for Protecting Water Resources.

Priority Ecological Area	Percent of County[1]
Areas of high aquifer recharge	6.74%
Aquifer areas with high susceptibility to pollution	18.21%
Water supply watersheds (buffered streams)	2.66%
Steep slopes	5.86%
Flood Zones (100 & 500 year)	11.46%
Wetlands (Buffered)	5.38%
Combined Areas*	34.88%

[1] *A note concerning the statistics*: The county boundary grid used in these analyses was approximately 351 square miles or 224,940 acres. This is 2.17% larger than the county area listed by the Census Bureau, which is 344 square miles, or 220,160 acres. This can be primarily attributed to the conversion of the county boundary to a raster format for analysis, and a modification of the boundary grid to comprehensively include both sides of the Conasauga River. The county percentages listed in the tables were calculated by using the Census Bureau's figure for total acreage; hence the numbers are slightly inflated. However, the purpose of this section is not to delineate exact acreages necessary for protection of natural resources. Rather, it is intended to provide an assessment of approximate areas necessary to comprehensively protect natural resources.

c. Ecological Hubs

There were twelve hubs identified in the process of creating the Murray County Ecological Network (see Figure VI-8). Ecological hubs represent the larger areas of ecological significance in the county that offer the best opportunities for conserving biodiversity and natural resources. Since Murray County has a large amount of natural land cover, there were many areas that met the criteria for ecological hubs. During the hub optimization process, some area was added to the core hubs to fill internal holes and to smooth the hub boundaries. Hubs encompass 61.52% of the county before optimization, and 62.13% of the county after optimization, and 88% of the entire network.

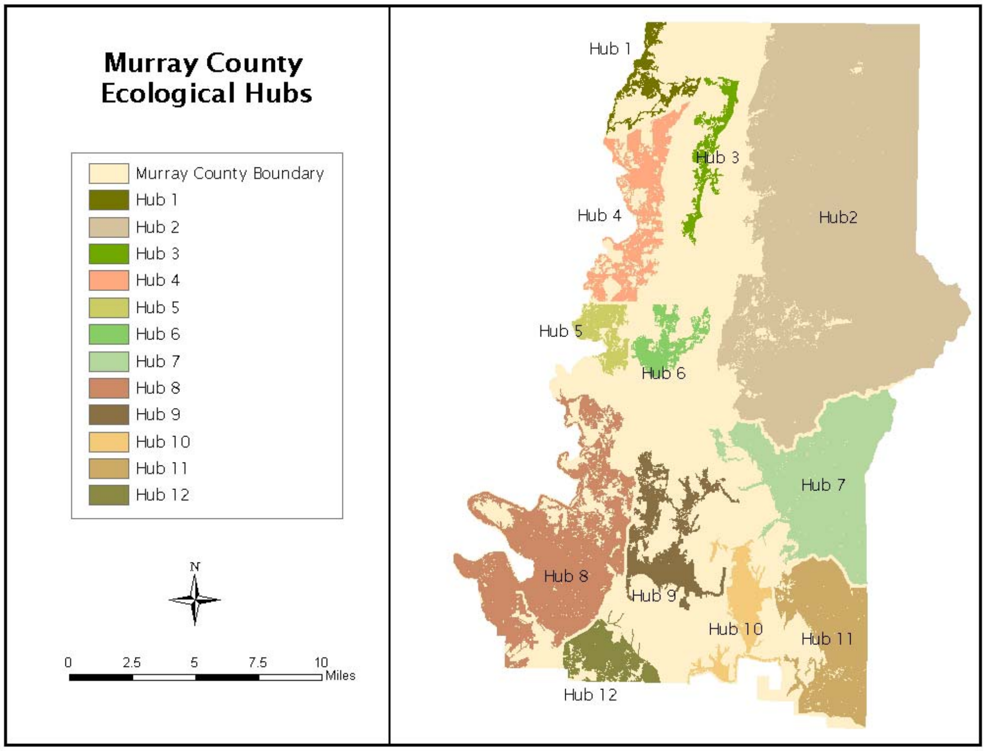
d. Hub Descriptions

Since hubs were created from the priority ecological areas identified, each hub contains significant areas for natural resource protection in the county. Below is a description of each hub and its primary PEA components. Hubs were given names to better conceptualize the locations of each.

Hub 1: Sugar Creek and Upper Conasauga River

Hub one consists of areas adjacent to Sugar Creek and the upper Conasauga River, and is approximately 1,980 acres. This area is important for water quality, as it contains

Figure VI-8. Murray County Ecological Hubs.



aquifer areas highly susceptible to pollution, flood zones, and wetlands. This area is also important for biodiversity, as Sugar Creek and the Conasauga both host many aquatic species of conservation interest.

Hub 2: Chattahoochee National Forest and Fort Mountain State Park

This is the largest hub, encompassing the northeastern portion of the county and containing approximately 69,000 acres, 66% of which is already protected as national forest lands and an additional 3% as a state park. It contains the northern section of the Chattahoochee National Forest, including Cohutta Wilderness Area, and Fort Mountain State Park, and significant lands in between. These areas are particularly important for biodiversity, as they contain significant roadless areas, steep slopes, potential black bear habitat, interior forest habitat, and habitat for species of local conservation concern. This hub is also important for protecting water quality, as many of the Conasauga's main tributaries originate in the national forest, in particular, the headwaters for Holly Creek, where downstream one of the county's public water intakes is located.

Hub 3: Central Ridge

This hub is located along the western side of the ridge that runs north-to-south in the central portion of the county. It is approximately 2,060 acres. This area is important for protecting water resources, as most of the hub contains aquifer areas vulnerable to pollution and areas of high aquifer recharge. It also contains floodplains for Sumac Creek and wetlands.

Hub 4: Middle Conasauga

This hub encompasses a significant portion of the middle Conasauga River, and adjacent lands. It is approximately 5,850 acres. This hub is significant for both biodiversity and water protection. The river itself offers habitat for aquatic species, while the adjacent lands are important for water quality, as they contain floodplains, aquifer areas susceptible to pollution, areas of high aquifer recharge, and wetlands.

Hub 5: Additional Middle Conasauga

This hub is located directly south of Hub 4, and consists of additional segments of the middle Conasauga River. It is approximately 2,120 acres. Similar to Hub 4, it contains floodplains, wetlands, aquifer areas susceptible to pollution, areas of high recharge areas and habitat for aquatic species. It also contains a small conservation easement.

Hub 6: Lower Mill Creek

This hub is located along the northern border of Chatsworth's city limits, encompassing Mill Creek and adjacent lands. It is approximately 2,240 acres. It is an extremely important hub for water protection, as it contains areas of high aquifer recharge, aquifer areas susceptible to pollution, wetlands, and floodplains for Mill Creek.

Hub 7: Additional National Forest Lands

This is the third largest hub, located directly south of Fort Mountain State Park, containing approximately 16,000 acres, of which 7,500 are additional portions of the Chattahoochee National Forest. It encompasses most of the lands between the State Park and the Coosawattee Wildlife Management Area, consequently providing connectivity between these fragmented National Forest lands located south of the primary portion of the forest. This hub is important for biodiversity, as it contains significant roadless areas, potential black bear habitat, and interior forest areas. It is also important for water quality, as it contains numerous steep slopes and headwaters for some of Holly Creek's tributaries.

Hub 8: Southwest Murray County

This is the second largest hub, encompassing much of the southwestern corner of the county and approximately 18,540 acres. It contains the lower portion of the Conasauga River, the lower part of Holly Creek, and the convergence of Holly Creek and the Conasauga River. This hub is particularly important for biodiversity, as it contains large roadless areas, large blocks of interior forest habitat, significant blocks of potential black bear habitat, and aquatic and plant species of conservation concern. This hub is also important for water quality as it contains floodplains for the lower Conasauga River and Holly Creek, wetlands, aquifer areas with high susceptibility to pollution, and part of a water supply watershed area (tributaries to the Coosawattee River).

Hub 9: Middle Holly Creek

This hub contains the middle segment of Holly Creek, a significant stream for aquatic biodiversity and a primary tributary for the Conasauga River. Two main components of this hub are the Holly Creek floodplain and aquifer areas with high susceptibility to pollution, including areas of high aquifer recharge. This hub also contains wetland areas and species of local conservation concern. It is approximately 5,330 acres.

Hub 10: Potential Black Bear Habitat

This hub is located in the southeastern portion of the county, just west of the Coosawattee Wildlife Management Area, and encompasses approximately 3,380 acres. Its primary component is a significant block of potential black bear habitat. It may also be significant as a landscape connector between known black bear habitat in the National Forest and Hub 8 in the southwestern portion of the county. It also contains a segment of the Coosawattee River, floodplains for the river and its tributaries, and wetlands.

Hub 11: Coosawattee Wildlife Management Area

This hub encompasses the Coosawattee Wildlife Management Area (WMA) and surrounding significant lands. It is approximately 9,890 acres, 6,200 of which are in the WMA. This hub is important for both water resources and biodiversity. It contains Carter's Lake, an important drinking water reservoir, and recreation area. It also contains significant roadless areas, potential black bear habitat, interior forest areas, aquifer areas susceptible to pollution, steep slopes, and flood plains for the Coosawattee River and Carter's Lake. Ideally, measures should be taken to put WMA lands under some form of permanent protection.

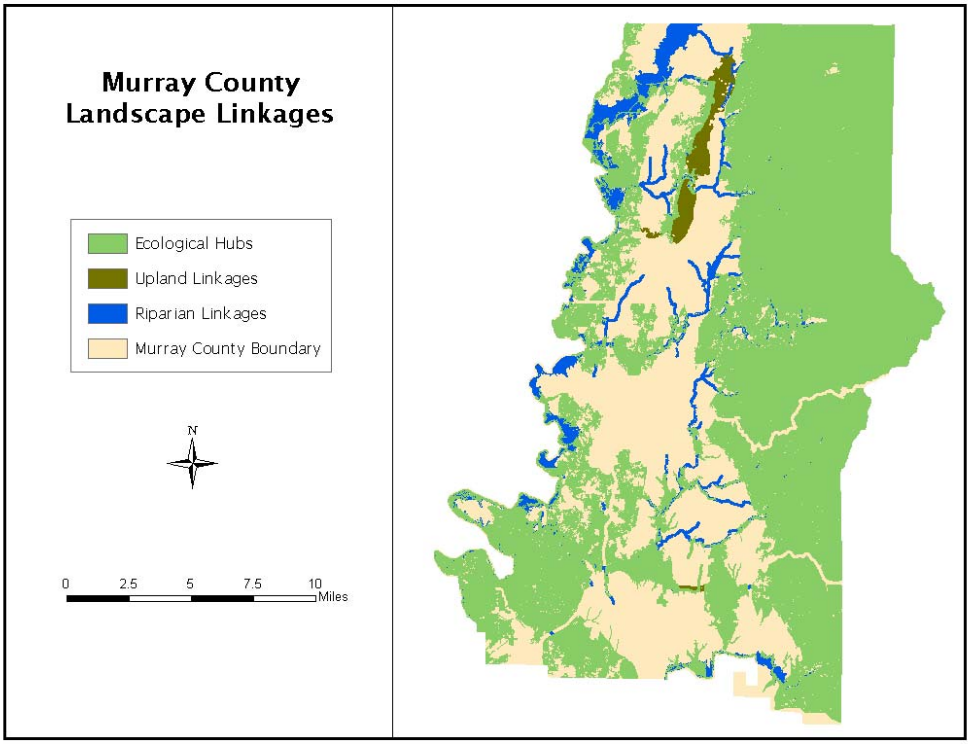
Hub 12: Coosawattee Watershed Protection Area

This hub is located on the southern border of the county and is approximately 3,320 acres. This area is particularly important for watershed protection, as the entire hub contains significant aquifer areas susceptible to pollution. It also contains areas of high aquifer recharge and part of a water supply watershed, consisting of tributaries feeding the Coosawattee River.

e. Landscape Linkages

Linkages comprise 8% of the total network and approximately 6% of the total county area. Riparian corridors with adjacent intact natural vegetation are significant for protecting water quality and aquatic habitats. In the linkage process, the Conasauga River and its primary tributaries were identified as riparian linkages. However, agricultural land uses surround much of these streams and there is not enough intact vegetation to provide functional riparian corridors. Where streamside vegetation can be restored, there are potential opportunities for functional riparian linkages. These areas are highlighted and included in the network since they are areas important for protecting water quality and should be the targets of streamside restoration projects in cooperative efforts with private landowners. Furthermore, the primary Conasauga tributaries in the county offer opportunities for connectivity between the east and west sides of the county, since many of the tributaries originate in the national forest and flow westward to converge with the Conasauga.

Figure VI-9. Murray County Landscape Linkages.



f. Using Regional Ecological Analyses

Two primary options for incorporating the regional ecological context into the local model were introduced in the methodology section. The first option involves the potential use of SEF components and analyses such as hubs, optimized hubs, and especially priority ecological areas datasets, as components to the local model. The second option involves the use of these analyses as an evaluative tool after completion of the local model.

i. USING REGIONAL ECOLOGICAL ANALYSES AS INPUTS TO THE LOCAL MODEL

After setting the conservation goals for the county network and collecting data from available sources, SEF data layers were evaluated to fill data gaps and augment local data. To determine the appropriateness of this option, regional analyses were individually evaluated within Murray County. The conclusion for most SEF components was that in this case they were either too coarse for county level analysis, or that local data sources existed that were more resolute and therefore more appropriate.

Using Regional Priority Ecological Areas as Components

Of the regional PEA analyses in the SEF process, six were identified in Murray County: areas with high stream start reach density, black bear habitat, conservation lands, buffered element occurrences, roadless areas, and the bump-up criterion, which is significant ecological areas (SEAs) that overlapped with significant riparian areas (discussed below).

SEF PEA Data Layers Identified in Murray County:

- Areas of High Start Reach Density: Areas of high start reach density were identified at the regional level as a water resource protection measure, based on the assumption that low order (especially first order streams) are important to protecting water quality. While the regional dataset does identify general areas with high densities of start reaches, it is too coarse for the Murray County analysis considering that more refined local data exist concerning stream headwaters important for protecting water resources. County drinking water intake points were used to delineate specific watershed areas important for protecting water quality.

- Black Bear Habitat: Regional model results for potential black bear habitat appear too generalized for the local scale, primarily because of the large thresholds used in the modeling process. The regional model results show large gaps in the National Forest lands (Chattahoochee) that have been identified as significant black bear habitat. These gaps are primarily due to the thresholds used for edge effects from roads. The large amount of national forest lands and natural land cover in the county can potentially offer additional black bear habitat. Hence, a potential black bear habitat model was completed at the county level to identify additional, smaller areas of potential habitat that were not identified in the regional model. Methods used in the local model followed those used in the regional model, with a primary modification for the habitat area threshold, in which 5,000 acres was used in the local model and 10,000 acres was used for the regional. The county model identified additional habitat in the southern portion of the county that may offer significant connectivity between national forest lands in the county and those southwest of the county.

- Bump-up: Regional bumpup areas are significant ecological areas (SEAs) that overlapped with significant riparian areas. SEAs are areas of ecological significance, but not considered as high priority as PEAs. Significant riparian areas are areas of intact natural land cover in 100-year flood zone areas, within close proximity (180m) to streams, or wetlands within close proximity to streams. In the SEF process, areas with both types of characteristics were identified as PEAs. Some of these areas had potential for inclusion in the local model, but they are too coarse, and a 180-meter stream buffer is too large for the local scale. A 300-foot buffer has consistently been used for streams used in the local model, after review of literature and research on stream buffers. However, the assumption underlying the regional model, that wetlands, floodplains, and intact natural cover near streams are significant for protecting water quality, is incorporated into the local model through other PEA layers.

- Conservation Lands: All existing conservation lands were included as Priority Ecological Areas in both models. Instead of using the regional conservation lands PEA in the local model, a modification to the regional methods was used to account for edge effects at the local scale. All conservation lands were buffered and included as priority ecological areas. Hence, it was unnecessary to include this regional PEA layer as a component to the local model.

- Buffered Element Occurrences (Species): The regional model result for buffered element occurrences was too coarse for the local level analysis, as most species' locations were buffered 1850 meters. Since most species in the element occurrence database (from the Natural Heritage Program) were aquatic, an 1850-meter buffer was not deemed necessary for protection of local habitats. Hence, a more refined version of this analysis was completed to more accurately identify significant aquatic habitats. However, similar filtering methods were used in the regional analysis to represent the most current and accurate species' occurrences and to determine species of conservation interest.

- Roadless Areas: The regional roadless areas layer was created using a regional roads dataset, of 1:100,000 scale. Since a 1:12,000 scale roads dataset was available for the county, it was more appropriate to use for delineation of the most accurate roadless areas.

ii. USING REGIONAL ECOLOGICAL ANALYSES AS AN EVALUATIVE TOOL

This option is more appropriate in the case of Murray County, as the scale of the regional analyses are generally too coarse for the county level model, considering that refined local data and information exists for more accurate delineation of ecologically significant features. The SEF was compared to the local network to identify similarities and differences in areas identified and to evaluate whether regionally significant areas are adequately represented in the local model.

Comparison of the SEF and Murray County Ecological Network

The models show similarities in the core areas identified (See Map 6 below): the western half of the county (Chattahoochee National Forest), the southwestern portion of the county, and the Conasauga River and adjacent lands. The county model actually identifies more total area than the regional model (See Table 4 below). This can be attributed to the refinement of the local model and the smaller hubs added in the process.

The SEF appears to be a generalized version of the preliminary county network, while the county network shows more refinement with smaller hubs in the central portion of the county that were not included in the SEF (because of the regional hub threshold of 5,000 acres). Additional areas identified in the SEF that did not appear in the preliminary county model were areas in the southern portion of the county that were added during the regional optimization process. These areas are important for connectivity, but not necessarily areas of highest priority for ecological significance.

Table VI-10. Comparison of Total Area Identified in Murray County and SEF Models.

Model	Total Acres Identified
Murray County Ecological Network	158,356
Southeastern Ecological Framework (in Murray County)	147,315

Figure VI-10. Southeastern Ecological Framework within Murray County.

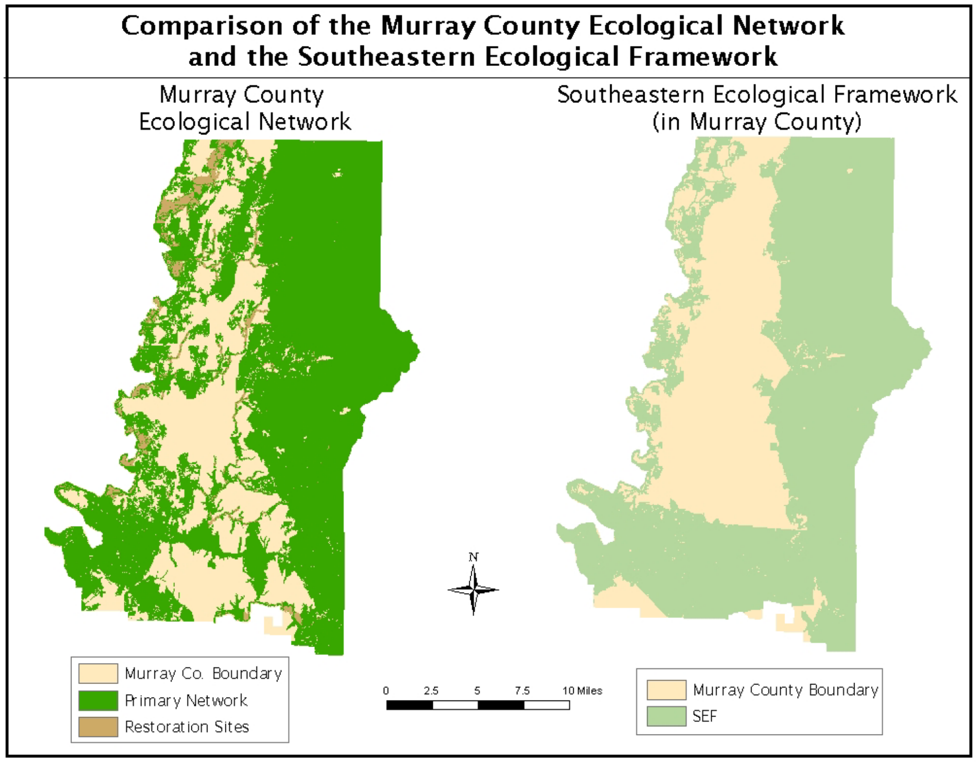
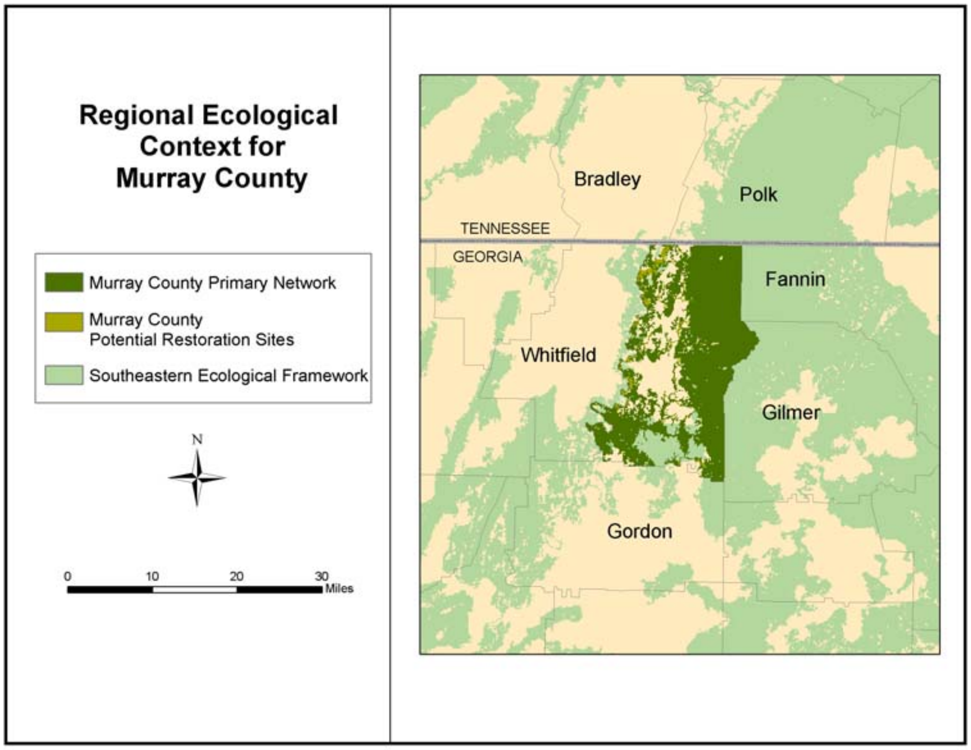


Figure VI-11. Regional Ecological Context.



Furthermore, the regional ecological context appears to be adequately represented when evaluating the regional model both within Murray County and adjacent counties: Whitfield, Gilmer, Fannin, Gordon, Polk, and Bradley (Figure VI-11). The Murray County Network is well connected and consistent with ecologically significant areas identified in the adjacent counties.

Setting Conservation Priorities

Based on the comparison above, the SEF can also be used to set conservation priorities at the local level based upon the overlap of areas identified in both models. In Murray County, overlap areas that could be considered for conservation priority would be the Conasauga River corridor, the Coosawattee Wildlife Management Area, and the southwestern portion of the county. All areas have been identified as ecologically significant in both models.

D. DISCUSSION

a. Applicability Of Using Regional Ecological Analyses

In the Murray County example, the availability of more refined local data sources negated the need to use the available regional analyses. This result is not necessarily representative of all cases. For counties with limited local data sources, the SEF can serve as a coarse assessment for areas important for natural resource protection. Furthermore, for analyses that may be multi-county, regional datasets are potentially useful if consistent county data do not exist for all counties within the study area. It is also important to note that although no regional datasets were used as direct inputs, regional methods were generally followed with modifications made for thresholds and buffers more appropriate for the county scale. Having the regional methods as a resource to follow was integral to the creation of the local model.

b. Determining Modeling Parameters

In the case of Murray County, it is clear that additional areas of significance were added during the local modeling process that did not show up as significant at the regional level. This can be attributed to a combination of more refined local data, specific conservation goals for the county, and the model parameters, such as thresholds and buffer amounts, used to identify ecologically significant areas.

i. CHOOSING BUFFER AMOUNTS AND THRESHOLDS

Buffer amounts and thresholds have been used throughout the modeling process in an effort to design a successful network that includes quality habitat, areas important for natural resource protection, and functional ecosystem processes that are sufficiently buffered from the negative effects of intensive or urban land uses. Examples of such buffers and thresholds include: stream buffers for water quality and aquatic habitats, wetland buffers, steep slopes proximities, habitat area requirements, etc.

In all cases, buffer amounts and thresholds used in the modeling process have been researched and appropriate numbers have been chosen from the current literature and expert knowledge available. However, the effects of development, human disturbance, and habitat fragmentation on the viability of species and the functioning of ecosystems are still in the process of being researched and quantified. Species-specific information regarding these effects is often not available, and the completion of all such analyses will take many years. However, information and data regarding other areas and similar species is often available, from which decisions can be made concerning proper buffer amounts and thresholds.

Furthermore, in absence of definitive numbers or information, it is important to use the precautionary principle, which advocates greater protection when faced with uncertainty (Noss et al 1997). Taking the conservative estimates from the available literature and research will insure more comprehensive inclusion of sensitive areas.

In general, choosing thresholds, buffer amounts, and general modeling of features will involve a combination of local knowledge, expert knowledge and input, research and methods from previous similar projects, and trial and error. Modeling processes set general guidelines for planners to follow. There is no one size fits all model, and models must be adapted to fit the goals and the geographic scale of the project at hand. Unfortunately, there is no set formula for determining all thresholds and decisions that must be made during the process. Instead, areas must be modeled, and then reviewed by local planners, ecologists, and technical staff to evaluate whether the areas accurately represent conservation goals and phenomenon that is occurring in the area of interest. When possible, experts should be consulted to set goals, identify data sources, and determine thresholds.

ii. SCALING DOWN: THRESHOLDS AT VARIOUS SCALES

The geographic scale of the analysis will contribute to determining the precision of conservation focus. At both the local and regional level, conservation plans should primarily focus on larger, intact areas of ecological significance, but what is considered "large" is variable depending on the scale of the analysis. Hence, model parameters, such as buffer amounts and thresholds, will vary. In the local example, the regional SEF methods were followed for many analyses, but thresholds and buffers were reduced, or "scaled down" for more refined identification of ecologically significant areas.

A primary example of scaling down includes determination of hub size for the county level. In the SEF model, minimum hub size was 5,000 acres, as opposed to the county level, where 1,000 acres was chosen. Significant riparian hubs, such as the Conasauga are not large enough to meet the 5,000-acre threshold, but should still be considered an ecological hub. Another example is the identification of riparian linkages. In the SEF model, only major rivers were buffered by one kilometer. For Murray County, the width of riparian linkages for rivers were determined by their respective floodplains and for streams a 300 feet buffer was used.

Another example of scaling down is the parameters used in the exclusion process. For the regional analyses, areas of high road densities were excluded from the model (road densities greater than 3 miles/square mile). When evaluating these areas at the local level, they were generalized and did not adequately capture areas of high road densities in the county. Hence, a larger threshold for road density was used (greater than 5 miles/square mile), which more accurately represented where multiple roads converge and where the network of roads is most dense and may affect species' migration.

c. Recommendations For Linkages

A variety of methods can be used to identify existing and potential areas important for connectivity. At the regional scale, cost surfaces were used to delineate linkages because the scale of region was so large that detailed knowledge of every area within the region was not available. At the local scale, the use of cost surfaces is less necessary because important areas for connectivity are more easily identified with the input of local knowledge and detailed evaluation of areas. Hence, a combination of approaches was used in the local model, including (1) the delineation of linkages along riparian corridors, (2) "manual" linkage delineation, with the aid of land cover data, and (3) the least cost path method using cost surfaces.

Ideally, the linkage process should be supplemented by specific knowledge of local animal movement corridors and migration paths. However, in the absence of such knowledge, linkages have been created to traverse the best quality habitat and through larger areas of intact natural cover, avoiding areas of intense human use. In addition, areas that are often considered natural guiding features for wildlife such as river and stream networks and ridgelines are often recognized as potentially significant areas to protect or restore corridors. Furthermore, in cases where specific knowledge is not available, cost surfaces may be appropriate to use as surrogates to identify areas with the best potential for connectivity.

Recommendation for Identifying Linkages: Where and when to focus on connectivity

- If there are stream corridors with existing intact vegetation alongside, then use those corridors to connect areas of ecological significance. Such stream corridors are often natural guiding features for many species and they can also provide water quality and flood protection.
- If there is no stream corridor, or if there is a stream corridor but it is disturbed because of intensive land uses such as urban or agriculture, then look for intact blocks of forest or other natural cover to maintain connectivity between areas of ecological significance.
- Ridgelines can be an important complement to wildlife corridors following stream networks.
- When possible, incorporate known animal migration routes and specific knowledge concerning local ecology for identification of wildlife corridors.
- Although all available local knowledge and expertise should be used to help determine important areas for maintaining ecological connectivity and wildlife corridors, the use of cost surfaces can potentially provide insights that will augment more deterministic approaches. The development of a cost (or suitability) surface requires that all areas within the study area be ranked based on their potential suitability for protecting connectivity. Cost surfaces can then either be assessed manually to determine the best potential linkages between hubs, or it can be quantitatively analyzed using the least cost path function in ESRI's Arc-Info or Arcview.

d. Data Gaps

Unfortunately, current and complete data will rarely exist for any GIS project or analysis. However, planning projects must continue with the best data available. Ideal datasets for inclusion into a future iteration of this model include: a more resolute and current land cover data set, known animal migration routes for delineation of wildlife corridors, additional biodiversity information concerning areas necessary to protect viable populations of specific species, and representation analyses of species and communities to insure that appropriate amounts of each are protected compared to their historical distributions.

e. Recommendations for Protection Measures: What This Network Can and Should Be Used For

The ecological network is not a blueprint for acquisition of future greenspace and conservation lands. Rather, it is an assessment of areas important for conserving natural resources in the county and can be used to guide a comprehensive conservation strategy, using a myriad of protection tools. In other words, it is an inventory of lands providing important opportunities to better protect the "green infrastructure" of the county. Conservation tools and strategies can encompass a mixture of conservation easements, fee-simple acquisition, development incentives and disincentives, zoning ordinances, land use planning, dedications, and more. Exactly which tools will be appropriate for which area will depend upon various factors such as the area targeted for protection (wetlands, floodplains, etc), land ownership, landowner cooperation, enforcement efficacy, property values, practicality, land acquisition budget, and the political climate. Appendix H will outline various conservation tools and strategies.

In general, Murray County should target the following areas identified in the network for natural resource protection through implementation and enforcement of county ordinances and zoning districts: wetlands, floodplains, steep slopes, water supply watersheds, areas of high aquifer recharge, and surficial aquifer areas vulnerable to pollution. Other county and city governments have already drafted ordinances and regulations for some of these sensitive areas, which can be followed and implemented. Enforcement of such ordinances is integral to the successful protection of these areas. While some of these areas can be incorporated into other protection measures such as fee-simple acquisition, conservation easements, open space districts, etc., these areas should be protected by zoning ordinances and districts as a minimum protection measure.

Furthermore, state and federal programs should be used as supplemental protection measures. Natural Resources Conservation Service and the Farm Service Agency offers a multitude of conservation programs to protect natural resources, wetlands, soil, agriculture, plants and animals. Programs include the Farmland Protection Program, Wetlands Reserve Program, Wildlife Habitat Incentive Program, Conservation Reserve Program, Forestry Incentive Program, and more. These are discussed in more detail in Appendix H.

E. CONCLUSIONS

The purpose of this workbook example was to explore and provide an example of how the Southeastern Ecological Framework methodology and data can be utilized at the local or county level. The utility of the SEF modeling methods and data products (regional analyses) was explored in the identification of an ecological network for Murray County, Georgia. The regional modeling process used for the SEF, which includes identification of priority ecological areas, hubs, and landscape linkages, was also used for the local model. Although some modifications concerning model parameters (thresholds and buffer amounts) were necessary for refinement of the county model, overall, the SEF methods used were successful and useful for systematically identifying ecologically significant areas in Murray County. Furthermore, the model modifications used herein can potentially serve as guidelines for other county or local entity to follow the SEF methods.

The utility of incorporating regional SEF analyses as components in the local model was also evaluated. The conclusion for the Murray County case was that direct inclusion of regional analyses was not appropriate for creating a refined ecological network, since other data sources existed which were more resolute for delineation of local features. However, it is important to note that the methods used to develop these regional PEA layers were extremely useful and guided the identification of local PEAs. Furthermore, this case is not representative of all cases, and for instances with limited data sources, the SEF data products can potentially serve as a surrogate data source for identification of ecologically significant areas. In addition, the regional data that was collected for the SEF model was used to fill data gaps in the local model.

The Murray County Ecological Network identifies additional ecologically significant areas that have not been identified at the regional level. This can be attributed to the differences in the model parameters used, varying conservation goals, and the inclusion of more refined local data sources in the modeling process. The identification of these additional areas demonstrates the primary purpose for completing such local level plans: although the SEF can serve as a coarse assessment of areas important for natural resource and biodiversity protection, it should be augmented by local conservation plans for comprehensive inclusion of ecologically significant areas. These additional local pieces identified in the county model arguably "flesh out" the skeleton build by the regional conservation plan. The skeleton, or backbone, is represented by the larger, regional areas of ecological that were identified in both models. These areas offer the best opportunities to support conservation of biodiversity, functional ecosystems, and ecological processes in the long-term *if* they are connected and augmented by local pieces of ecological significance.

Section VII: Literature Cited

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Section VIII: Glossary

Buffer: A buffer is a zone adjacent to and surrounding a particular area. Buffers generally serve to protect ecologically sensitive areas such as streams, rivers, wetlands, floodplains, and conservation lands, from direct human disturbance and negative effects of intensive land uses.

EMAP: A geographic unit of measure used by EPA for various analyses, which is a hexagon with an area of 648.7 square kilometers.

FEN: The FEN, or Florida Ecological Network, is the ecological component of the Florida Greenways Program. The University of Florida was hired in 1995 by the Florida Department of Environmental Protection to develop a GIS (Geographic Information Systems) model to identify the best opportunities to protect a recreational and ecological greenways system throughout the state. The FEN delinetes a connected system of public and private lands important for conservation from the Everglades in South Florida to the western tip of the Florida panhandle.

GAP Analysis: Gap Analysis is a federal (USGS) program to assess biodiversity conservation needs nationwide. GAP analysis is being conducted in every state and many of the state analyses are complete or are close to completion. However, none of these state GAP Analysis efforts were completed in the southeastern United States when the Southeastern Ecological Framework (SEF) delineation or prioritization was being conducted, and therefore the data could not be incorporated. These projects will produce habitat or natural community vegetation maps for each state and potential habitat models for native vertebrate species. The vegetation maps tend to have a more resolute classification of natural community or habitat types than the NLCD (National Land Cover Dataset) and could be used to conduct representation analyses to determine which vegetation types are not currently well represented within existing conservation lands. Also the habitat models can be used to identify specific areas that potentially support species of conservation interest, and they will be used in the GAP program to identify biodiversity hotspots that are not currently protected. Obviously this data will be useful for a variety of conservation planning efforts, and future iterations of the SEF will incorporate this information.

GIS: Geographic Information System. GIS is the primary means by which these analyses have been conducted and mapped. It is a collection of computer hardware, software, geographic data, and people designed to capture, store, retrieve, analyze, display, update and manipulate geographically referenced information (ESRI 1993).

Hubs: Hubs are the primary component of the Southeastern Ecological Framework (SEF). They are Priority Ecological Areas (PEAs) that after going through a process to delete intensive land uses are 5000 acres or greater is size. Optimized Hubs are created by filling gaps within hubs or smoothing their edges where suitable land use is available. This is possible because not all areas of suitable land use in classified as PEA. See the Southeastern Ecological Framework Delineation Report for more details.

HUC: Hydrologic Unit Code. Hierarchical classification system used by U.S.G.S., which divides the United States into four levels (listed largest to smallest): regions, sub-regions, accounting units, and cataloging units. Each unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system. The fourth and smallest level of classification is the cataloging unit, which is represented by eight digits. The cataloging unit was used in several of the ABI biodiversity analyses.

Linkages: Linkages are the other major component of the Southeastern Ecological Framework (SEF). They were identified to connect Hubs wherever appropriate land use was available. Linkages serve to integrate Hubs and make it more likely that functional ecological processes and biodiversity will be protected. The identification of linkages within the SEF included riparian, upland, and general linkages. Although connectivity between hubs is a primary function of all these linkage types, riparian linkages are also intended to buffer major rivers to protect water quality and other hydrological functions. For more information on the delineation of linkages see the Southeastern Ecological Framework Delineation Report. Other terms for linkages include landscape linkage and (wildlife) corridors. Landscape linkages are large swaths of land that are provide habitat while also serving to functionally connect broad areas. Wildlife or conservation corridors may be more narrow, linear features that provide connectivity. Intact riparian corridors along rivers are a good example of this type of linkage.

MUA: Multiple Utility Assignment. The combination of two or more SUAs (Single Utility Assignment). See definition for SUA for more details.

PEA / PEAX: PEAs, or Priority Ecological Areas, are the primary building blocks of the Southeastern Ecological Framework (SEF). PEAs are areas of high natural resource signficance delineated based on various data and analyses indicating areas important for conserving ecosystem services or biodiversity. PEAX are PEAs that remain after excluding all intensive land use or other areas that may have compromised ecological integrity. See the Southeastern Ecological Framework Delineation Report for more details.

Reclassification/reclassified: The process by which a range of data values is grouped into a number of classes for display or ranking of data. For this project, reclassification was used to convert datasets to a common scale of utility from which mutliple datasets could then be combined and compared. All datasets were reclassified into values from 1 to 10. After a dataset has been reclassified, it is considered a SUA (Single Utility Assignment). Reclassification methods used in this project include equal interval, equal area, and natural breaks.

SEA / SEAs: SEAs, or Signficant Ecological Areas, are areas of secondary signficance identified during the Southeastern Ecological Framework (SEF) delineation process. SEAs are areas with natural resource signficance delineated based on various data and analyses indicating areas important for conserving ecosystem services or biodiversity. Although SEAs are not used to delineate Hubs as are PEAs, they are used in the Linkage delineation process and otherwise be incorporated into the SEF during the spatial optimization steps. See the Southeastern Ecological Framework Delineation Report for more details.

SEF: The SEF, or Southeastern Ecological Framework, is a representation of large, intact or relatively intact areas of ecological significance across the eight states within EPA Region 4. The SEF was delineated using a GIS (Geographic Information Systems) modeling process that identified areas important for protecting ecosystem services and biodiversity across the region using available data. Larger areas of ecological significance were identified (Hubs) and then the best opportunities to maintain or restore ecological connectivity between Hubs were then delineated. These two components were then combined and spatially optimized to create the SEF. The SEF is a first iteration product that should be updated as new data becomes available. See the Southeastern Ecological Framework Delineation Report for more details.

SUA: Single Utility Assignment. A SUA is the product of reclassification, a dataset that has been converted to a common scale of utility from which multiple datasets can then be combined and compared. The common scale of utility for this project is from 1 to 10, where a one represents a low priority ranking and a ten represents a high priority ranking. All datasets have been converted to this 1 to 10 scale, using one of the following reclassification methods: equal interval, equal area, or natural breaks.

Section IX: Guide to Resources for Regional Conservation Planning

The following guide is divided into separate categories relevant to the science, data collection, decision support methods, and planning strategies for regional conservation planning. Resources include book, journal, and report citations, links to relevant websites, and training opportunities. Although we have attempted to provide all the resources we used in our project as well as additional materials that may be helpful, resources now available to support regional conservation planning are varied and numerous and no listing of material can be considered comprehensive. In addition, internet links can be very dynamic and changes in web site addresses and web resources should be expected. All links included in this resource guide were valid at the time of report completion, but internet resources can change significantly with time.

Regional Conservation Planning

Ahern, J. 1999. Spatial concepts, planning strategies, and future scenarios: a framework method for integrating landscape ecology and landscape planning. J. M. Klopatek and R. H. Gardner, editors. Landscape ecological analysis: issues and applications. Springer-Verlag, New York.

Benedict, M. 2000. Green infrastructure: a strategic approach to land conservation. PAS Memo, American Planning Association, October 2000.

Benedict, Mark A. and Edward T. McMahon, Green Infrastructure: Smart Conservation for the 21st Century, Sprawl Watch Clearinghouse Monograph Series, Washington, D.C., 2002.

Collins, B. R., and E. W. B. Russell, editors. 1988. Protecting the New Jersey Pinelands. Rutgers University Press, New Brunswick, NJ.

Fabos, J. G., and J. Ahern. 1996. Greenways: the beginning of an international movement. Elsevier, Amsterdam.

Florida Greenways Commission. 1994. Report to the Governor: creating a statewide greenways system: for people . . . for wildlife . . . for Florida. Florida Department of Environmental Protection, Tallahassee.

Johnson, K. N., F. Swanson, M. Herring, S. Greene, editors. 1999. Bioregional assessments: science at the crossroads of management and policy. Island Press, Washington, D.C.

Jongman, R. H. G. 1995. Nature conservation planning in Europe: developing ecological networks. Landscape and Urban Planning. 32:169-183.

Knight, R. L., and P. B. Landres. 1998. Stewardship across boundaries. Island Press, Washington, D.C.

McHarg, I. 1969. Design with nature. Natural history press, Garden City, New York.

O'Connell, M. A. 1996. Managing biodiversity on private lands. Pages 665-678 in R. C. Szaro and D. W. Johnston. Biodiversity in managed landscapes: theory and practice. Oxford University Press, New York.

Green Infrastructure planning website:
http://www.greeninfrastructure.net/

Conservation Fund’s website:
http://www.conservationfund.org/
Website for California’s land conservation program:
http://ccrisp.ca.gov/
Website for Florida Department of Environmental Protection, which includes links to Florida’s Greenways Program and Florida Forever land protection program:
http://www.dep.state.fl.us/
Camp Pendleton regional conservation planning website:
http://www.gsd.harvard.edu/studios/brc/brc.html

Conservation Biology

Baydack, R. K., H. Campa, and J. B. Haufler, editors. 1999. Practical approaches to the conservation of biological diversity. Island Press, Wahsington, D.C.

Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida’s wildlife habitat conservation system: recommendations to meet minimum conservation goals for declining wildlife species and rare plant and animal communities. Florida Game and Fresh Water Fish Commission, Tallahassee Florida.

Cox, J., and R. Kautz. 2000. Habitat conservation needs of rare and imperiled wildlife in Florida. Office of Environmental Services, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Gray, P.A., D. Cameron, and I. Kirkham. 1996. Wildlife habitat evaluation in forested ecosystems: some examples from Canada and the United States. Pages 407-536 in R. M. DeGraaf and R. I. Miller, editors. Conservation of faunal diversity in forested landscapes. Chapman and Hall, London.

Hunter, M. 2002. Fundamentals of conservation biology. Blackwell Science, Abingdon, UK.

Kautz, R., and J. Cox. 2001. Strategic habitats for biodiversity conservation in Florida. Conservation Biology 15:55-77.

Marcot, B. G., and D. D. Murphy. 1996. On population viability analysis and management. Pages 58-76 in R. C. Szaro and D. W. Johnston. Biodiversity in managed landscapes: theory and practice. Oxford University Press, New York.

Meffe, G. K., C.R. Carroll, and contributors. 1997. Principles of conservation biology. 2nd edition. Sinauer Associates, Sunderland, MA.

Miller, K. R. 1996. Conserving biodiversity in managed landscapes. Pages 425-441 in R. C. Szaro and D. W. Johnston. Biodiversity in managed landscapes: theory and practice. Oxford University Press, New York.

Noss, R. F., M. A. O’Connell, and D. D. Murphy. 1997. The science of conservation planning: habitat conservation under the endangered species act. Island Press, Washington, D.C.

Pickett, S. T. A., R. S. Ostfeld, M. Shachak, and G. E. Likens, editors. 1997. The ecological basis of conservation. Chapman and Hall, New York.

Short, H. L., J. B. Hestbeck, and R. W. Tiner. 1996. Ecosearch: a new paradigm for evaluating the utility of wildlife habitat. Pages 569-594 in R. M. DeGraaf and R. I.

Miller, editors. Conservation of faunal diversity in forested landscapes. Chapman and Hall, London.

Soulé, M.E., editor. 1986. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts.

Soulé, M.E., editor. 1987. Viable populations for conservation. Cambridge University Press, Cambridge, United Kingdom.

Soulé, M.E., and B.A. Wilcox, editors. 1980. Conservation biology: an evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts.

Voller, J., and S. Harrison, editors. 1998. Conservation biology principles for forested landscapes. UBC Press, Vancouver, Canada.

Web version of report on endangered ecosystems in the United States:
http://biology.usgs.gov/pubs/ecosys.htm

Society for Conservation Biology website:
http://conbio.net/scb/

Landscape Ecology

Farina, Almo. 1998. Principles and Methods in Landscape Ecology. Chapman & Hall, London.

Forman, R. T. T. 1987. The ethics of isolation, the spread of disturbance, and landscape ecology. Pages 213-229 in M. G. Turner, editor. Landscape heterogeneity and disturbance. Springer-Verlag, New York.

Forman, R. T. T. 1995. Land mosaics: the ecology of landscapes and regions. Cambridge University Press, Cambridge, United Kingdom.

Forman, R.T.T. and M. Godron. 1986. Landscape Ecology. John Wiley & Sons, New York.

Forman, R.T.T., and S. K. Collinge. 1996. The "spatial solution" to conserving biodiversity in landscape and regions. Pages 537-568 in R. M. DeGraaf and R. I. Miller, editors. Conservation of faunal diversity in forested landscapes. Chapman and Hall, London.

Harris, L.D., T.S. Hoctor, and S.E. Gergel, 1996. Landscape processes and their significance to biodiversity conservation. Pages 319-347 in O.E. Rhodes Jr., K. Chesser, and M.H. Smith, editors, Population dynamics in ecological space and time. The University of Chicago Press. Chicago.

Klopatek, J. M., and R. H. Gardner, editors. 1999. Landscape ecological analysis: issues and applications. Springer-Verlag, New York.

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice: pattern and process. Springer-Verlag, New York.

Dramstad, W. E., J. D. Olson, and R. T. T. Forman. 1996. Landscape ecology principles in landscape architecture and land-use planning. Island Press, Washington, D.C.

U.S. chapter of the International Association for Landscape Ecology website:

http://sslsun02.tamu.edu/iale/iale.htm

Ecosystem Services

Binford, M. W., and M. J. Buchenau. 1993. Riparian Greenways and Water Resources. Ecology of Greenways: Design and Function of Linear Conservation Areas. University of Minnesota Press, Minneapolis.

Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, T. Erickson, S.S. Cooke. 1992. Wetland Buffers: Use and Effectiveness. Adolfson Associates, Inc., Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, Pub. No. 92-10.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Daily, G. C. 1997. Introduction: what are ecosystem services? Pages 1-10 in G. C. Daily, editor. Nature's services: societal dependence on natural ecosystems. Island Press, Washington, D.C.

Daily, G.C., 2000. Management objectives for the protection of ecosystem services. Environmental Science and Policy 3(6):333-339.

Jones, Edmunds & Associates, Inc. (JEA), M. T. Brown, J. S. Wade, and R. Hamann. 1999. Background Report in Support of Development of a Wetland Buffer Zone Ordinance. Project No. 19270-485-01. Jones, Edmunds & Associates, Inc. Gainesville, FL.

Noss, R. F. 2000. Maintaining the Ecological Integrity of Landscapes and Regions. Pages 191 – 208 in D. Pimentel, L. Westra, and R. Noss, editors. Ecological Integrity: integrating environment, conservation, and health. Island Press, Washington, D.C.

Woodley, S., J. Kay, and G. Francis, editors. 1993. Ecological integrity and the management of ecosystems. St. Lucie Press, Ottawa, Canada.

U.S. Environmental Protection Agency. 1999. "Values and Functions of Wetlands." Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds. http://www.epa.gov/owow/wetlands/facts/fact2.html

Wisconsin Department of Natural Resources (WNDNR). 1999. "Why Protect Floodplains?" http://www.dnr.state.wi.us/org/water/wm/dsfm/flood/whyprotect.htm

For watershed planning, water quality buffers, stormwater management, and land conservation: EPA:
Office of Wetlands, Oceans, and Watersheds (http://www.epa.gov/OWOW/)
Center for Watershed Protection (http://www.cwp.org)

Carbon Sequestration websites:
http://sequestration.mit.edu/
http://www.ornl.gov/carbon_sequestration/

Reserve Design

Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system: recommendations to meet minimum conservation goals for declining wildlife species and rare plant and animal communities. Florida Game and Fresh Water Fish Commission, Tallahassee Florida.

Cox, J., and R. Kautz. 2000. Habitat conservation needs of rare and imperiled wildlife in Florida. Office of Environmental Services, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Harris, L. D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. University of Chicago Press, Chicago.

Harris, L. D. 1985. Conservation corridors: a highway system for wildlife. ENFO Report 85-5, Florida Conservation Foundation, Winter Park.

Harris, L. D., and P. B. Gallagher. 1989. New initiatives for wildlife conservation: the need for movement corridors. Pages 12-34 in G. Macintosh, editor. In defense of wildlife: preserving communities and corridors. Defenders of Wildlife, Washington D.C.

Harris, L. D., and K. Atkins. 1991. Faunal movement corridors in Florida. Pages 117-134 in W.E. Hudson, editor. Landscape linkages and biodiversity. Island Press and Defenders of Wildlife, Washington, D.C.

Harris, L. D., and J. Scheck. 1991. From implications to applications: the dispersal corridor approach to the conservation of biological diversity. Pages 189-220 in D.A. Saunders and R. J. Hobbs, editors. Nature conservation 2: the role of corridors. Surrey Beatty and Sons, Chipping Norton, New South Wales, Australia.

Harris, L. D., T. Hoctor, D. Maehr, and J. Sanderson. 1996b. The role of networks and corridors in enhancing the value and protection of parks and equivalent areas. Pages 173-198 in R. G. Wright, editor. National parks and protected areas: their role in environmental areas. Blackwell Science, Cambridge, MA.

Hoctor, T.S., M.H. Carr, and P.D. Zwick. 2000. Identifying a linked reserve system using a regional landscape approach: the Florida ecological network. Conservation Biology 14:4:984-1000.

Kautz, R., and J. Cox. 2001. Strategic habitats for biodiversity conservation in Florida. Conservation Biology 15:55-77.

Landres, P. B., R. L. Knight, S. T. A. Pickett, and M. L. Cadenasso. 1998. Ecological effects of administrative boundaries. Pages 39-64 in R. L. Knight and P. B. Landres. Stewardship across boundaries. Island Press, Washington, D.C.

Landres, P. B., S. Marsh, L. Merigliano, D. Ritter, and A. Norman. 1998. Boundary effects on wilderness and other natural areas. Pages 117-140 in R. L. Knight and P. B. Landres. Stewardship across boundaries. Island Press, Washington, D.C.

Noss, R. F. 1983. A regional landscape approach to maintain diversity. BioScience 33:700-706.

Noss, R. F. 1987. Protecting natural areas in fragmented landscapes. Natural Areas Journal 7:2-13.

Noss, R.F. 1987. Corridors in real landscapes: A reply to Simberloff and Cox. Conservation Biology 1:159-64.

Noss, R.F., 1991. Landscape connectivity: different functions at different scales. Pages 27-39 in W. E. Hudson, editor. Landscape linkages and biodiversity. Island Press and

Defenders of Wildlife, Washington, D.C.
Noss, R. F. 1992. The Wildlands Project: land conservation strategy. Wild Earth (Special Issue):10-25.
Noss, R.F. 1993. Wildlife Corridors. Pages 43-68 in D. S. Smith and P.C. Hellmund, editors. Ecology of Greenways. University of Minnesota Press, Minneapolis, MN. pp.43-68.
Noss, R.F., 1996. Protected areas: how much is enough? Pages 91-120 in R.G. Wright, editor, National parks and protected areas: their role in environmental protection. Blackwell Science, Cambridge, Massachusetts.
Noss, R. F., and L. D. Harris. 1986. Nodes, networks, and MUMs: preserving diversity at all scales. Environmental Management 10:299-309.
Noss, R. F., and C. A. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Defenders of Wildlife and Island Press, Washington, D.C.
Pasquarello, T. 1998. Wilderness and working landscapes: the Adirondack Park as a model bioregion. Pages 279-294 in R. L. Knight and P. B. Landres. Stewardship across boundaries. Island Press, Washington, D.C.
Schonewald-Cox, C. M. 1988. Boundaries in the protection of nature reserves: translating multidisciplinary knowledge into practical conservation. BioScience. 38: 480-486.
Scott, J. M., F. Davis, B. Csuti, R. F. Noss, B. Butterfield, C. Groves, J. Anderson, S. Caicco, F. D'Erchia, T. C. Edwards, J. Ulliman, and R.G. Wright. 1993. Gap analysis: a geographic approach to protection of biological diversity. Wildlife Monographs 123:1-41.
Smith D. J., 1999. Highway-wildlife relationships (Development of a decision-based wildlife underpass road project prioritization model on GIS with statewide application). Technical report, Florida Department of Transportation, Tallahassee.
Soulé, M. E., and J. Terborgh, editors. 1999. Continental conservation: scientific foundations of regional reserve networks. Island Press, Washington, D.C.
Stein, B., L. Kutner, J. Adams. 2000. Precious heritage: the status of biodiversity in the United States. Oxford University Press, Oxford, Great Britain.

RAMAS GIS software package website, which includes software to run GIS-based population viability models:
http://www.ramas.com/index.htm
Website for the federal GAP Analysis program:
http://www.gap.uidaho.edu/

Conservation History

History of the Park System (http://xroads.virginia.edu/~CAP/NPS/nps.html)

Conservation Strategies

Daniels, T., and D. Bowers. 1997. Holding our ground: protecting America's farms and farmlands. Island Press, Washington, D.C.

Natural Resources Conservation Service Conservation Programs, U.S. Dept of Agriculture (http://www.nhq.nrcs.usda.gov/PROGRAMS/cpindex.html)

Farm Service Agency, U.S. Dept of Agriculture (http://www.fsa.usda.gov/dafp/cepd/conserva.htm)

Preserving Virginia's Heritage: Approaches for Protecting Open Space (http://www.virginiaconservation.org/openspacepaper.htm#purchaseprogram)

For model ordinances on stream buffers, erosion and sediment control, open space zoning, groundwater protection:
Model Ordinances (http://www.stormwatercenter.net)

Website for California's land conservation program:
http://ccrisp.ca.gov/

Website for Florida Department of Environmental Protection, which includes links to Florida's Greenways Program and Florida Forever land protection program:
http://www.dep.state.fl.us/

Biodiversity partnership website, which is a good site for assessing existing programs across the United States for conserving biodiversity:
http://www.biodiversitypartners.org/#

Green Infrastructure planning website:
http://www.greeninfrastructure.net/

Conservation Fund's website:
http://www.conservationfund.org/

GIS

Burrough, Peter A, and R. A.McDonnell. 1998. Principles of Geographic Information Systems. Oxford University Press, Oxford, UK. Good general introduction and discussion of data issues and analysis.

Chrisman, N. 2002. Exploring geographic information systems. 2nd edition. Wiley, New York. Good source for advanced GIS theory.

ESRI. 1993. Understanding GIS: The ARC/INFO Method. Environmental Systems Research Institute, Redlands, CA.

ESRI. 1994. Cell-based modeling with GRID. Environmental Systems Research Institute, Redlands, CA.

ESRI. 1996. Working with ArcView Spatial Analyst. Environmental Systems Research Institute, Redlands, CA.

Goodchild, M. F., L. T. Steyaert, B. O. Parks, C. Johnston, D. Maidment, M. Crane, and S. Glendinning. 1996. GIS and environmental modeling: progress and research. GIS World Books, Fort Collins, Colorado.

Goodchild, M. F., P. A. Longley, D. J. Maguire, and D. Rhind, editors. 1999. Geographic Information Systems: principles, techniques, management and applications. John Wiley, New York.

Heywood, I., S. Cornelius, and S. Carver. 2000. An Introduction to Geographical Information Systems. Prentice Hall, New York. An excellent introductory text.

Molenaar, M. 1998. An introduction to the theory of spatial object modelling for GIS. Taylor and Francis, London. Covers some of the database and the Geometric fundamentals upon which GIS is based.

The National Center for Geographic Information Analysis (Excellent Resource for Comprehensive GIS Concepts)
http://www.geog.ubc.ca/courses/klink/gis.notes/ncgia/toc.html

Conservation GIS website, sponsored by TheConservation Fund, is a great source for information on using GIS in regional conservation planning:
http://www.conservationgis.com/

ESRI Virtual Campus: Library, Resources, On-line Training and Classes
http://campus.esri.com/

The Geographer's Craft: Projections and Coordinate Systems, Datums, Aerial Photography and Remote Sensing
http://www.colorado.edu/geography/gcraft/contents.html

The University Consortium for Geographic Information Science
http://www.ucgis.org/index.html

The University of Edinburgh and Association for Geographic Information (AGI). 1996. "GIS Dictionary". http://www.geo.ed.ac.uk/agidict/

GIS Data

Starting the Hunt: Guide to Mostly On-line and Mostly Free U.S. Geospatial and Attribute Data, Center for Advanced Spatial Technologies
http://www.cast.uark.edu/local/hunt/

List of GIS Resources on the Web, with Multi-State and State Specific Sites: Kentucky, North Carolina, Tennessee, Virginia, West Virginia, South Carolina, Hawaii, Oregon, Alaska, Ohio
http://euclid.dne.wvnet.edu/~jvg/ACA_GIS/State_GIS.html

Georgia GIS Data Clearinghouse
http://www.gis.state.ga.us/Clearinghouse/clearinghouse.html

North Carolina Geographic Data Clearinghouse
http://cgia.cgia.state.nc.us:80/ncgdc/

South Carolina Department of Natural Resources GIS Data Clearinghouse
http://water.dnr.state.sc.us/gisdata/

U.S. Fish & Wildlife Service GIS Data Sets by State
http://www.fws.gov/data/statdata/index.html

FIA: Forest Inventory & Analysis, U.S. Forest Service
http://fia.fs.fed.us/

National Atlas
http://www.nationalatlas.gov/

National Hydrolography Dataset
http://nhd.usgs.gov/

Website for the federal GAP Analysis program:
http://www.gap.uidaho.edu/

USGS data:
http://mapping.usgs.gov/

EPA websites:
http://www.epa.gov/ceisweb1/ceishome/atlas/
http://www.epa.gov/enviro/html/mod/index.html

Website for Nature Serve, which is the association for all state natural heritage programs a potential source of data on species of conservation interest and natural communities:
http://natureserve.org/

The University of Florida GeoPlan Center website:
http://www.geoplan.ufl.edu/

Related Projects

Florida Greenways Commission. 1994. Report to the Governor: creating a statewide greenways system: for people . . . for wildlife . . . for Florida. Florida Department of Environmental Protection, Tallahassee.

Hoctor, T.S., M.H. Carr, and P.D. Zwick. 2000. Identifying a linked reserve system using a regional landscape approach: the Florida ecological network. Conservation Biology 14:4:984-1000.

Jongman, R. H. G. 1995. Nature conservation planning in Europe: developing ecological networks. Landscape and Urban Planning. 32:169-183.

Website for Florida Department of Environmental Protection, which includes links to Florida's Greenways Program:
http://www.dep.state.fl.us/
The University of Florida GeoPlan Center website, which is :
http://www.geoplan.ufl.edu/

Maryland Greenways and GreenPrint Program:
http://www.dnr.state.md.us/greenways/

New Jersey Landscape and Greenways programs:
http://www.state.nj.us/dep/fgw/lndscpe.htm
http://www.njconservation.org/

Oregon Biodiversity Project:
http://www.biodiversitypartners.org/Oregon/orprofile.html

USGS GAP Analysis program:
http://www.gap.uidaho.edu/

Environmental Law Institute's report on state biodiversity initiatives:
http://www.eli.org/

--TNC ecoregional planning
--land transformation modeling (LEAM/gigalopolis models)

Training Opportunities

The USFWS National Conservation Training Center offers courses on conservation planning, GIS, and habitat modeling:
http://training.fws.gov/

ESRI offers both traditional and web-based GIS courses and publications:
http://campus.esri.com/

Section X: Data Library

Included with this document are many of the GIS data layers used in the delineation and prioritization of the SEF; development of the Mississippi Delta Framework, and the assessment of significant natural resource areas for Murray County, Georgia. These data are included on three separate CDs: CD 1 contains the data associated with delineation of the SEF including the priority ecological areas datasets; CD 2 contains the data from the characterization and prioritization of the SEF; and CD 3 contains the data for both the Mississippi Delta and Murray County, Georgia projects. Significant data not included are species occurrence data from the natural heritage programs (Florida, Georgia, and Alabama) and significant natural areas data from natural heritage programs (Florida and North Carolina) are not included due to data use agreements we had with those entities. This information is either considered sensitive or is updated regularly, so users should contact the various natural heritage programs directly for such data.

Appendix C includes two detailed lists of data that were used or created during the SEF modeling process. The first data list represents a brief description of the data sets used. The second data list includes more detailed information on the sources and methods used to create each layer. On both lists, all data sets that are not included in the data library are marked with an asterisk. Users should check with the sources of these data sets listed in the second list for their availability. In addition, users should be aware that many input data layers may be modified over time, and although some are included in the data library, the original sources should be consulted for updates and more detailed information. Appendix C also includes a list of data sources and contact information.

Appendix A: SEF Delineation Methods Flowcharts

Chart 1

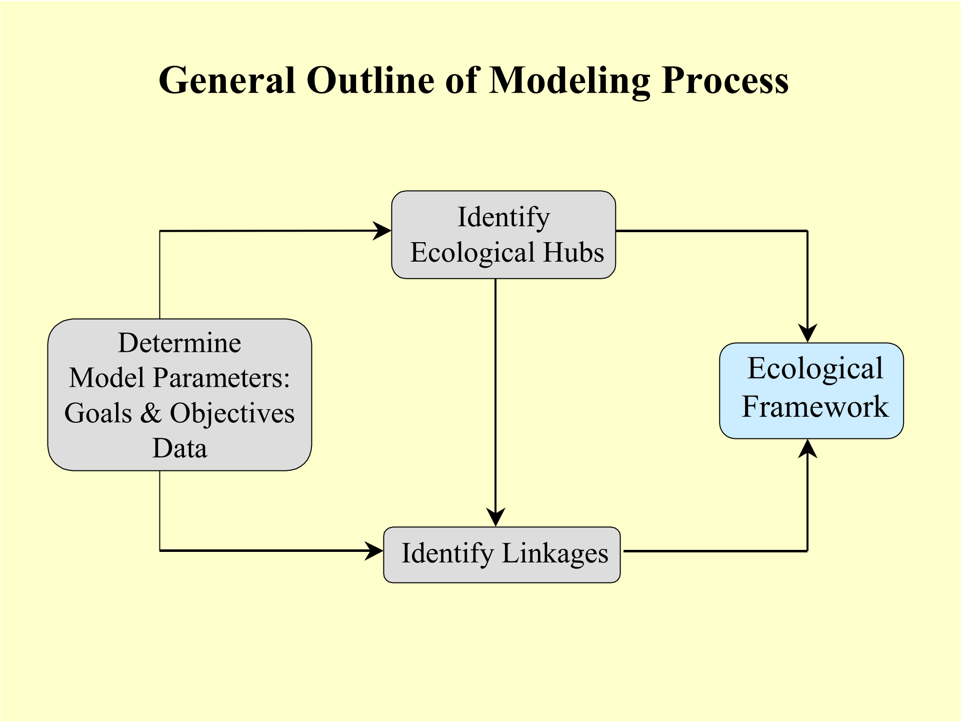


Chart 2

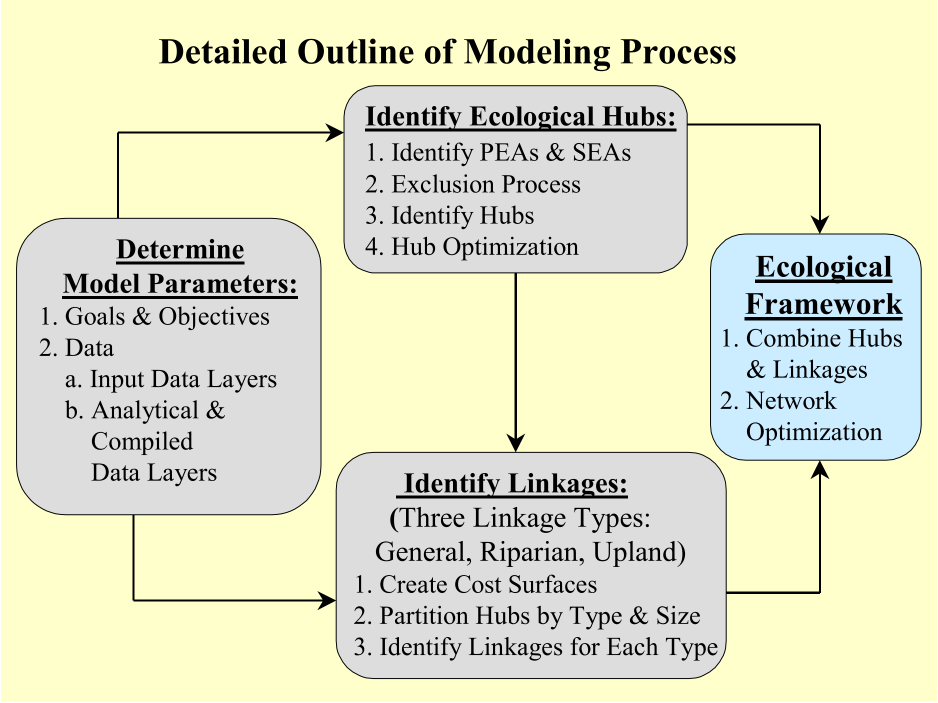
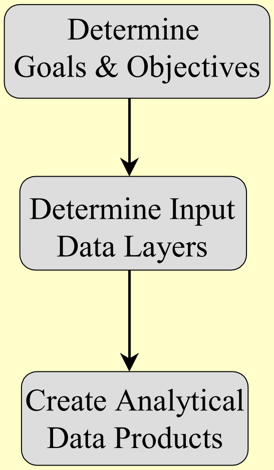


Chart 3

Establish Modeling Parameters


Determine Goals & Objectives

Determine Input Data Layers

Create Analytical Data Products

Chart 4

Input Data Layers:

Regional:

- MRLC (TVA Land use data)
- LUDA (Land use/land cover data)
- FEMA
- USGS 1:100,000 Hydrology
- National Estuary Research Reserves
- Road Grid Regional (Tiger Roads 1:100,000)
- Ecoregions
- National Forest Boundaries
- Forest Inventory Assessment
- Shellfish Areas
- Conservation Lands
- RF3 (River Reach Files)
- City Limits

State Data:

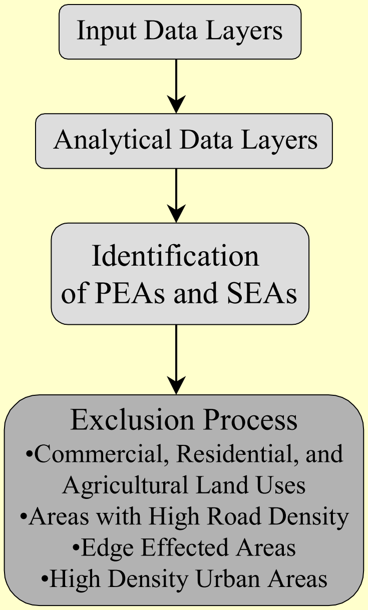
- FL Aquatic Preserves
- FL Areas of Conservation Interest
- FL Potential Natural Areas
- FL Fish & Wildlife Conservation Commission Strategic Habitat Conservation Areas
- FL Fish & Wildlife Conservation Commission Species Hot Spots
- FL Water Management District Land Use
- Element Occurrence (Florida, Alabama, Georgia)
- NC Significant Natural Areas
- NC Land Trust Priority Areas
- NC Anadromous Fish Spawning Areas
- NC Coastal Reserves
- NC Fishery Nursery Areas

Chart 5

Analytical & Compiled Data Products:

- Conservation Lands
- Wetlands
- Hydrographic Areas
- Major Rivers
- Wild and Scenic Rivers
- Stream Start Reaches
- Cat123 (Simplified Land Use Categories)
- Hybrid Land Use
- Riparian Areas
- Habitat Diversity
- Natural Edge Habitat
- Black Bear Habitat
- Road Density
- Roadless Areas
- Negative Edge Effect

Chart 6



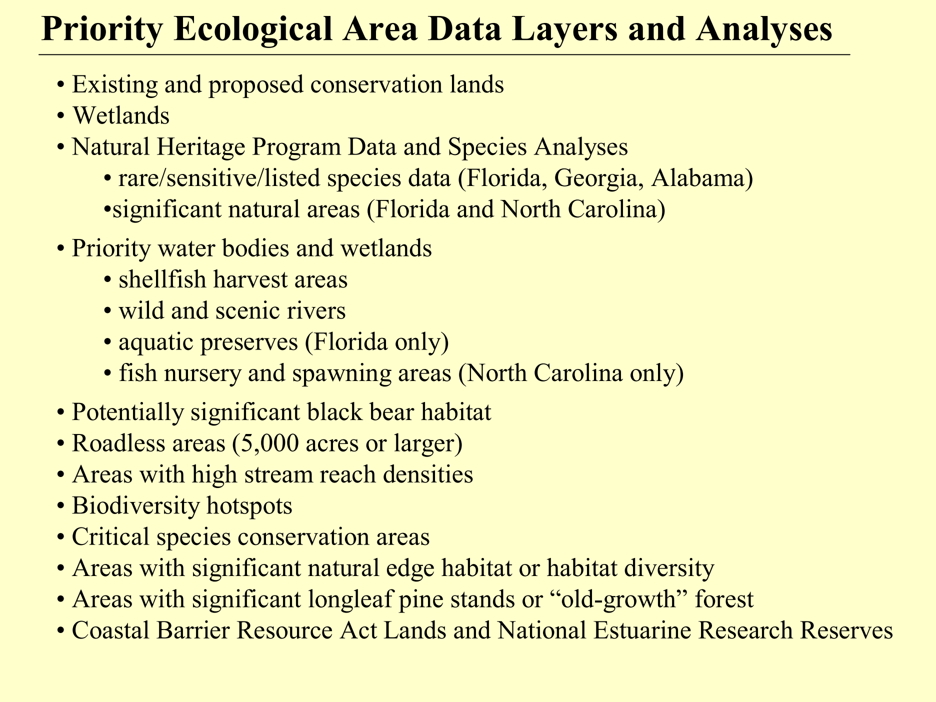
Input Data Layers

Analytical Data Layers

Identification of PEAs and SEAs

Exclusion Process
- Commercial, Residential, and Agricultural Land Uses
- Areas with High Road Density
- Edge Effected Areas
- High Density Urban Areas

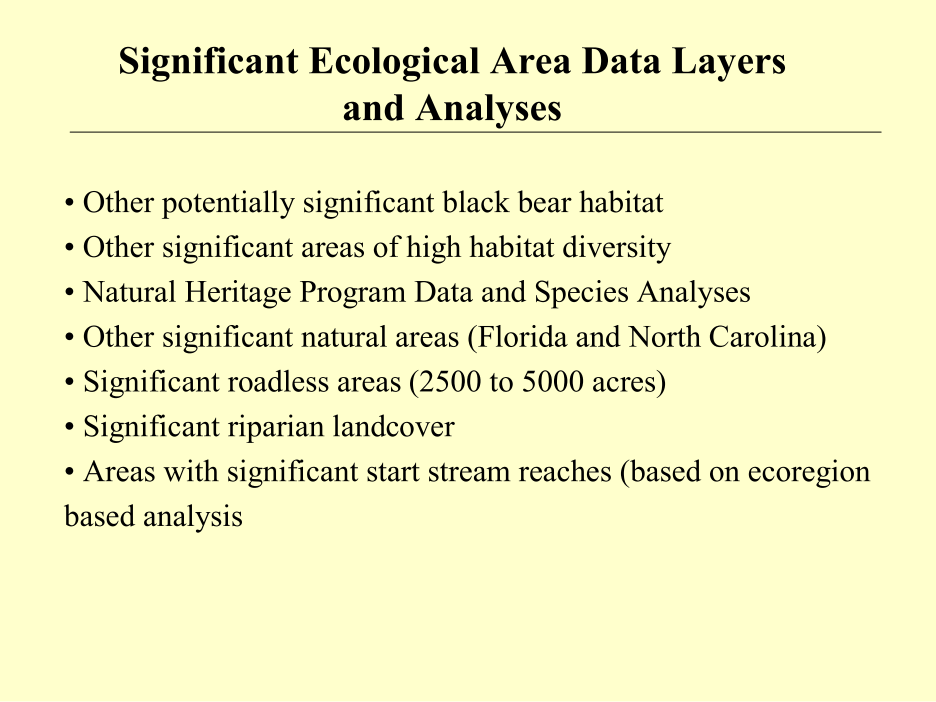
Chart 7



Priority Ecological Area Data Layers and Analyses

- Existing and proposed conservation lands
- Wetlands
- Natural Heritage Program Data and Species Analyses
    - rare/sensitive/listed species data (Florida, Georgia, Alabama)
    - significant natural areas (Florida and North Carolina)
- Priority water bodies and wetlands
    - shellfish harvest areas
    - wild and scenic rivers
    - aquatic preserves (Florida only)
    - fish nursery and spawning areas (North Carolina only)
- Potentially significant black bear habitat
- Roadless areas (5,000 acres or larger)
- Areas with high stream reach densities
- Biodiversity hotspots
- Critical species conservation areas
- Areas with significant natural edge habitat or habitat diversity
- Areas with significant longleaf pine stands or “old-growth” forest
- Coastal Barrier Resource Act Lands and National Estuarine Research Reserves

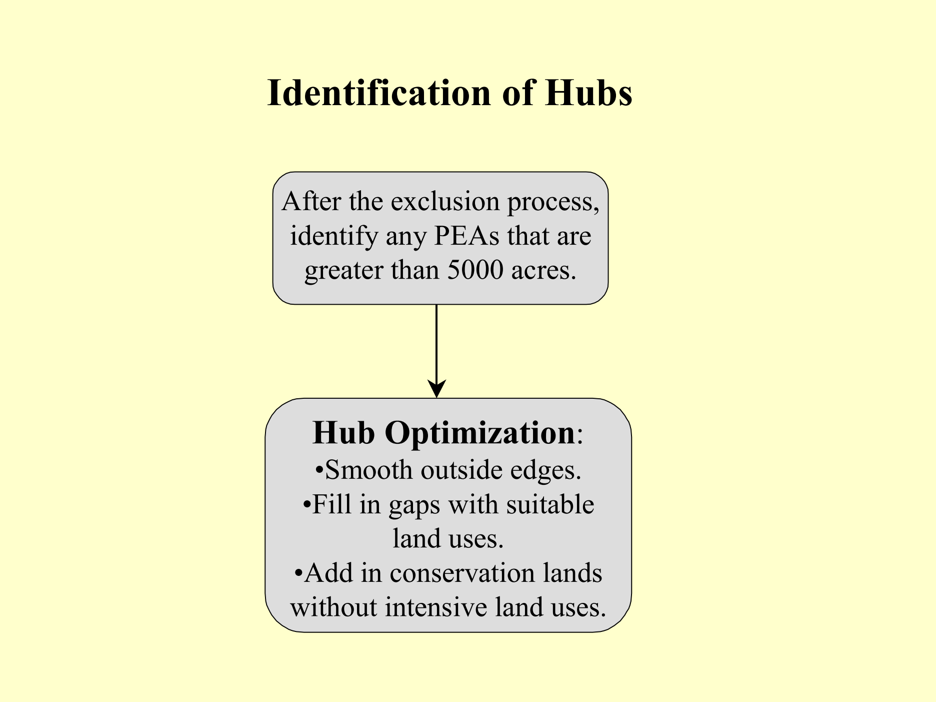
Chart 8



Significant Ecological Area Data Layers and Analyses

- Other potentially significant black bear habitat
- Other significant areas of high habitat diversity
- Natural Heritage Program Data and Species Analyses
- Other significant natural areas (Florida and North Carolina)
- Significant roadless areas (2500 to 5000 acres)
- Significant riparian landcover
- Areas with significant start stream reaches (based on ecoregion based analysis

Chart 9

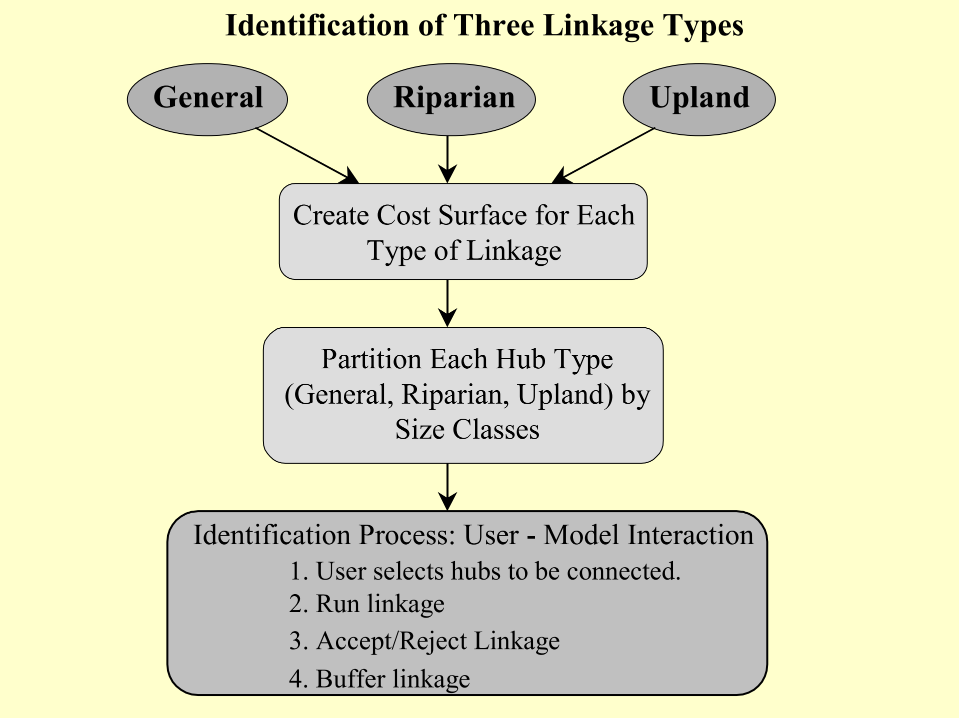


Identification of Hubs

After the exclusion process, identify any PEAs that are greater than 5000 acres.

Hub Optimization:
- Smooth outside edges.
- Fill in gaps with suitable land uses.
- Add in conservation lands without intensive land uses.

Chart 10



Identification of Three Linkage Types

General

Riparian

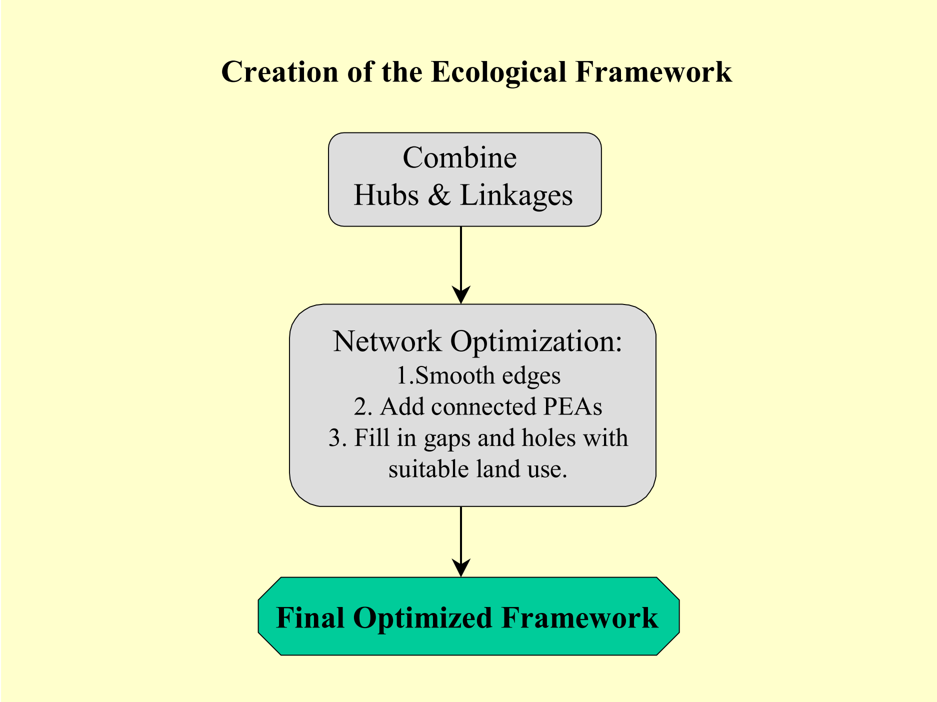
Upland

Create Cost Surface for Each Type of Linkage

Partition Each Hub Type (General, Riparian, Upland) by Size Classes

Identification Process: User - Model Interaction
1. User selects hubs to be connected.
2. Run linkage
3. Accept/Reject Linkage
4. Buffer linkage

Chart 11


Creation of the Ecological Framework
Combine
Hubs & Linkages
Network Optimization:
1.Smooth edges
2. Add connected PEAs
3. Fill in gaps and holes with
suitable land use.
Final Optimized Framework

Appendix B: Cost Surfaces for Modeling Riparian, Upland, and General Hub to Hub Landscape Linkages for SEF Delineation

The following three cost surfaces were used to identify riparian, upland, and general hub to hub linkages respectively. These cost surfaces were the inputs on which the least cost path function in Arc-Info GRID was run. The least cost path function attempts to minimize the accumulated "cost" required to link a source to a destination. Therefore, the algorithm can accomplish this goal by both minimizing the distance needed to connect the source and destination and by minimizing the number of high cost grid cells crossed. Therefore, in cost surfaces the categories with the lowest value (which is a value of 1 in this case) has the highest suitability for accommodating an ecological linkage. Users may also notice that the cost surfaces are not necessarily ordered sequentially based on value. This is due to that fact that various land use categories and types can overlap and the order of the cost surface reported here is critical for ensuring that the final surface places the appropriate value with various combinations of land uses and other landscape features.

General Cost Surface

Value	Description
ND*	Category III land uses
100,000	Open water
200,000	Major roads (class 1 only)
7,000	Pasture w/in 270m of significant water bodies
8,000	Other category II land use w/in 270m of significant water bodies
70,000	Other pasture
80,000	Other category II land use
700	Category I land uses with edge effects, within city boundaries, tva_urbden (high urban density), high road density, or class II roads
600	Native habitat with edge effects, within city boundaries, tva_urbden (high urban density), high road density, or class II roads
1	PEAs less than or equal to (le) 270m from significant water and within large intact areas* (5000 acre or larger areas of natural/semi-natural vegetation identified with a neighborhood habitat density analysis)
2	Other PEAs within large intact areas
3	PEAs le 270m from significant water and within moderate intact areas* (1000-5000 acre areas of natural/semi-natural vegetation identified with a neighborhood habitat density analysis)
4	Other PEAs within moderate intact areas
5	SEAs le 270m from significant water and within large intact areas
6	Other SEAs within large intact areas
7	SEAs le 270m from significant water and within moderate intact areas
8	Other SEAs within moderate intact areas
9	Native habitat le 270m from significant water and within large, intact areas
10	Other native habitat within large intact areas

General Cost Surface continued

Value	Description
11	Native habitat le 270m from significant water and within moderate intact areas
12	Other native habitat within moderate intact areas
13	Category I land use le 270m from significant water and within large intact areas
14	Other category I land use within large intact areas
15	Category I land use le 270m from significant water and within moderate intact areas
16	Other category I land use within moderate intact areas
17	PEAs le 270m from significant water
18	Other PEAs
19	SEAs le 270m from significant water
20	Other SEAs
21	Native habitat le 270m from significant water
22	Other native habitat
23	Category I land use le 270m from significant water
24	Other category I land use

Upland Cost Surface

Value	Description
ND*	Category II & Category III land use
200,000	Major roads (class I only)
150,000	Water
100,000	Wetlands (from PEA wetland data layer)
6000	Category I land use that overlaps with upland in MRLC (forest and shrubland only) with edge effects, within city boundaries, tva_urbden (high urban density), high road density, or class II roads
500	Uplands with edge effects, within city boundaries, tva_urbden (high urban density), high road density, or class II roads
1	Uplands within large intact areas and PEAs
2	Uplands within moderate intact areas and PEAs
3	Other uplands that are in PEAs
4	Uplands within large intact areas and SEAs
5	Uplands within moderate intact areas and SEAs
6	Other uplands that are in SEAs
7	Uplands within large intact areas
8	Uplands within moderate intact areas
9	Other uplands
100	Category I land use that overlaps with upland in MRLC (forest and shrubland only) within large intact areas (done to reconcile Florida land use data with MRLC data)
110	Category I land use that overlaps with upland in MRLC (forest and shrubland only) within moderate intact areas (done to reconcile Florida land use data with MRLC data)
120	Category I land use that overlaps with upland in MRLC (forest and shrubland only) (done to reconcile Florida land use data with MRLC data)

10,000	Wetlands in MRLC but not in PEA wetlands data layer
ND*	All other cells

Riparian Cost Surface

Value	Description
100	Wetlands or open water with edge effects, within city boundaries, tva_urbden (high urban density), high road density, or class I and II roads
1	Wetlands or open water within large intact areas and PEAs
2	Wetlands or open water within moderate intact areas and PEAs
3	Wetlands or open water and PEAs
4	Wetlands or open water within large intact areas and SEAs
5	Wetlands or open water within moderate intact areas and SEAs
6	Wetlands or open water and SEAs
7	Wetlands or open water within large intact areas
8	Wetlands or open water within moderate intact areas
9	Other wetlands open water
ND*	All other cells

* ND represents cells or areas that are assigned no value, which is called No Data. In the least cost path modeling process these are areas considered to be unsuitable for that particular linkage type, and the algorithm will not incorporate cells that are assigned as No Data. Therefore, if two Hubs are completed separated by areas of No Data the least cost path function will not identify a linkage between them.

* All three cost surfaces include the identification of large blocks of intact natural or semi-natural vegetation to help locate landscape linkages in wide, intact areas instead of narrow corridors whenever possible. These intact areas are separated into two classes: large and moderate. Large intact areas are defined as natural and semi-natural vegetation within both a 590 hectare area and 65 hectare area containing 90% or more natural or semi-natural vegetation in blocks 5000 acres or larger and without primary roads. Moderate intact areas are defined as natural and semi-natural vegetation within both a 590 hectare area and 65 hectare area containing 90% or more natural or semi-natural vegetation in blocks 1000 acres or larger and without primary roads.

Appendix C: Data Lists of All Region 4 EPA Ecological Framework Delineation Data Layers

This appendix includes two data lists for the SEF Delineation Layers. The first data list represents a brief description of the data sets used in the SEF Delineation process, including input data layers, analytical data layers, Priority Ecological Areas data layers, and Significant Ecological Areas data layers. The second data list includes more detailed information on the methods used to create each layer and their corresponding attribute information. Users should check with the sources of these data sets listed in the second list for their availability. In addition, users should be aware that many input data layers may be modified over time, and although some are included in the data library, the original sources should be consulted for updates and more detailed information.

TABLE 1: DESCRIPTION OF SEF DATA LAYERS

REGION 4 DATA LAYERS

Layer Name	***Description***	***Data Source***
ROAD DENSITY	Road densities for all classifications of roads in the 1990 TIGER road coverages.	US Bureau of the Census TIGER Roads {1990}
HIGH ROAD DENSITY	Areas of high road density (greater than 3 mi/sq.mi) for all classifications of roads in the 1990 TIGER road coverages.	US Bureau of the Census TIGER Roads {1990}
BLACK BEAR HABITAT	Potential black bear habitat according to land cover type, forest patch size, distance from primary roads, and road density.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} Environmental Systems Research Institute Roads
OCCUPIED BLACK BEAR SITES	This dataset delineates several areas where populations of black bears are known to exist.	Maehr, DS. Distribution of Black Bears in Eastern North America. Page 74 in DS Maehr and JR Brady, eds. Seventh Eastern Workshop on Black Bears and Management. Florida Game and Fresh Water Fish Commission. Cox, JA, MR Pelton, and JB Wooding. 1994. Distribution of Black Bears in the Southeastern Coastal Plain. Proc. Annu. Conf. Southeastern Assoc. Fish and Wildlife Agencies 48: 270-275.

Layer Name	***Description***	***Data Source***
OCCUPIED BLACK BEAR SITES, BUFFERED	This dataset consists of buffers around areas where populations of black bears are known to exist. The two buffer distances represented are 0-100km and 100-140km from the occupied black bear sites.	Maehr, DS. Distribution of Black Bears in Eastern North America. Page 74 in DS Maehr and JR Brady, eds. Seventh Eastern Workshop on Black Bears & Management. Florida Game and Fresh Water Fish Commission. Cox, JA, MR Pelton, and JB Wooding. 1994. Distribution of Black Bears in the Southeastern Coastal Plain. Proc. Annu. Conf. Southeastern Assoc. Fish and Wildlife Agencies 48: 270-275.
LANDUSE CATEGORIES 0123	This dataset contains land use data from several data sources categorized into three generalized categories and resampled to 90 meter by 90 meter resolution. Data used includes MRLC landuse, Florida Water Management Districts' landuse; and SAMAB landuse. Category 0 is natural/semi-natural, Category 1 is low intensity (rangelands, pine plantations), Category 2 is moderate intensity (most agriculture), and Category 3 is intensive land use (residential, commercial, industrial).	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} Florida Water Management Districts {1990; 1994} The Southern Appalachian Assessment (SAA) {1996; Version 3.0}

Layer Name	*Description*	*Data Source*
LANDUSE CATEGORIES 01	Natural and semi-natural land cover or low intensity land use areas as identified in several data sources.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} Florida Water Management Districts {1990; 1994} The Southern Appalachian Assessment (SAA) {1996; Version 3.0}
CITY LIMIT BOUNDARIES	City limit boundaries.	US Environmental Protection Agency
CONSERVATION LANDS	Conservation lands within region 4, obtained from both state and regional sources.	(1) US Environmental Protection Agency - Forest Service Ownership Boundaries; (2) NASA / University of California at Santa Barbara {1996} - Comprehensive Managed Areas Spatial Database; (3) US Geological Survey - Federal and Indian Lands; (4) US Forest Service {1995-1998} - Alabama Forest Service Ownership Boundaries; (5) University of Florida GeoPlan Center {1994-1998} - Florida Conservation Areas Database; (6) GA Natural Heritage Program {1998} - Georgia Department of Natural Resources Lands; (7) GA Gap Project {1999} - Public and Private Conservation Lands; (8) US Geological Survey -Kentucky Wildlife Management Areas; (9) US Geological Survey -Kentucky State Managed Forests; (10) US Geological Survey; KY Department of Parks Facilities Guide {1991-1997} -Kentucky State Parks; (11) US Forest

Layer Name	*Description*	*Data Source*
CONSERVATION LANDS	Conservation lands within region 4, obtained from both state and regional sources	CON'T: Service {1994-1996} - Mississippi National Forest Ownership Boundaries; (12) US Geological Survey {1997} - Mississippi National Park Boundaries; (13) MS Department of Wildlife, Fisheries, and Parks {1997} - Mississippi State Park Boundaries; (14) MS Department of Wildlife, Fisheries, and Parks {1997} - Mississippi Wildlife Management Areas; (15) US Geological Survey - South Carolina Nation Forests, Parks, Refuges, Reservations and Wildlife Management Areas Boundaries; (16) The Conservation Fund - North Carolina Conservation Areas; (17) US Environmental Protection Agency - North Carolina Lands Owned by The Nature Conservancy
UNDEVELOPED COASTAL BARRIER AREA	Undeveloped Coastal Barrier Areas (COBRA) as identified using Q3 Flood Data in the Federal Emergency Management Agency s Flood Insurance Rate Maps (FIRMs).	Federal Emergency Management Agency {1996, 1998}
SHELLFISH AREAS	Approved and Conditionally Approved Shellfish Areas.	EPA BASINS Coverage
HABITAT DIVERSITY	Index of habitat diversity indentifying the number of different habitat types within a 27 x 27 neighborhood.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07}

Layer Name	*Description*	*Data Source*
ECOREGIONS	Level III ecoregions for the conterminous United States, derived from ecoregions of the conterminous United States and from refinements of Omernik's framework that have been made for other projects.	U.S. Environmental Protection Agency; Office of Water; OST
NEGATIVE EDGE EFFECT	Urban land use and areas within 270m of urban land use.	Land Use Categories 0123 Dataset, (created from the following sources): Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} Florida Water Management Districts {1990; 1994} The Southern Appalachian Assessment (SAA) {1996; Version 3.0}
FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) - Q3 FLOOD DATA	The Q3 Flood Data are derived from the Flood Insurance Rate Maps (FIRMs) published by the Federal Emergency Management Agency (FEMA). The FIRM is the basis for floodplain management, mitigation, and insurance activities for the National Flood Insurance Program (NFIP). The Q3 Flood Data files are intended to provide users with automated flood risk data that may be used to locate Special Flood Hazard Areas (SFHAs).	Federal Emergency Management Agency {1996, 1998}

Layer Name	*Description*	*Data Source*
HYDROGRAPHIC AREAS	Natural waters, non-natural waters, wetlands, dam/canal lock, bays, estuaries, gulfs, oceans, and seas, derived from the USGS 1:100000 Digital Line Graphs (DLG3).	US Geological Survey 1:100000 Digital Line Graphs (DLG3)
QUADRANGLES OF LANDUSE/ LANDCOVER GIRAS SPATIAL DATA IN THE CONTERMINOUS U.S.	Land Use Classification.	US Environmental Protection Agency
MAJOR RIVERS	Large or otherwise significant rivers and creeks.	USGS Hydrography {1990} US Environmental Protection Agency River Reach File 3 (RF3) {1994; Version 3.0} FL Department of Environmental Protection {1989} The Conservation Fund {1998}
MRLC LAND COVER EXCLUDING ROADS	MRLC landuse classifications, excluding roads.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} Version 98-07} Tennessee Valley Authority {1999}
NON-JEEP-TRAIL ROAD DENSITY	Road densities for all non-jeep-trail roads in the 1990 TIGER road coverages.	US Bureau of the Census TIGER Roads {1990}
HIGH DENSITY OF NON-JEEP-TRAIL ROADS	Areas of high road density (greater than 3 mi/sq.mi) for all non-jeep-trail roads in the 1990 TIGER road coverages.	US Bureau of the Census TIGER Roads {1990}

Layer Name	***Description***	***Data Source***
ROADS	Roads as identified in the 1990 Tiger road coverages.	US Bureau of the Census TIGER Roads {1990}
RIPARIAN AREAS	Riparian areas within EPA Region 4, for use in creating riparian paritions and the riparian costsurface.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} USGS Hydrology {1990} USGS LUDA land use/land cover data {ranges from mid 1970s to early 1980s; Version 94} GEOPLAN Major Rivers: compiled & selected from FL DEP, EPA BASINS RF3, USGS Hydro, and US Bureau of Census TIGER/Line files.
ROADLESS AREAS	Roadless areas including wetlands, but excluding open water.	HYDROGRAPHIC AREAS GRID (US Geological Survey); ROADS GRID (US Bureau of the Census TIGER Roads {1990})
SIGNIFICANT RIPARIAN	This data set identifies areas that are considered to be significant riparian land by meeting the following criteria: 1) they are classified as native land cover in MRLC, meet a criterion of 75% density (of native landcover) in a 5 x 5 neighborhood, and are contained within a 180m stream buffer; or 2) they are classified as wetlands in MRLC and intersect a 180m stream buffer; or 3) they are classified as 100 year floodplain in FEMA.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} Federal Emergency Management Agency (FEMA) coverage, 1996 USGS Hydrology {1990}.

Layer Name	*Description*	*Data Source*
START REACHES	All reaches in region 4 which are considered to be start reaches or headwaters. Reaches were obtained from EPA River Reach File 3 (RF3).	United States Environmental Protection Agency River Reach File 3 (RF3).
MRLC LAND COVER	TVA MRLC Land used/Land cover classification.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07}
URBAN DENSITY	Areas that are made up of greater than 40% urban land uses at each of three scales: 3 x 3, 9 x 9, and 27 x 27 neighborhoods with 30 m cells.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07}
UPLAND AREAS	Upland areas within EPA Region 4. For use in creating upland paritions and the upland costsurface.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07}
WETLANDS	Wetland areas for EPA Region 4 (by state) as delineated by MRLC, USGS 1:100000 Hydrology, and by LUDA (USGS land use/land cover data)	United States Geological Survey Hydrology {1990} Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} USGS LUDA land use/land cover data {mid 1970s to early 1980s; 94}
WILD & SCENIC RIVERS	National Wild and Scenic Rivers	United States Environmental Protection Agency River Reach File 3 (RF3).

PRIORITY ECOLOGICAL AREA (PEA) LAYERS

Layer Name	*Description*	*Data Source*
CUMULATIVE PRIORITY ECOLOGICAL AREAS	Contains all of the areas that are found in any of the individual pea layers.	See individual data layer sources.
POTENTIAL BLACK BEAR HABITAT	This dataset identifies potential black bear habitat according to land cover type, forest patch size, distance from primary roads, and road density. The areas identified must be within 0-100km of occupied black bear sites.	Same as regional " BLACK BEAR HABITAT" dataset
CONSERVATION LANDS	Conservation lands within region 4, obtained from state and regional sources.	Same as regional "CONSERVATION LANDS" dataset
UNDEVELOPED COASTAL BARRIER AREA	Undeveloped Coastal Barrier Areas (COBRA) as identified using Q3 Flood Data in the Federal Emergency Management Agency s Flood Insurance Rate Maps (FIRMs). Any open water was excluded; only land was considered PEA.	Federal Emergency Management Agency {1996, 1998} USGS Hydrology {1990}
SHELLFISH AREAS	All Approved and Conditionally Approved Shellfish areas buffered by 1000 meters.	EPA BASINS Coverage
HABITAT DIVERSITY	This grid identifies areas of high habitat diversity. High habitat diversity is defined as 5 or 6 different habitat types located within a 27 x 27 neighborhood.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07}

Layer Name	*Description*	*Data Source*
FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION HOT SPOTS	The "hot spot" dataset represents native biological diversity, and was created by aggregating predictive habitat maps for wading birds, important natural communities & focal species. The original dataset consisted of values 1-26. All areas w/ values 10 and greater were designated PEAs.	Florida Game and Fresh Water Fish Commission {1990}
ELEMENT OCCURRENCE (FLORIDA, GEORGIA, ALABAMA)	Occurrences of endangered or rare plants and animals, good examples of natural communities and other ecological sites in the FNAI database. All occurrences that had a GRANK of G1, G2, or G3, or had a SRANK of S1, S2, and were observed after 1975. EOBUFF are occurrences buffered based on precision or species community type. EODEN are areas with high densities of rare species.	Florida Natural Areas Inventory Element Occurrence 1998 Georgia Natural Heritage Program Alabama Natural Heritage Program
FLORIDA NATURAL AREAS INVENTORY (FNAI) POTENTIAL NATURAL AREA	Potential Natural Areas as identified by FNAI. Natural areas identified using aerial photography and ground surveys that are of conservation significance.	Florida Natural Areas Inventory
FNAI AREAS OF CONSERVATION INTEREST	Areas of conservation interest (ACIs) as categorized by the Florida Natural Areas Inventory (FNAI). ACIs are sites that support currently unprotected examples of important natural communities and rare species.	Florida Natural Areas Inventory

Layer Name	*Description*	*Data Source*
FLORIDA FISH & WILDLIFE CONSERVATION COMMISSION STATEGIC HABITAT CONSERVATION AREAS	Includes lands outside existing protected areas needed to maintain or restore minimally viable populations of 30 focal vertebrate species, rare natural community types, important wetlands for wading birds, and globally rare plant species. Many focal species used in this analysis are umbrella species whose conservation requirements will meet the needs of other species and the natural communities identified represent a "coarse filter" approach to protect suites of species.	Florida Game and Fresh Water Fish Commission
FLORIDA AQUATIC PRESERVES	Florida aquatic preserves as compiled by Department of Environmental Protection's Florida Marine Research Institute.	University of Florida Geoplan Center Conservation Lands Dataset
HABITAT EDGE	Identifies areas that border both significant natural open habitat and forest areas.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} Game & Fish Commission Habitat Grid
LONGLEAF PINE FOREST STANDS	Mature longleaf pine forests from the Eastwide Forest Areas Inventory Dataset. Longleaf pine stands are defined as stands that are at least 50 years old.	US Forest Service - Eastwide Forest Inventory Areas
NORTH CAROLINA ANADROMOUS FISH SPAWNING AREAS	Anadromous Fish Spawning Areas, as identified by the Division of Marine Fisheries (DMF), buffered by 1000 meters.	The North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) - Division of Marine Fisheries (DMF)

Layer Name	*Description*	*Data Source*
NORTH CAROLINA COASTAL RESERVES	Coastal Reserves of North Carolina, state-owned research areas that are completely protected, buffered by 1000 meters.	The North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) - Division of Marine Fisheries (DMF)
NORTH CAROLINA FISHERIES NURSERY AREAS	Fisheries Nursery Areas (FNA) of North Carolina, buffered by 1000 meters. It includes areas where the initial post-larval and juvenile development of young finfish and crustaceans in North Carolina occurs.	The North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) - Division of Marine Fisheries (DMF)
NORTH CAROLINA LAND TRUST PRIORITIES	Areas identified by land trust organizations in the State of North Carolina as priority conservation areas.	The Conservation Fund {1998}
NORTH CAROLINA SIGNIFICANT NATURAL HERITAGE AREAS	Areas that are of national or state significance according to the North Carolina Significant Natural Heritage Areas database.	North Caroina Deptment of Natural Resources {1993-1998} - Division of Parks and Recreation, Natural Heritage Program
NATIONAL ESTUARINE RESEARCH RESERVES (NERR)	National Estuarine Research Reserves and all areas within 1 km of these reserves.	National Oceanic and Atmospheric Administration (NOAA)
OLD GROWTH FOREST STANDS	Old growth stands from the Eastwide Forest Areas Inventory Dataset. Old growth stands are defined as stands that are at least 100 years old.	US Forest Service - Eastwide Forest Inventory Areas
ROADLESS AREAS	Roadless areas that are greater than or equal to 5000 acres, excluding open water.	HYDROGRAPHIC AREAS GRID (US Geological Survey) ROADS GRID (US Bureau of the Census TIGER Roads {1990})

Layer Name	***Description***	***Data Source***
START REACHES	This grid represents areas with high start reach densities. The area of these reaches represents the top 10% of the total region 4 area.	United States Environmental Protection Agency River Reach File 3 (RF3).
WETLANDS	Wetland areas for EPA Region 4 as delineated by MRLC and USGS 1:100000 Hydrology or USGS land use/land cover data.	Same as regional "WETLANDS" dataset
WILD AND SCENIC RIVERS	All rivers designated as national Wild & Scenic Rivers, buffered by 1000 meters. Also includes 2 state designated wild and scenic rivers in Florida.	United States Environmental Protection Agency River Reach File 3 (RF3).
PRIORITY ECOLOGICAL AREAS - BUMP UP	Areas identified in SEA_SIGRIP that were also identified in at least one other SEA layer, thus satisfying the "bump up" criteria. See SEA criteria below.	See individual data layer sources.

SIGNIFICANT ECOLOGICAL AREA (SEA) LAYERS

Layer Name	*Description*	*Data Source*
CUMULATIVE SIGNIFICANT ECOLOGICAL AREAS	Contains all of the areas that are found in any of the individual SEA layers.	See individual data layer sources.
POTENTIAL BLACK BEAR HABITAT	Potential black bear habitat according to land cover type, forest patch size, distance from primary roads, and road density. The areas identified must be within 100-140km of occupied black bear sites.	Same as regional "BLACK BEAR HABITAT" dataset
HABITAT DIVERSITY	Areas of high, but not highest habitat diversity. Areas of highest habitat diversity are respresented in the PEA Habitat Diversity Grid. Areas within this grid are defined as areas that have 4 different habitat types within a 27 x 27 neighborhood with 90 meter cells.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07}
FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION HOT SPOTS	The "hot spot" data set represents native biological diversity, and was created by aggregating predictive habitat maps for wading birds, important natural communities, and focal species. The original dataset consisted of values 1-26. All areas with values 6-9 were designated secondary ecological area.	Florida Game and Fresh Water Fish Commission {1990}
NORTH CAROLINA SIGNIFICANT NATURAL HERITAGE AREAS	Areas of regional significance according to the North Carolina Significant Natural Heritage Areas database.	North Caroina Deptment of Natural Resources {1993-1998} - Division of Parks and Recreation, Natural Heritage Program

Layer Name	***Description***	***Data Source***
ROADLESS AREAS	Roadless areas of at least 2500 acres and less than 5000 acres, excluding open water.	HYDROGRAPHIC AREAS GRID (US Geological Survey) ROADS GRID (US Bureau of the Census TIGER Roads {1990})
SIGNIFICANT RIPARIAN	This data set identifies areas that are considered to be significant riparian land by meeting the following criteria: 1) they are classified as native land cover in MRLC, meet a criterion of 75% density (of natural/semi-natural landcover) in a 5 x 5 neighborhood, and are contained within a 180m stream buffer; or 2) they are classified as wetlands in MRLC and intersect a 180m stream buffer; or 3) they are classified as 100 year floodplain in FEMA.	Tennessee Valley Authority MRLC Landsat thematic mapper (TM) {1991, 1992, 1993; Version 98-07} Federal Emergency Management Agency (FEMA) coverage, 1996 USGS Hydrology {1990}.
START REACHES	Areas of high start reach densities, defined as the top 10% in each ecoregion of EPA Region 4.	United States Environmental Protection Agency River Reach File 3 (RF3).

HUB AND ECOLOGICAL FRAMEWORK LAYERS

Layer Name	***Description***	***Data Source***
PRIORITY ECOLOGICAL AREAS, EXCLUDING UNSUITABLE LAND USES	Cumulative PEA grid, excluding urban land uses and intensive agricultural lands identified in R4_CAT123, high road density (greater than 3 miles/square mile), areas within 270 meters of urban land uses, or areas with high densities of urban land uses.	Not Applicable: See Model Outline for further information.
PRIORITY ECOLOGICAL AREAS, SIZE CLASS 1	Post exclusion PEA's that are 2000 to 5000 acres.	Not Applicable: See Model Outline for further information.
HUBS	Post exclusion PEA's that are 5000 acres or larger.	Not Applicable: See Model Outline for further information.
OPTIMIZED HUBS	These are the Hubs optimized through a process that includes smoothing boundaries with the expand and shrink functions and filling holes of less than 25000 acres.	Not Applicable: See Model Outline for further information.
ECOLOGICAL FRAMEWORK	Final model results with all optimized hubs and optimized linkages added together.	Not Applicable: See Model Outline for further information.
FINAL OPTIMIZED FRAMEWORK	Ecological framework after optmization process, which includes smoothing edges, adding in connected PEAs, and filling in gaps and holes with suitable land uses.	Not Applicable: See Model Outline for further information.

TABLE 2: DATA LAYER METHODS & ATTRIBUTE DESCRIPTIONS

REGIONAL LAND USE			
Grid Name	***Component Layers***	***Cell Size***	***Attribute Description***
TVA_MRLC30	MRLC (30m x 30m)	30m x 30m	See metadata
R4_NEWMRLC	MRLC (30m x 30m)	30m x 30m	See metadata
R4_MRLC90	MRLC (30m x 30m)		See metadata
R4_HYLUSE	MRLC (30m x 30m) SAA land cover (1:100,000) FL WMD land use (1:40,000)	30m x 30m	See metadata
R4_LUDA	USGS / EPA (1:250,000)	100m x 100m	See metadata
R4_CAT123	MRLC (30m x 30m) SAA land cover (1:100,000) FL WMD land use (1:40,000)	30m x 30m	0 = water, forest, or wetlands 1 = bare or exposed areas, deciduous scrub, or grassland 2 = extractive or agriculture 3 = residential or commercial
R4_CAT123_90	MRLC (30m x 30m) SAA land cover (1:100,000) FL WMD land use (1:40,000)	30m x 30m	0 = water, forest, or wetlands 1 = bare or exposed areas, deciduous scrub, or grassland 2 = extractive or agriculture 3 = residential or commercial
R4_TVA_URBDEN	TVA DATA, urb_den3 urb_den9, urb_den27 30m x 30m	30m x 30m	0 = less than 40% of surrounding 2, 18, and 162 acres is urban 1 = more than 40% of surrounding 2, 18, and 162 acres is urban

Grid Name	*Component Layers*	*Cell Size*	*Attribute Description*
R4_EDGE	MRLC (30m x 30m) SAA land cover (1:100,000) FL WMD land use (1:40,000)	90m x 90m	0 = other 1 = within 270m of urban land use
R4_CLAN	See metadata	30m x 30m	0 = other 1 = existing conservation land 2 = proposed conservation land
R4_CITY	EPA	30m x 30m	0 = other 1 = within city boundaries
REGIONAL HYDROLOGY			
R4_HYPOLY	USGS hydrology 1:100,000	30m x 30m	0 = other 1 = natural waters 2 = non-natural waters 3 = wetlands 4 = dam/canal lock 5 = bays, estuaries, gulfs, ocean, seas
R4_MJRIV	EPA Basins RF3, USGS hydrology, TFC (1:100,000) FL DEP (unknown resolution)	30m x 30m	0 = other 1 = major river
R4_WSRIV	EPA Basins RF3 (1:100,000)	30m x 30m	0 = other 1 = wild and scenic river
R4_STREACH	EPA Basins RF3 (1:100,000)	30m x 30m	0 = other 1 = wild and scenic river

Grid Name	*Component Layers*	*Cell Size*	*Attribute Description*
R4_FEMA	FEMA 1:24,000	30m x 30m	0 = other 1 = 100 year flood plain (SFHA) 10 = COBRA 11 = SFHA and COBRA 100 = county data not available
R4_COBRA	FEMA 1:24,000	30m x 30m	0 = other 1 = COBRA (undeveloped coastal barrier area)
R4_WETLANDS	MRLC (30m x 30m) USGS hydrology (1:100,000) USGS / EPA (1:250,000)	30m x 30m	0 = other 1 = wetland
R4_CSA	EPA basins rf3 1:100,000	90m x 90m	0 = other 1 = approved or conditionally approved shellfish harvest area
R4_SIGRIP	MRLC (30m x 30m) FEMA (1:24,000) USGS hydrology (1:100,000)	30m x 30m	0 = other 1 = significant riparian area
R4_RIP90	MRLC (30m x 30m) EPA Basins RF3 USGS hydrology GEOPLAN major rivers 1:100,000 USGS land use (1:100,000)	90m x 90m	0 = other 1 = riparian habitat

REGIONAL ROADS

Grid Name	***Component Layers***	***Cell Size***	***Attribute Description***
R4_RDGRD	TIGER roads 1:100,000	30m x 30m	0 = excluded 1 = primary road 2 = secondary 3 = local or teriary 5 = jeep trail 77 = utilities 88 = rails 99 = other
R4_ALLDENS R4_NJPDENS	TIGER roads 1:100,000	30m x 30m	1 = area has < 0.5 mi/sq mi roads 2 = 0.5 - 1.0 3 = 1.0 - 1.5 4 = 1.5 - 2.0 5 = 2.0 - 2.5 6 = 2.5 - 3.0 7 = area has > 3.0 mi/sq mi roads
R4_RDLSS	TIGER roads 1:100,000 USGS hydrology 1:100,000	30m x 30m	0 = roads 1 = areas not intersected by roads

REGIONAL BIODIVERSITY

Grid Name	***Component Layers***	***Cell Size***	***Attribute Description***
R4_ECOREG	EPA / Omernik 1:250,000	90m x 90m	See metadata
R4_DIV	MRLC 30m x 30m	90m x 90m	0-6 = Number of habitat types in surrounding 162 acre neighborhood
R4_UP90	MRLC 30m x 30m	90m x 90m	0 = other 1 = upland habitat
R4_BBHAB	MRLC 30m x 30m TIGER roads 1:100,000	30m x 30m	0 = other 1 = potential black bear habitat
R4_BBSITE	Maehr, DS Cox, JA Pelton, MR Wooding, JB	30m x 30m	0 = other 1 = known black bear populations
R4_BBBUF	Maehr, DS Cox, JA Pelton, MR Wooding, JB	30m x 30m	0 = other 1 = black bear sites buffered by 100km 2 = areas 100-140km from black bear sites

PEAS IDENTIFIED IN PREVIOUS RESOURCE ASSESSMENTS			
Grid Name	***Component Layers***	***Cell Size***	***Attribute Description***
PEA_CLAN	See metadata	90m x 90m	0 = other 1 = existing conservation land 2 = proposed conservation land
PEA_EOBUF	FNAI Heritage GA DNR Heritage AL DCNR Heritage	90m x 90m	0 = other 1 = areas with high density of element occurrences that satisfied specific rank, accuracy, & date criteria
PEA_EODEN	FNAI Heritage GA DNR Heritage AL DCNR Heritage	90m x 90m	0 = other 1 = buffered occurrences that satisfied specific rank, accuracy, & date criteria
PEA_NCLTRUST	TCF 1:100,000	90m x 90m	0 = other 1 = land trust priority conservation area
PEA_NCSNHA	NC DENR Heritage 1:24,000	90m x 90m	0 = other 1 = areas of national or state significance
PEA_FLACI	FNAI Heritage 1:230,000	90m x 90m	0 = other 1 = area of conservation interest
PEA_FLPNA	FNAI Heritage 1:230,000	90m x 90m	0 = other 1 = priority rank 1-4
PEA_FLSHCA	FL FWCC	90m x 90m	0 = other 1 = strategic habitat conservation area

Grid Name	***Component Layers***	***Cell Size***	***Attribute Description***
PEA_GFCHOT	FL FWCC	90m x 90m	0 = other 1 = values 10 and greater in FL GFC hot spots dataset
PEA_FLAQUATIC	See metadata	90m x 90m	0 = other 1 = aquatic preserve 2 = 1km buffer around aquatic preserve
PEA TERRESTRIAL			
PEA_DIV	MRLC 30m x 30m	90m x 90m	5-6 = Number of habitat types in surrounding 162 acre neighborhood
PEA_HABEDGE	MRLC (30m x 30m) FL FWCC habitat (35m x 35m)	90m x 90m	0 = other 1 = open / forested habitat edge
PEA_OLDSTAND	USFS FIA (Forest Inventory Analysis)	90m x 90m	0 = other 1 = stand age 100+ years
PEA_LONGLEAF	USFS FIA (Forest Inventory Analysis)	90m x 90m	0 = other 1 = stand age 50+ years & 50+% of sampled trees were longleaf pine
PEA_RDLSS	TIGER roads (1:100,000) USGS hydrology (1:100,000)	90m x 90m	0 = roads 1 = 5000+ acre areas, excluding open water, not intersected by roads
PEA_BBHAB	MRLC (30m x 30m) TIGER roads (1:100,000) Maehr, DS Cox, JA Pelton, MR Wooding, JB	90m x 90m	0 = other 1 = potential black bear habitat within 100km of known black bear populations

PEA HYDROLOGY

Grid Name	*Component Layers*	*Cell Size*	*Attribute Description*
PEA_WSRIV	EPA basins rf3 1:100,000	90m x 90m	0 = other 1 = wild and scenic river
PEA_STREACH	MRLC (30m x 30m) EPA Basins RF3 (1:100,000)	90m x 90m	0 = other 1 = area of high start reach density
PEA_WETLANDS	MRLC (30m x 30m) USGS hydrology (1:100,000) USGS / EPA (1:250,000)	90m x 90m	0 = other 1 = wetland
PEA_COBRA	FEMA (1:24,000)	90m x 90m	0 = other 1 = COBRA (undeveloped coastal barrier area)
PEA_CSA	EPA Basins RF3 (1:100,000)	90m x 90m	0 = other 1 = approved or conditionally approved shellfish harvest area
PEA_NERR	NOAA (1:24,000)	90m x 90m	0 = other 1 = national estuarine research reserve (NERR) 2 = within 1km of NERR
PEA_NCAFSA	NC DEHNR - DMF 1:100,000	90m x 90m	0 = other 1 = anadromous fish spawning areas (AFSA) 2 = within 1km of AFSA
PEA_NCCOASTR	NC DEHNR - DMF 1:24,000	90m x 90m	0 = other 1 = anadromous fish spawning areas (AFSA) 2 = within 1km of AFSA

Grid Name	*Component Layers*	*Cell Size*	*Attribute Description*
PEA_NCFNA	NC DEHNR - DMF 1:24,000	90m x 90m	0 = other 1 = fish nursery 2 = within 1km of fish nursery
PEA_BUMPUP	ALL SEA LAYERS	90m x 90m	0 = other 1 = area identified in SEA_SIGRIP and 1+ other SEA layers
PEA_ALL	ALL PEA LAYERS	90m x 90m	0 = other 1 = if an area occurs in any PEA layer, it is considered a priority ecological area
PEA_ADD	ALL PEA LAYERS	90m x 90m	0 = other 1-13 = number of PEA layers calculated for each cell
PEA_ADDX	ALL PEA LAYERS	90m x 90m	0 = other 1-13 = number of post exclusion PEA layers calculated for each cell
SEA IDENTIFIED IN PREVIOUS RESOURCE ASSESSMENTS			
SEA_GFCHOT	FL FWCC	90m x 90m	0 = other 1 = values 6-9 in FL GFC hot spots dataset
SEA_FLPNA	FNAI Heritage 1:230,000	90m x 90m	0 = other 1 = priority rank 5
SEA_NCSNHA	NC DENR Heritage 1:24,000	90m x 90m	0 = other 1 = areas of regional significance

SEA TERRESTRIAL

Grid Name	***Component Layers***	***Cell Size***	***Attribute Description***
SEA_BBHAB	MRLC (30m x 30m) TIGER roads (1:100,000) Maehr, DS, Cox, JA, Pelton, MR, Wooding, JB	90m x 90m	0 = other 1 = potential black bear habitat 100-140km from known black bear populations
SEA_DIV	MRLC 30m x 30m	90m x 90m	4 = Number of habitat types in surrounding 162 acre neighborhood
SEA_RDLSS	TIGER roads (1:100,000) USGS hydrology (1:100,000)	90m x 90m	0 = roads 1 = 2500-5000 acre areas, excluding open water, not intersected by roads
SEA HYDROLOGY			
SEA_SIGRIP	MRLC (30m x 30m) FEMA (1:24,000) USGS hydrology (1:100,000)	30m x 30m	0 = other 1 = significant riparian area
SEA_STREACH	MRLC (30m x 30m) EPA basins RF3 (1:100,000)	90m x 90m	0 = other 1 = area of high start reach density
SEA_ALL	ALL SEA LAYERS	90m x 90m	0 = other 1 = if an area occurs in any SEA layer it is considered a significant ecological area

Appendix D: SEF Prioritization Methods Summary

I. Regional Prioritizations
    A. Ecosystem Services
        1. Surficial Aquifer Areas Vulnerable to Pollution
        2. Size & Proximity to Wetlands
        3. Surface Water Source Priorities
        4. Ground Water Priorities
        5. Major and Wild & Scenic Rivers Buffers
        6. Coastal Storm Protection Areas
        7. Proximity to Shellfish Harvesting Areas

    B. Biodiversity
        1. Size & Proximity to Conservation Lands
        2. Interior Forests
        3. Old Growth and Significant Longleaf Pine Forest Stands
        4. Imperiled Species Priority Areas
        5. Listed Species Priority Areas
        6. At-risk Aquatic Species by Watersheds (HUCs)
        7. Critical Watersheds for Aquatic Biodiversity
        8. Black Bear Habitat Suitability Analysis
        9. PEA Size Classification

    C. Threats
        1. Context Analysis
        2. Urban Growth Pressure Model

    D. Recreation Potential

II. Hub Prioritizations

    A. Ecosystem Services
        1. Number of Stream Start Reaches per Hub
        2. Percent Wetlands per Hub
        3. Percent Uplands per Hub
        4. Spatial Mix of Wetlands and Uplands by Percent in Hubs
        5. Surficial Aquifer Areas Vulnerable to Pollution by Hub
        6. Size & Proximity to Wetlands by Hub
        7. Coastal Storm Protection Areas by Hub
        8. Major and Wild & Scenic Rivers Buffers by Hub
        9. Shellfish Harvesting Areas Buffers by Hub

    B. Biodiversity
        1. Topographic Diversity

    2. Size & Proximity to Conservation Lands
    3. Black Bear Habitat Suitability Analysis
    4. Interior Forests by Hub
    5. PEA Size Classification
    6. Imperiled Species Priorities by Hub
    7. Listed Species Priorities by Hub
    8. At-risk Aquatic Species by Watershed
    9. Critical Aquatic Biodiversity Watersheds

C. Threats
    1. Landscape Viability Context Index
    2. Urban Growth Pressure Model

D. Recreation Potential
    1. Influence of Urban Areas
    2. Influence of Public Lands
    3. Influence of Water Based Recreation
    4. Influence of Points of Interest

E. Hub Function & Structure
    1. Internal Gaps/ Hub Density
    2. Internal Context: Percent PEA
    3. Internal Context: Percent SEA
    4. Hub Land Use Context Index
    5. External Context: Land Use
    6. External Context: Percent PEA
    7. External Context: Percent SEA
    8. Hub Total Area Index
    9. Hub Core Area Index
    10. Hub Core Roadless Area Index
    11. Perimeter of Circle to Perimeter of Patch (Hub)
    12. Perimeter to Area Ratio
    13. Amount of Roads per Hub

III. Linkage Prioritizations

Separating Linkages into Discrete Segments

A. Internal Context Analyses
    1. Internal Context: Percent PEA
    2. Internal Context: Percent SEA
    3. Internal Context: Percent of Primary and Secondary Roads
    4. Internal Land Use Context

B. External Context Analyses
    1. External Context: PEAs
    2. External Context: SEAs
    3. External Context: Land Use

C. Width Analysis
    1. Perimeter to Area Ratio
    2. Density

D. Hub Ranks
    1. Prioritizing Linkages by Hub Priority Rank

I. REGIONAL PRIORITIZATIONS

A. REGIONAL ECOSYSTEM SERVICES

Ecosystem or ecological services are ecological processes and functions provided by natural and semi-natural areas that help sustain or enhance human life (Daily 1997). Primary ecosystem services include water and air protection and purification, flood and storm protection, functional nutrient cycling, etc. The ecosystem service prioritizations are based on available data and techniques. Other analyses including water and air purification assessments could be added in future iterations.

1. Surficial Aquifer Areas Vulnerable to Pollution

U.S. Environmental Protection Agency (USEPA) and the National Water Well Association (NWWA) developed a method to map potential aquifer vulnerability to pollution. The analysis, referred to by the acronym DRASTIC, depicts areas which are more or less sensitive to land use changes which may affect ground water quality. The analysis is composed of eight individually mapped hydrogeological parameters. Seven of these parameters (depth to water - D, net recharge - R, aquifer media - A, soil media - S, topography - T, impact of the vadose zone - I and hydraulic conductivity - C) are used to derive the DRASTIC summary index score (Aller et al. 1987).

This prioritization identifies areas in the region that are most vulnerable to surficial aquifer pollution, and hence most important for protecting ground water. A regional DRASTIC analysis, created by EPA Region 4 Planning & Analysis Branch, was used to delineate these vulnerable areas. The DRASTIC summary index score was reclassified into 1-10 ranks by equal interval, with one representing aquifer areas least vulnerable to pollution, and ten representing areas most vulnerable.

2. Size & Proximity to Wetlands

Functional wetland systems are important for protecting (drinking) water resources as they operate as a natural filter, trapping sediments and toxins from water before it percolates into the aquifer. Larger wetland areas are arguably more important for protecting water resources, as they retain the ability to filter larger volumes of water. Areas adjacent to wetlands are also important in moderating edge effects from neighboring intensive land uses, and offering additional filtering functions.

This analysis aims at identifying those larger wetlands and adjacent areas, and giving those areas a higher priority rank. Wetland areas were first grouped into categories based on their size. Each size category was then buffered between 90 and 810 meters, with the largest wetland size class being buffered the greatest distance and the smallest wetland size class buffered the least. Each buffer zone was then reclassified into ranks which represent the priority of that area in proximity to the wetland. The result was a dataset of areas ranked from 1-10, where ten represents large wetlands or areas in close proximity to large wetlands, and one represents smaller wetlands or areas in proximity to smaller wetlands. For more details on the ranking system or size classification, see the Technical Methods in Appendix E.

3. Surface Water Source Priorities

As a basic assessment of priority areas surrounding surface water sources for potable water, surface water intake points obtained from EPA were prioritized using population numbers associated with each surface water source point. Surface water intake points were buffered by 5 miles to indicate a potential area of influence around the intake point. The buffered points were then separated into 10 priority classes based on the population served by the intake point. Although this analysis can serve as a coarse indicator of relative priority areas for protecting surface drinking water sources, a more specific analysis requiring the identification of all upstream watercourses above intake points would greatly increase the scope and specificity of this analysis. However, the analysis does indicate immediate areas of interest around surface water intake points prioritized by the size of the population served.

4. Ground Water Source Priorities

As a coarse assessment of priority buffer areas adjacent to ground water sources, ground water intake points obtained from EPA were prioritized by a proximity analysis. Ground water intake points were all buffered by 1 mile. The buffer zone was then separated into nine equal intervals and assigned ranks of 10 to 2 based on proximity to the intake point. All areas more than a mile from an intake point were assigned a rank of 1.

5. Major and Wild and Scenic River Buffers

Protection of riparian zones and additional upland buffers around rivers should be a high priority. To indicate the significance of areas adjacent to rivers within Region 4, all major rivers and Wild and Scenic Rivers were buffered by approximately 2500 meters on each side. The buffers were then separated into nine equal intervals and assigned ranks of 10 to 2 based on proximity to the river. All areas beyond the buffer were assigned a rank of 1. Major rivers were the same as those used in the riparian corridor analysis in the development of the Southeastern Ecological Framework.

6. Coastal Storm Protection Areas

Intact natural and semi-natural land cover within coastal areas can be important for minimizing storm damage related to coastal storms and especially hurricanes. As a surrogate for more specific FEMA data on coastal surge and flood areas, an analysis was created which identified all natural and semi-natural landcover in coastal areas and prioritized these areas by size. Natural and semi-natural cover classes within 10 kilometers of coastal water bodies were identified. These areas were then separated into 9 priority size classes ranging from 2 to 118,773 acres using equal intervals with the largest areas receiving the highest ranks. All other areas within the region were assigned a rank of 1.

7. Shellfish Harvest Area Buffers

Approved coastal shellfish harvest areas must meet certain water quality standards to remain open to harvest. Although water quality within estuaries is dependent on all freshwater inflows, immediate buffer zones adjacent to estuaries harboring shellfish harvest waters are also important for maintaining water quality. This prioritization analysis identifies all areas designated as approved or conditionally approved shellfish harvest areas and buffers them by 5000 meters. The entire region was then separated into 10 priority levels based on proximity to these shellfish harvest zones. The approved and conditionally approved shellfish harvest areas were assigned a rank of 10 and then adjacent areas were ranked from 9 to 2 in 625 meter intervals with areas closest receiving the higher ranks. Areas greater than 5000 meters from approved and conditionally approved shellfish harvest areas were assigned a rank of 1.

B. REGIONAL BIODIVERSITY PRIORITIZATIONS

Biodiversity can be defined as the variety of life including genes, species, natural communities, and landscapes. Biodiversity is threatened by factors including habitat loss and fragmentation, negative ecological impacts associated with intensive land uses, alien or weedy species, etc. (Meffe and Carroll 1997). The following prioritizations all contain assessments relevant to identifying areas that are potentially most important for conserving biodiversity. This includes some information on areas containing the most species of conservation significance and areas that are most likely to support viable opportunities to conserve biodiversity. However, additional data on locations of species of conservation interest and natural communities and the identification of areas most important for conserving viable populations of such species will be important to enhance future iterations.

1. Conservation Lands Size Classes and Proximity

Existing public conservation lands and private preserves are focal areas for efforts to conserve biological diversity in most regions. As land transformation to agricultural, suburban, urban, and industrial uses continues on private lands, conservation lands become increasingly important for harboring intact natural communities and other components of biodiversity including listed species. Also, the theory and practice of reserve design for conserving biodiversity demonstrate that larger conservation areas will often have a better opportunity to maintain intact ecosystems with functional processes. Therefore, these areas are more likely to contain viable populations of species of conservation interest and to conserve biodiversity into the future. In addition, areas adjacent to existing public conservation lands and private preserves are very significant for effective conservation planning. Such lands can provide functional buffers for conservation lands, provide additional habitat for species of conservation interest, especially wide-ranging species, or can provide corridors or landscape linkages connecting existing conservation areas.

Existing conservation lands and adjacent areas were prioritized based on both the size of the existing conservation area and proximity to these conservation areas. Larger conservation areas were assigned a higher priority and areas closer to larger conservation areas were assigned a higher priority as well. Conservation areas were separated into 8 size classes. These size classes were then buffered between 540 to 4320 meters with the largest size class of conservation lands buffered the greatest distance and the smallest size class buffered the least. The resulting grid assigns values ranging from 10 to 1, with areas within large or near large conservation areas getting the highest ranks and with very small conservation lands, areas near very small conservation lands, and areas far from all conservation lands receiving the lowest ranks. For more details on the combined ranking system based on both the size of existing conservation lands and proximity to these conservation lands, see the Technical Methods in Appendix E.

2. Interior Forests

Interior forests are critical for conserving forest interior species and other forest dependent species including species that require large blocks of intact forest. Interior forests can be defined as forested lands that are sufficiently buffered from external effects or negative edge effects to provide intact forest habitat with interior conditions that are not edge-influenced. Forest type is potentially another important consideration. Forest interior habitat is especially important for various neotropical migrant birds. Such bird species are more prevalent within the deciduous hardwood and mixed forests in the northern two-thirds of the region especially within the Piedmont, Appalachian, and Plateau ecoregions. However, forest interior conditions may be important in other areas as well including pine forest in the coastal plain. Also, the National Land Cover Data set (NLCD) does not allow for an accurate delineation of intensive silvicultural areas including pine plantations in the Coastal Plain and Piedmont ecoregions. Such plantation forestry will frequently not provide the intact forest structure necessary to establish or maintain forest interior habitat. However, due to the inability to adequately identify such plantations throughout the region, all forest cover was included as an input in this prioritization analysis. Future data sets including landcover data from the federal GAP Analysis project may allow for the identification of plantation forestry to enhance this analysis in the near future.

The development of the forest interior patches involved several steps. First land uses expected to generate significant negative edge effects were identified including urban, residential, and agricultural land uses. Such land uses were then separated into three size classes using only patches 10 acres or larger. The three size classes were then buffered either 100, 300, or 1000 meters, with the largest patch size class buffered the greatest distance. This differential buffering was used to simulate the potential distance of negative edge effects based on the assumption that larger areas of land uses that generate negative external influences will result in negative edge effects further into forest patches. Primary, secondary, and tertiary roads (Class 3 and Class 4 roads combined) were also buffered by 300, 200, and 100 meters respectively. This differential buffering is based on the assumption that wider roads with more traffic will generate more negative edge effects over a greater distance. These buffered areas representing zones of influence near land uses resulting in negative edge effects were then “subtracted” from the forest cover data.

Finally, a density or neighborhood analysis was also run that identified square kilometer areas that had less that 25% intensive land uses and at least 75% forest cover.

Any forest areas that did not meet this additional condition were also removed. The remaining forest patches were then separated into 9 size classes ranging from greater than 100 acres to greater than 100,000 acres and were ranked from 2 to 10, with the largest patches receiving the highest rank. All remaining areas within the region were assigned a value of 1.

3. Old Growth and Significant Longleaf Pine Forest Stands

Old growth forest and significant longleaf pine stands were identified using Forest Inventory Assessment (FIA) data as part of the Priority Ecological Area analysis for the Southeastern Ecological Framework. These old growth and significant longleaf pine stands were assigned a value of 10 and all other cells within the region were given a value of 1.

4. Imperiled Species Priority Areas

As part of the book, *Precious Heritage: the Status of Biodiversity in the United States*, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). Their imperiled species analysis used the Environmental Protection Agency's EMAP hexagons (648.7 square kilometers) as a base unit to summarize the distribution of imperiled species across the United States. Imperiled species were defined as species that are either critically imperiled (G1) or imperiled (G2) using the natural heritage G rank classification system. These data contained the number of imperiled species found in each EMAP hexagon. The prioritization analysis was created by converting the EMAP hexagon data into a grid and then assigning priorities based on the number of imperiled species found in each area. Equal area slices were used to create priority levels ranging from 1 to 10, with areas containing no imperiled species receiving a priority rank of 1 and areas with 13 or more imperiled species receiving a rank of 10. For more details on the priority ranking distribution, see the Technical Methods in Appendix E.

5. Listed Species Priority Areas

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). Their analysis of federally listed species used the Environmental Protection Agency's EMAP hexagons (648.7 square kilometers) as a base unit to summarize the occurrence of listed species across the United States. This data contained the number of listed species found in each EMAP hexagon. The prioritization analysis was created by converting the EMAP hexagon data into a grid and then assigning priorities based on the number of listed species found in each area. Equal area slices were used to create priority levels ranging from 1 to 10, with areas containing no listed species receiving a priority rank of 1 and areas with 12 or more listed species receiving a rank of 10. For more details on the priority ranking distribution, see the Technical Methods in Appendix E.

6. At-Risk Aquatic Species by Watersheds (HUCs)

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). The analysis of aquatic biodiversity was based on assessing the number of G1, G2, G3 aquatic species (fish and mussels only) found within watersheds represented by the U.S. Geologic Survey's eight digit Hydrologic Cataloguing Unit (HUC). The prioritization analysis was created by converting the HUC-based data into a grid and then assigning priorities based on the number of listed species found in each area. Equal area slices were used to create priority levels ranging from 1 to 10, with areas containing no at risk aquatic species receiving a priority rank of 1 and areas with 18 or more at risk aquatic species receiving a rank of 10. For more details on the priority ranking distribution, see the Technical Methods in Appendix E.

7. Critical Watersheds for Aquatic Biodiversity

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). The critical watersheds analysis identified all of the watersheds (based on eight digits HUCs) needed to contain all fish and mussels species found in the natural heritage database. This included identification of at least two watersheds for each species to ensure some redundancy and the inclusion of at least one watershed for each of 63 eccoregions in the continental United States. The prioritization analysis based on the critical watershed analysis was a simple reclassification, where all critical watersheds were assigned a rank of 10 and all other areas within the region were given a 1.

8. Black Bear Habitat Suitability Analysis

This analysis creates a cumulative index of habitat suitability for Black Bears (*Ursus americanus*) in EPA's Region 4. The purpose of this analysis is to identify potentially significant habitat blocks and landscape linkages to promote long term viability of black bear within the Southeastern United States. There are 11 individual analyses indicating relative significance for black bear habitat potential that are then combined into a single, cumulative index:

8.1. Potential Primary, Secondary and Tertiary Habitat

This dataset identifies and ranks land use/land cover based on categorizations of habitat based on black bear presence and use of habitats (see Cox et al. 1994). Potential primary habitat were all patches of evergreen, deciduous and mixed forests and woody wetlands from the National Land Cover Data (NLCD). Secondary habitat was comprised of deciduous shrubland and transitional lands. Tertiary habitat was comprised of grassland/herbaceous and emergent herbaceous wetland communities.

8.2. Potential Core Black Bear Habitat

This dataset is used to identify potential core black bear areas. Potential core black bear habitat was identified by first selecting patches of potential primary habitat greater than 37 acres (per Mykytka and Pelton 1989) where such habitat patches were found to be important components of black bear habitat in Osceola National Forest, Florida. After those patches were selected, a one kilometer buffer was created to surround these patches. Then, any primary or secondary habitat patches within the one kilometer buffer were selected and combined with the 37 acre or greater habitat patches. From this point, urban areas and hydrological features were removed from consideration for core black bear areas.

A focal sum analysis was then performed to measure the density of the habitat patches to be considered as core areas in 1 square kilometer neighborhoods. To increase selectivity of lands to be considered as core black bear areas, only those lands with greater than 89% density of primary potential habitat were selected. Then, to further validate applicability of this model, only the areas with the selected density and within existing conservation lands were considered.

Next, areas greater than 100,000 acres were identified. Then, to make sure that the areas just defined fell in close proximity to the bear population areas in the southeastern United States delineated in the grid "r4_bbsitesf" (which is based on bear population and range data combined from two sources: Maehr 1984; Wooding et al. 1994) only primary habitat areas meeting the above criteria that were also within 100 kilometers of known bear populations were kept.

8.3. Distance from Potential Core Black Bear Habitat

A dataset to determine proximity to the identified potential core areas was created. Potential core areas were buffered by 100 kilometers, and the buffer areas were split into 10 kilometer intervals. Each distance interval was assigned a priority rank from 1 to 10, in which the closer the proximity to core habitat areas, the higher the rank.

8.4. Ranking roadless areas based on size classes and percentage of primary habitat contained within

This dataset identified roadless areas ranked based on the percentage of potential primary black bear habitat contained within roadless areas of different size classes. Primary habitat patches were separated with roads to better define contiguous blocks of habitat. Then, roadless areas were identified in three size classes: 2,500 acres or larger, 5,000 acres or larger, and 10,000 acres or larger. These roadless areas were then ranked based on the varying amounts of habitats contained within the roadless blocks in three classes: 10-40%, 40-70% and greater than 70% potential primary black bear habitat. The largest roadless areas with the highest percentage of primary habitat received the highest rank.

8.5. Diversity of Habitats

The first step to develop a black bear habitat diversity index involved classifying potential habitats into four categories: forested wetlands, forested uplands, freshwater and saltwater marshes, and low stature open brush lands. Since black bear habitat may be higher quality in areas with a greater diversity of natural habitat types (see Pelton 1986, Mollohan and LeCount 1989, Maehr and Wooding 1992), a diversity analysis using a one square mile neighborhood was conducted on this categorized grid using the four land cover types. The habitats were based on the NLCD data:

Habitat Category	NLCD Value	NLCD Description
Forested wetlands	91	Woody wetlands
Forested uplands	41	Evergreen Forest
	42	Deciduous Forest
	43	Mixed Forest
Freshwater marsh	71	Grassland/Herbaceous
	92	Emergent Herbaceous
Open brush lands	55	Shrub and brushland
	33	Transitional

Areas that contained all 4 major habitat categories received the highest ranks and areas with no habitat received the lowest rank.

8.6. Land use intensity

The purpose of this dataset is to rank lands based on land use intensity. A ranked grid was created where high intensity land uses (urban and residential land uses), moderate intensity land uses (most agricultural and extractive land uses), low intensity land uses (bare or exposed Areas, deciduous shrub, or grassland), and natural and semi-natural cover (water, forests, or wetlands) were separated into 4 ranked classes where natural/semi-natural areas received the highest rank and intensive land uses received the lowest.

8.7. Distance from intensive land uses greater than 100 acres in size

Areas of high intensity land use 100 acres or greater were identified. Distance from these areas was then calculated where areas furthest away from intensive land uses received the best ranks. Areas within 100 meters of intensive land uses were assigned a rank of 1, areas between 100 and 500 meters were assigned a 2, and lands 500 to 1000 meters away were given a 3. From this point, areas were ranked as distance from intensive land uses increased in 1000 meter increments until a value of 10 was reached.

8.8. Distance from Primary roads

Distance from primary roads from 1:100,000 Tiger roads data set was calculated and a data layer was created where areas furthest from such roads were ranked highest. Areas within 100 meters of primary roads were assigned a 1, areas between 100 and 500 meters were assigned a 2, and lands 500 to 1000 meters away from primary roads were given a 3. From this point, areas were increasingly ranked as distance from the primary roads increased in 1000 meter increments until a value of 10 was reached.

8.9. Conservation lands

Using a dataset of all public and private conservation lands in the southeast, existing and proposed conservation lands were identified and ranked. Conservation lands were assigned a rank of 10 and all other lands received a 1.

8.10. Road density grid

This dataset contains a ranking of areas based on their road density excluding Class 5 roads from the 1:100,000 Tiger roads data. Areas less than or equal to 0.5 miles/sq. mile were given the highest value and areas with a road density of 3.0 miles/sq. mile or greater were given the lowest value.

8.11. Potential primary habitat in size classes

This dataset identifies potential primary habitat in size classes using the original primary habitat identified for determining prime potential bear habitat (see Black Bear Potential Core Areas) and then separated by primary roads. Ranks were based on size classes for habitat blocks ranging from 10,000 acres to greater than 500,000 acres, with the largest blocks over 500,000 acres receiving the highest ranks.

BEAR FINAL PROCESSING

Each grid was weighted based on knowledge of black bear biology and management and the scientific literature (Tom Hoctor, personal communication) and then combined to create a MUA prioritizing areas based on their potential landscape-level habitat qaulity for the black bear. This data layer was then further refined in two steps to more conservatively assess areas of potential habitat significance. First, the combined grid was modified to include higher ranked areas only within 140 kilometers of known black bear population areas (based on maximal bear dispersal distances), and all areas outside this buffer distance were assigned the lowest rank of 1. Next, this data set was further refined by maintaining higher rankings for only potential habitat cover types discussed above, and all other areas not supporting potential habitat were assigned a rank of 1. This data layer was the version used when creating the combined biodiversity MUA discussed below. For more information on the eleven input analyses and the combination of them to create the final prioritization, see the Technical Methods in Appendix E.

9. Size Classification of Priority Ecological Area after Exclusion

This prioritization ranked all PEAs based upon their size, where larger-sized PEAs received a higher rank. Since there is a direct relationship between patch size and species diversity (Forman and Godron 1986) and because larger patches are more likely to conserve viable populations and functional ecological processes (Meffe and Carroll 1997; Forman 1995), larger PEAs are considered higher priority. The entire region is assigned priority ranks from 1 to 10, with 1 representing non-PEAs, 2 representing the smallest PEAs, and 10 representing the largest PEAs. For more details on the size classifications, see the Technical Methods in Appendix E.

C. REGIONAL RECREATION POTENTIAL

The recreation potential prioritization was created to identify recreation opportunities in the region. In order to identify opportunities, the influence of urban areas, conservation lands, water based recreation and points of interest were evaluated.

1. Influence of Urban Areas

This analysis is a measure of recreational demand based on the population of urban hubs. The theory behind this analysis is that the demand for resource-based recreation services increases with increasing population.

Urban hubs were used as a representation of populated areas with a regional influence. Cities within three miles of one another were considered to be part of a common urban hub. The population of a hub is the sum total of the population of the individual cities making up the hub. Hubs were divided into 10 individual groups based on population. A gravity model was developed for the ranked urban hubs with the mean population of each group used as the attraction or value for recreation potential. The results of the model were ranked 1-10 based on the natural breaks method. The basis of the model is that areas with higher populations or areas near urban hubs with larger populations have greater recreation potential. For more details on the ranking system or size classification, see the Technical Methods in Appendix E.

2. Influence of Conservation Lands

This analysis relates level of resource based recreational service provided by existing conservation lands to the potential for recreation. The size of the conservation land is used as a surrogate measure of the potential level of service. The greater the level of service provided, the greater the potential to recreate.

Conservation areas were divided into 10 individual groups based on acreage. A gravity model was developed for the ranked conservation areas with the mean acreage of each group used as the attraction or value for recreation potential. The results of the model were broken into ten groups. The results of the model were ranked 1-10 based on the natural breaks method. For more details on the ranking system or size classification, see the Technical Methods in Appendix E.

3. Water Based Recreation

This analysis relates the association of water-based amenities and recreation potential. Water based recreational amenities are often the focal point of parks and public lands. Even when the land surrounding a water body is under private ownership, the water itself will still have recreational value. The entire economy of many coastal areas is driven by the attraction to the water. This analysis defines the level of recreational potential provided by the water-based amenities.

Water bodies were divided into three individual groups based on their recreation potential. Coastal areas were given the highest recreational potential, with Wild and Scenic Rivers given the next highest and other rivers, lakes and streams given the lowest value for recreational potential. Coastal areas were highest due to the diversity of resources available and the demonstrated attraction that most coastlines have for recreational interest. Wild and Scenic Rivers were separated from other inland water bodies and given the next highest rank based on the supposition that these areas may tend to attract more recreational attention given their status. A gravity model was developed for the ranked water features. The results of the model were ranked 1-10 based on the natural breaks method. For more details on the ranking system or size classification, see the Technical Methods in Appendix E.

4. Influence of Points of Interest

Points of Interest are geographic locals that have an attraction because of their natural beauty and uniqueness, their recreational potential or their historical value and other factors. This attraction is the equivalent of recreation potential.
In this analysis only those points of interests involving a natural or historical aesthetic were used. These points of interest were then divided into three ranks based on their recreational potential. “Named”natural features such as springs (Itchetucknee Springs, FL), summits (Mt. Mitchell, NC) and islands (Cumberland Island, GA) were ranked the highest; campgrounds, hiking trails, lookouts and other nature based passive recreation features were ranked next highest; and less passive nature based points of interest including city parks were ranked the lowest. A gravity model was developed for the ranked points of interest. The results of the model were ranked 1-10 based on the natural breaks method. For more details on the ranking system or size classification, see the Technical Methods in Appendix E.

D. REGIONAL THREATS

The regional threats analysis incorporate two related analyses that assess the threats from intensive land uses and roads that can both negatively affect ecological integrity existing natural and semi-natural lands, and the likelihood that such natural, semi-natural and agricultural lands will be converted to residential or urban land uses.

1. Context Analysis: Landscape Viability Index

The purpose of this analysis was to create an index of threats to ecological integrity based on the intensity and proximity of potential disturbances. Potential disturbances on natural areas from highly urbanized areas include habitat loss and fragmentation, wildlife mortality from automobiles, runoff, soil erosion, proliferation of exotic and/or invasive plants, and noise and air pollution. Areas close to intensive land uses (such as urban and intensive agriculture) will have more disturbances and generally have poorer suitability for maintaining ecological integrity than areas further away from urban land uses.

The index to evaluate threats is composed of four analyses: proximity to areas of intensive land uses, proximity to major roads (primary & secondary), road density, and density of intensive land uses. The resulting MUA is an index of areas ranked from 1-10, where one represents an area with poor landscape suitability for the maintenance of ecological integrity and ten represents an area with high landscape suitability.

2. Urban Growth Potential Model

The potential for future urban growth was modeled using a set of parameters that evaluate existing urban land uses and infrastructure (roads) as an indicator of future growth. The parameters used were: distance from roads; distance from urban areas; urban density at a small scale; and urban density at a large scale. The 1992

National Land Cover Database (NLCD 30 meter resolution) was used for the distance from urban areas and the urban density measures. The distance from roads was done using the 1995 Tiger Roads database. The short distance urban density was calculated by evaluating the amount of urban areas in one-half square mile neighborhood areas. The large scale urban density was calculated by evaluating the amount of urban areas in approximately 5 square mile neighborhood areas. The large scale density analysis was intended to capture the impact of large urban areas. The four layers were then averaged together to create the final growth potential model. For more details on the components of this model, see the Technical Methods in Appendix E.

II. HUB PRIORITIZATIONS

There are 1128 ecological hubs, which can be considered the backbone of the SEF. They are created by compiling all the PEA criteria and identifying contiguous areas of 5000 acres or greater. Hence, each hub contains one or more priority ecological areas (PEAs). Hubs were prioritized to identify hot spots of priority areas, to evaluate the types of priority areas contained within each hub, and to analyze hub shape and composition. There are five types of prioritizations used to evaluate hubs: hub structure and function, ecosystem services, biodiversity, threats, and recreation potential.

Hub Prioritizations Adapted From Regional Prioritizations

Many of the ecosystem services and biodiversity prioritizations that were completed for the entire region were summarized by hub to enhance and complete hub prioritization. These prioritizations were necessary to complete at the regional scale, but also important to summarize by hub, as hubs serve as the building blocks of the ecological framework. Regional prioritizations were summarized by calculating the average rankings of each per hub.

The following regional prioritizations were summarized by hub:

Ecosystem Services:
Shellfish Harvesting Areas
Major Rivers and Wild & Scenic Rivers
Wetlands: Size and Proximity
Surficial Aquifer Pollution Vulnerability
Coastal Areas Storm Protection

Recreation Potential
Influence of Urban Areas
Influence of Conservation Lands
Water Based Recreation
Influence of Points of Interest

Biodiversity:
Critical Aquatic Biodiversity Watersheds
Threatened & Endangered Species
Imperiled Species
At-Risk Aquatic Species
Conservation Lands: Size & Proximity
Interior Forest Areas
PEA Classes
Potential Black Bear Habitat

Threats
Context Analysis
Urban Growth Potential

A. HUB PRIORITIZATIONS: ECOSYSTEM SERVICES

Ecosystem or ecological services are ecological processes and functions provided by natural and semi-natural areas that help sustain or enhance human life (Daily 1997). Primary ecosystem services include water and air protection and purification, flood and storm protection, functional nutrient cycling, etc. These analyses ranking hubs based on their value for providing specific ecosystem services is based on data available for this first iteration. Additional data such as comprehensive watershed analyses for drinking water should be conducted in future iterations.

1. Number of Stream Start Reaches per Hub

This prioritization is used to rank hubs based on the number of stream start reaches that exist within each of the Hubs. Stream start reaches can be important for significantly influencing water quality in watersheds downstream, so hubs with high numbers of stream start reaches are more significant for protecting water quality than those with fewer start stream reaches. Hubs within each of the ecoregions were compared with the start stream reaches data. This analysis was done by ecoregions within Region 4 to avoid comparisons between areas with vastly different elevational gradients, geology, etc., such as the Appalachians versus the Southeastern Coastal Plain. The range of values identified were split into 10 categories (equal interval) and then a 1-10 ranking system was applied based on the respective intervals, with hubs having the highest number of start stream reaches receiving the highest rank.

2. Percent Wetlands per Hub

This prioritization is used to measure the amount of wetlands that exist within each of the hubs. The range of wetland percentage per hub was split into 10 categories based on equal interval, and each category was assigned a priority rank from 1 to 10. A higher percentage of wetlands per hub corresponds to a higher priority rank, and a lower percentage of wetlands per hub corresponds to a lower priority rank.

3. Spatial Mix of Wetlands and Uplands

This analysis identifies hubs with significant mixes of upland forests and forested or herbaceous wetlands. Hubs that contain at least a 20%/50% mix of upland forest and wetlands are identified (i.e. hubs that are at least 20% of one and at least 50% of the other). All hubs meeting this criterion are assigned a priority rank of 10 and all other hubs are assigned a priority rank of 1. Hubs containing significant mixes of wetlands and uplands are more likely to have functional flooding and fire processes especially in the Southeastern Coastal Plain. Although this analysis is included within the ecosystem service section, such areas can also have important biodiversity values.

4. Surficial Aquifer Vulnerability to Pollution by Hub

For this analysis, the regional prioritization for surficial aquifer vulnerability was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional rankings, where a rank of one indicates low vulnerability to pollution and a ten represents high vulnerability. For more details, see the full description for the regional prioritization in Part I.A.1: Regional Ecosystem Services Prioritizations, Surficial Aquifer Areas Vulnerable to Pollution.

5. Size of & Proximity to Wetlands by Hub

For this analysis, the regional prioritization for size and proximity to wetlands was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional rankings, where a rank of one indicates smaller wetlands and areas in close proximity to smaller wetlands, and a rank of ten indicates larger wetlands and areas in close proximity to larger wetlands. For details, see the description for the regional prioritization in Part I.A.2: Regional Ecosystem Services Prioritizations, Size & Proximity to Wetlands.

6. Coastal Storm Protection Areas by Hub

For this analysis, the regional prioritization for coastal storm protection areas was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional rankings, where a higher rank indicates a hub with larger areas of native coastal habitats. For more details, see the description for the regional prioritization in Part I.A.6: Regional Ecosystem Services Prioritizations, Coastal Storm Protection Areas.

7. Major and Wild & Scenic Rivers by Hub

For this analysis, the regional prioritization for major and wild and scenic rivers was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional rankings, where a higher rank indicates a hub with many wild and scenic or major rivers. For more details, see the full description for the regional prioritization in Part I.A.5: Regional Ecosystem Services Prioritizations, Major and Wild & Scenic Rivers.

8. Shellfish Harvesting Areas Buffer by Hub

For this analysis, the regional prioritization for shellfish harvesting areas was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional rankings, where a one indicates hubs far away from shellfish harvesting areas and a ten indicates hubs in close proximity to shellfish harvesting areas. For more details, see the full description for the regional prioritization in Part I.A.7: Regional Ecosystem Services Prioritizations, Shellfish Harvesting Areas Buffer.

C. HUB PRIORITIZATIONS: BIODIVERSITY

The following prioritizations all contain assessments relevant to identifying areas that are potentially most important for conserving biodiversity. This includes some information on areas containing the most species of conservation significance and areas that are most likely to support viable opportunities to conserve biodiversity. However, additional data on locations of species of conservation interest and natural communities and the identification of areas most important for conserving viable populations of such species will be important to enhance future iterations.

1. Topographic Diversity

This prioritization is used to rank hubs based on the topographic diversity that exists within each of the hubs. Hubs with greater topographic diversity are expected to have greater elevational gradients that may be significantly correlated with the potential to support biodiversity. Hubs within each of the ecoregions in EPA Region 4 (13 are either completely or partially within Region 4) were combined with a digital elevation model (DEM) for the region. This analysis was done by ecoregions within Region 4 to avoid comparisons between areas with vastly different elevational gradients, geology, etc., such as the Appalachians versus the southeastern coastal plain. Average standard deviations of topographical diversity were calculated for each hub. Then, the standard deviations for each ecoregion were reclassified into 10 categories based on equal interval, and each category was assigned a priority rank from 1 to 10. A higher standard deviation indicates higher topographic diversity and corresponds to a higher priority rank, while lower standard deviations correspond to a lower priority rank.

2. Size & Proximity to Conservation Lands

For this analysis, the regional prioritization for size and proximity to conservation lands was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional ranks. A higher rank indicates a hub that contains large areas of conservation lands or a hub in close proximity to large areas of conservation lands. For more details, see the full description for the regional prioritization in Part I.B.1: Regional Biodiversity Prioritizations, Size & Proximity to Conservation Lands.

3. Black Bear Habitat Suitability Analysis

For this analysis, the regional prioritization for black bear habitat suitability was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional ranks. A higher rank indicates a hub with higher suitability for black bear habitat. For more details, see the full description for the regional prioritization in Part I.B.8: Regional Biodiversity Prioritizations, Black Bear Habitat Suitability Analysis.

4. Interior Forests by Hub

For this analysis, the regional interior forests prioritization was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional ranks. A higher rank indicates a hub with more interior forest areas. For more details, see the full description for the regional prioritization in Part I.B.2: Regional Biodiversity Prioritizations, Interior Forests.

5. PEA Size Classification

For this analysis, the regional PEA size classification prioritization was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional ranks, and a higher rank indicates a hub with a large, contiguous PEA. For more details, see the full description of the regional prioritization in Part I.B.9: Regional Biodiversity Prioritizations, PEA Size Classification.

6. Imperiled Species Priorities by Hub

For this analysis, the regional prioritization for imperiled species was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional ranks, and the higher the rank, the greater the number of imperiled species per hub. For more details, see the full description of the regional prioritization in Part I.B.4: Regional Biodiversity Prioritizations, Imperiled Species Priority Areas.

7. Listed Species Priorities by Hub

For this analysis, the regional prioritization for listed species was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional ranks, and the higher the rank, the greater the number of listed species per hub. For more details, see the full description of the regional prioritization in Part I.B.5: Regional Biodiversity Prioritizations, Listed Species Priorities.

8. Aquatic Biodiversity

For this analysis, the regional prioritization for at-risk aquatic species was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional ranks. A higher rank indicates a hub that has a high number of at-risk aquatic species. For more details, see the full description of the regional prioritization in Part I.B.6: Regional Biodiversity Prioritizations, Aquatic Biodiversity by Watersheds (HUCs).

9. Critical Watersheds for Aquatic Biodiversity

For this analysis, the regional prioritization for critical aquatic biodiversity watersheds was summarized by hub. Hubs were then assigned priority ranks from 1 to 10 based on their summarized regional ranks. Hubs are ranks based upon whether or not they contain a critical biodiversity watershed and the area of critical watershed they contain. A higher rank indicates a hub that contains the highest level priority watershed. For more details, see the full description of the regional prioritization in Part I.B.7: Regional Biodiversity Prioritizations, Critical Watersheds for Aquatic Biodiversity.

C. HUB RECREATION POTENTIAL

The recreation potential prioritization was created to identify recreation opportunities by hub. In order to identify opportunities, the influence of urban areas, conservation lands, water based recreation and points of interest were evaluated. These regional analyses were then summarized for hubs by calculating the average index value for each hub. For more information on each analysis, see Part C. Regional Recreation Potential of Appendix A.

D. HUB THREATS

The regional threats analysis incorporates two related analyses that assess the threats from intensive land uses and roads that can both negatively affect ecological integrity existing natural and semi-natural lands, and the likelihood that such natural, semi-natural and agricultural lands will be converted to residential or urban land uses. The two regional analyses, Context Analysis and Urban Growth Potential, were then summarized for hubs by calculating the average index value for each hub.

E. HUB STRUCTURE AND FUNCTION

The goal of the hub structure and function prioritizations was to evaluate hubs based on their shape, size, and internal and external compositions. An optimal hub is one characterized by a low amount of edge habitat (low perimeter to area ratio), low internal fragmentation, high quality internal habitat, and surrounded by natural, semi-natural or generally low intensity land uses.

Principles of landscape ecology are used to evaluate patch characteristics, such as composition, size, and shape, in relation to the patch's ability to support viable ecosystems or natural communities. Patch composition, in terms of appropriate habitat and suitable land use, is important for providing adequate resources for species of conservation interest and functional ecological processes. Patch size is important because larger patches are more likely to support viable populations of species of conservation interest, functional ecological and evolutionary processes, and important ecosystem services. Patch shape is important as different shapes offer varying amounts of interior habitat. A circle is considered an optimal shape since it is the most compact shape, with the least amount of edge (perimeter) per area. The amount of edge habitat within a patch is important because the habitat composition and structure that is found in edge habitats differs significantly from the interior habitat (Forman and Godron 1986). Patches with more edge-affected habitat are more likely to have reduced ecological integrity associated with negative edge effects.

The land uses which surround hubs, or the external context (composition) of hubs, is also important because of the negative effects from high intensity land uses that can extend into the hubs. Negative effects include habitat loss and fragmentation, wildlife mortality from automobiles, runoff, soil erosion, proliferation of exotic and/or invasive plants, and noise and air pollution. Hubs surrounded by lower intensity land uses will be less influenced by these effects.

1. Internal Gaps / Hub Density

This analysis is used as measurement of the contiguity or density of each individual hub. Hubs with contiguous areas and minimum gaps or holes offer more suitable habitat areas with less opportunity for disturbance by poor land uses that may occupy areas within the overall hub.

A focal sum analysis was performed on the hubs to measure the density of hub cells in a 1 square kilometer neighborhood. Focal sum values were then averaged for the hub and the hub was given a rank based on that average.

Although this will measure density, it is not a perfect measure of density because the focal sum analysis is biased towards larger areas, which are more likely to receive a higher overall score after the focal sum values are averaged over the entire hub. To help counteract the size bias, hubs are split up into size classes, and then focal sum ranges within each size class are reclassified into priority ranks from 1 to 10. A priority rank of one represents a hub with many holes/gaps and a rank of ten represents a hub with little holes/gaps.

2. Internal Context of Hubs: Percent PEA per Hub

This prioritization is used to measure the proportion of Priority Ecological Areas (after exclusion) that are contained within each hub. Hubs, by definition are PEAs after exclusion that are contiguously 5000 acres or greater. However, through the processes of hub optimization and network optimization, other areas that are not PEAs, but are of suitable land use, are added to the core hubs. This analysis gives a measure of how much area was added during the two optimization processes. Hubs are assigned priority ranks from 1 to 10, in which the higher the rank, the higher percentage of PEA. There are no hubs comprised of less than 63% PEA.

3. Internal Context of Hubs: Percent SEA per Hub

This prioritization is used to measure the proportion of Significant Ecological Areas (after exclusion) that are contained within each hub. Hubs are assigned priority ranks from 1 to 10, in which the higher the rank, the higher the percent SEA. Hubs contained between 2 and 100% SEAs. The range of percents for SEA per hub varies more than PEAs because SEAs are not the primary component in the creation of hubs.

4. Internal Context of Hubs: Land Use Context Index

Intensive land uses are excluded from hubs during the exclusion process, however pockets of intensive land uses may be enclosed within and surrounded by hubs and exert a negative influence on hubs. This prioritization evaluates the influence of intensive land uses within hubs. First, land uses were grouped into 4 categories (categories 0,1,2,3), with category 0 representing natural land uses (water, forests, wetlands), category 1 representing semi-natural land uses (shrub, grasslands), category 2 representing moderate intensity land uses (agricultural, extractive), and category 3 representing highly intensive land uses (residential, commercial). Throughout the SEF modeling process, category 0 and 1 land uses are considered suitable for inclusion with Hubs and categories 2 and 3 are considered unsuitable.

The land use context index generates values from 0-125 depending on the quantity and proximity of category 2 and 3 land uses within a 50 acre neighborhood. A higher index value indicates close proximity to poor land uses (category 2 or 3). This index was created for the entire region 4 for use in evaluating the land use intensities of the region, hubs and linkages. In this prioritization in particular, index values were summarized by hubs and then inverted to remain consistent with the other prioritizations (where the higher the rank, the higher the priority or better suitability). Values by hub are then reclassified into priority ranks from 1 to 10, with a lower rank indicating poor land use context (i.e., close proximity to poor land uses) and a higher rank indicating better land use context (i.e. not located near poor land uses). For further details on land use classifications and the land use ranking system, see Technical Methods in Appendix E.

5. External Context of Hubs: Land Use Context

This prioritization is used to measure the intensity of land uses adjacent to hubs. Land use intensity is measured using the Land Use Context Index (see description above) within a 5 kilometer buffer of each hub. The index scores are reclassified into priority ranks from 1 to 10 ranks based on equal interval, in which a higher rank indicates lower intensity adjacent land uses and a lower rank indicates higher intensity land uses.

6. External Context of Hubs: PEAs

This prioritization is used to measure the amount of PEAs that exist within a 5 kilometer buffer of the Hubs. The percentage of PEAs in the buffer was reclassified into priority ranks from 1 to 10 based on natural breaks, in which a higher rank indicates a higher percent of PEA in the buffer, and a lower rank indicates a lower percent of PEA in the buffer.

7. External Context of Hubs: SEAs

This prioritization is used to measure the amount of SEAs that exist within a 5 kilometer buffer of the hubs. The percentage of SEAs in the buffer was reclassified into priority ranks from 1 to 10 based natural breaks, in which a higher rank indicates a higher percent of SEA in the buffer, and a lower rank indicates a lower percent of SEA in the buffer.

8. Hub Total Area Index

Total Area Index values were determined by reclassifying total hub acreages into priority ranks from 1 to 10, in which a higher rank corresponds to hubs with larger acreages and a lower rank corresponds to hubs with smaller acreages. For details on the size classification, see Technical Methods in Appendix E.

9. Hub Core Area Index

The purpose of this prioritization is to calculate the core or interior area for each hub. Core areas are important because they are the most remote areas within the hub and are least likely subjected to negative edge effects. Core area is defined as the area of the largest circle that fits within the hub, also called the largest-circle-fit technique (Forman 1995). To calculate core area, each hub was first shrunk by 500 meters (i.e., its outer edges were drawn-in 500 meters) to account for negative edge effects. Then, the core area of each of the hubs was found. These core areas were then reclassified into priority ranks from 1 to 10, where a higher rank corresponds to a larger core area. For details on the size classification, see Technical Methods in Appendix E.

10. Hub Core Roadless Area Index

The purpose of this prioritization was not to identify any roadless area, but specifically core roadless areas with compact shapes and low amounts of edge. Core roadless areas are determined by calculating the largest circle that fits within a hub that is not bisected by major roads (primary or secondary roads). After the largest, most compact roadless area within each hub is identified, all hubs are reclassified into priority ranks from 1 to 10, where a higher rank indicates a hub with a larger roadless area, and a lower rank indicates a hub with a smaller roadless area. For details on the size classification, see Technical Methods in Appendix E.

11. Perimeter of Circle to Perimeter of Patch (Hub) Ratio

The purpose of this prioritization was to analyze hub shape as it compares to a circle. As stated in the description of the Hub Function & Structure Prioritizations, a circle is considered an ideal shape because it is the most compact shape with the least amount of edge. To compare hub shape to that of a circle, the ratio of the perimeter of each hub to the perimeter of a circle having the same area as the hub was calculated.

To calculate the ratio, the area and perimeter of each hub were first found. Then, the perimeter of a circle with the same area as each hub was calculated. Next, the two perimeters were divided to calculate the ratio. This ratio is based on a shape factor equation for measuring patch shape:

$$SF = pc / p$$

where SF = shape factor, pc = perimeter of circle having same area as patch (hub), p = perimeter of a patch (hub) (Bosch 1978, Davis 1986, Forman 1995). Finally, the ratios were reclassified into priority ranks from 1 to 10, where a higher rank correlates to a better hub shape (more similar to a circle) and lower rank correlates to a worse hub shape.

12. Hub Corrected Perimeter to Area Ratio

The purpose of this prioritization was to compare hub perimeter to hub area. The basic premise here is that if two hubs have the same area, the one with a smaller perimeter is more compact and has less edge, and is more desirable because it has more interior habitat area and is less susceptible to negative edge effects. However, because a simple perimeter-to-area ratio is dependent on size as well as perimeter, it is necessary to use an equation that corrects for variance caused by change in hub size if such a ratio is to be a helpful indicator of hub shape. Otherwise, hubs of the same shape and proportion would receive different ratio values if their areas are different.

An equation for the corrected-perimeter-to-area ratio, found in *Principles and Methods in Landscape Ecology* by Almo Farina (1998), was used to derive the cor_p_aindex. The equation is as follows:

$$\text{Corrected Perimeter:Area} = (0.282 * \text{perimeter}) / \text{sqrt\_area}).$$

After being calculated, corrected-perimeter-to-area ratios were reclassified into priority ranks from 1 to 10, where a lower ranking correlates to a poorer hub shape and a higher ranking correlates to a better hub shape (more compact, less edge).

13. Amount of Roads Per Hub

This prioritization calculated the percentage of primary and secondary road cells per hub. The hubs were given priority ranks from 1 to 10, with a rank of one indicating a high percentage of road cells, and a rank of ten indicating a low percentage of road cells.

III. LINKAGE PRIORITIZATIONS

Linkages were identified to provide the opportunity for connectivity between hubs. Optimal linkages are characterized by a contiguous swath of land with adequate width and high quality habitat. Through the use of the cost surfaces and the least cost path function (in Arc/Info GRID), linkages were delineated to traverse the areas of highest quality land use between the hubs that they connect. However, the quality of linkages delineated in the SEF was variable.

To analyze the habitat quality, width, and contiguity of linkages, three main types of prioritizations were completed: Internal Context Analyses, External Context Analyses, and Width. In addition, a fourth prioritization ranks the linkages based upon the overall prioritization ranking of the hubs that they connect.

There are three types of linkages: general, upland, and riparian, based upon the type of hubs they connect. Linkages were prioritized separately for each type.

Separating Linkages into Discrete Segments

The first step in prioritizing linkages was to separate them into discrete segments for evaluation. Although linkages were created to connect one hub to another, one linkage can cross through or between many hubs. For prioritization, it was decided that linkages would be separated into segments that connected at least two different hubs.

A. LINKAGES: INTERNAL CONTEXT ANALYSES

To measure the habitat quality and potential functionality of linkages, the percentage of PEAX (Priority Ecological Areas after excluding unsuitable land uses) and SEAX (Significant Ecological Areas after excluding unsuitable land uses) in each linkage were calculated. To measure the negative edge effects from roads and possible fragmentation, the percent of primary and secondary roads per linkage was calculated. Also, the overall intensity of land uses within the linkages was evaluated as a measure of land use quality within the linkages.

1. Percent Priority Ecological Areas per Linkage

The percentage of PEAX (priority ecological areas after excluding unsuitable land uses) was calculated per linkage. The range of percentages for each linkage type was as follows:

Linkage Type	*Percent PEAX in Linkage*
General	0 - 61%
Upland	0 - 42%
Riparian	0 - 97%

The range of percentages were reclassified into priority ranks from 1 to 10 based on equal interval, where the higher the rank, the higher the percent of PEAX in the linkage.

2. Percent Significant Ecological Areas per Linkage

The percentage of SEAX (significant ecological areas after excluding unsuitable land uses) was calculated per linkage. The range of percentages for each linkage type was as follows:

Linkage Type	*Percent SEAX in Linkage*
General	0 - 87%
Upland	0 - 94%
Riparian	0 - 99%

The range of percentages were reclassified into priority ranks from 1 to 10 based on equal interval, where the higher the rank, the higher the percent of SEAX in the linkage.

3. Percent of Primary & Secondary Roads per Linkage

The percentage of primary and secondary roads per linkage was calculated by dividing the number of primary and secondary road cells per total number of linkage cells. The cell size of the road grid was 90 meters, which was an overestimate of the actual width of the roads. Hence, the percentages are slightly inflated.

Linkage Type	*% Major Roads per Linkage*
General	0 - 29%
Upland	0 - 18%
Riparian	0 - 34%

The range of percentages were reclassified into priority ranks from 1 to 10 based on natural breaks, where the higher the rank, the lower the percent of major roads in the linkage.

4. Internal Land Use Context

This analysis prioritizes the linkages by the intensity of land uses within or surrounded by the linkage. Although intensive land uses are not included in most linkages, some linkages include agricultural land use. Furthermore pockets or nodes of agricultural or urban land uses can in some cases be surrounded by linkages. Land use intensity is measured using the Land Use Context Index methods completed for hub prioritizations (See Part II.A.2: Hub Prioritizations, Land Use Context Index, for more details). Land use context index scores are averaged for each linkage, and then reclassified into priority ranks from 1 to 10 based on natural breaks. A low priority rank represents linkages with high land use intensities and a high priority rank represents linkages with low land use intensities.

B. LINKAGES: EXTERNAL CONTEXT ANALYSES

The purpose of the external context analyses is to obtain a measure of the landscape context surrounding the linkages. Linkages surrounded by low intensity land uses, priority or significant ecological areas are less affected by negative edge effects and offer better opportunities for functional connectivity. In all three of these analyses a one kilometer buffer was chosen as the area of potential influence directly relevant for determining the contextual quality of the linkages based on a conservative estimate of the potential for edge effects and other types of landscape interactions (Forman 1995).

1. Priority Ecological Areas Context of Linkages

This prioritization measures the amount of PEAX (priority ecological areas after excluding unsuitable land use) within a one kilometer buffer area of each linkage. The range of percentages for each linkage type are as follows:

Linkage Type	***Percent PEAX in Buffer***
General	7 - 87%
Upland	23 - 92%
Riparian	4 - 85%

The range of percentages were reclassified into priority ranks from 1 to 10 based on equal interval, where the higher the rank, the higher the percent of PEAX in the linkage buffer area.

2. Significant Ecological Areas Context of Linkages

This prioritization measures the amount of SEAX (significant ecological areas after excluding unsuitable land use) within a one kilometer buffer area of each linkage. The ranges of percent SEAX per linkage were as follows:

Linkage Type	***Percent SEAX in Buffer***
General	3 - 90%
Upland	10 - 77%
Riparian	2 - 86%

The range of percentages were reclassified into priority ranks from 1 to 10 based on equal interval, where the higher the rank, the higher the percent of SEAX in the linkage buffer area.

3. Land Use Context of Linkages

This analysis prioritizes linkages by the intensity of the land use within a one kilometer buffer of the linkage. Land use intensity is measured using the Land Use Context Index methods completed for hub prioritizations (See Part II.A.2: Hub Prioritizations, Land Use Context Index, for more details). The average land use context index score within the one kilometer buffer area was calculated in order to prioritize the linkages. Linkages are ranked from 1 to 10 based on natural breaks, with a rank of one representing buffer areas with high land use intensities, and ten representing buffer areas with low land use intensities.

C. WIDTH ANALYSES

In addition to containing high quality habitat, an optimal linkage should also include a swath of contiguous land area with adequate width. Although there remains no exact determination of "how wide should a linkage be", it is generally accepted that "the wider, the better" (Noss 1987b; Hunter 1990; Noss 1993; Beier and Noss 1998). Functional widths will also be influenced by the context of the linkage, with the assumption that linkages surrounded by more intensive land uses will need to be wider. Length is also an important factor, and linkages should be wider as length increases, especially if the linkage is intended to support wide-ranging species such as black bear. To measure linkage contiguity and width, two analyses were completed: Density Analysis and Perimeter to Area Ratio. It should be noted that these analyses can only serve as surrogates for measuring actual widths, average widths, or variation in width of the linkages included in the SEF. Due to limitations of raster analysis in Arc-Info Grid direct measures of linkage widths, especially with so many linkages, would be difficult. However, the analyses included can serve as a means to evaluate the linkages relative to each other to determine which are more likely to have functional characteristics.

1. Density Analysis of Linkages

A density analysis was performed as a measure of contiguity or the amount of gaps/holes contained in the linkages. One square kilometer areas were evaluated one at a time to measure the amount of linkage cells contained within each. The more linkage cells contained within the neighborhood, the denser or more contiguous the linkage was considered. Linkage densities were ranked from 1 to 10 based on natural breaks, where the higher the rank, the more dense or contiguous the linkage.

2. Width Measurement: Corrected Perimeter to Area Ratio

A perimeter to area ratio was completed as another measure of contiguity. The basic premise being that if two linkages have the same area, the one with a smaller perimeter to area ratio is more compact and has less edge, and therefore possesses a better shape. However, because a simple perimeter-to-area ratio is dependent on size as well as perimeter, it is necessary to use an equation that corrects for variance caused by change in overall size if such a ratio is to be a helpful indicator of shape. Otherwise, linkages of the same shape and proportion would receive different ratio values if their areas are different.

Following this premise, a linkage with more holes/gaps should have a high perimeter to area ratio, and a more contiguous and compact linkage would have a lower ratio. An equation for the corrected-perimeter-to-area ratio, found in *Principles and Methods in Landscape Ecology* by Almo Farina (1998), was used to calculate this prioritization:

Corrected Perimeter:Area = (0.282 * perimeter) / sqrt_area)

After the ratio was calculated for all linkages, the ratio values were reclassified into priority ranks from 1 to 10 based on natural breaks, in which the higher the rank, the lower the P:A ratio and the more compact, contiguous the linkage.

D. HUB RANKS

1. Ranking of Linkages by Overall Prioritization Ranking of Hubs They Connect

The purpose of this prioritization was to rank linkages based upon the priority ranking of the hubs which they connect. Linkages that provide connectivity between high priority hubs should be of higher priority themselves, as linkages can potentially enhance the hub's ability to support viable ecosystems and natural communities through exchange and movement of resources between hubs. After all hub prioritizations were completed and the overall hub ranks were calculated, the linkages were evaluated based upon the overall rank of the hubs which they connected.

Appendix E: SEF Prioritization Technical Methods

Introduction

Prioritizations

I. Regional Prioritizations
    A. Ecosystem Services
        1. Surficial Aquifer Areas Vulnerable to Pollution
        2. Size & Proximity to Wetlands
        3. Surface Water Source Priorities
        4. Ground Water Priorities
        5. Major and Wild & Scenic Rivers Buffers
        6. Coastal Storm Protection Areas
        7. Proximity to Shellfish Harvesting Areas

    B. Biodiversity
        1. Size & Proximity to Conservation Lands
        2. Interior Forests
        3. Old Growth and Significant Longleaf Pine Forest Stands
        4. Imperiled Species Priority Areas
        5. Listed Species Priority Areas
        6. At-risk Aquatic Species by Watersheds (HUCs)
        7. Critical Watersheds for Aquatic Biodiversity
        8. Black Bear Habitat Suitability Analysis
        9. PEA Size Classification

    C. Threats
        1. Context Analysis
        2. Urban Growth Pressure Model

    D. Recreation Potential

II. Hub Prioritizations

    A. Ecosystem Services
        1. Number of Stream Start Reaches per Hub
        2. Percent Wetlands per Hub
        3. Percent Uplands per Hub
        4. Spatial Mix of Wetlands and Uplands by Percent in Hubs
        5. Surficial Aquifer Areas Vulnerable to Pollution by Hub
        6. Size & Proximity to Wetlands by Hub
        7. Coastal Storm Protection Areas by Hub
        8. Major and Wild & Scenic Rivers Buffers by Hub
        9. Shellfish Harvesting Areas Buffers by Hub

B. Biodiversity
    1. Topographic Diversity
    2. Size & Proximity to Conservation Lands
    3. Black Bear Habitat Suitability Analysis
    4. Interior Forests by Hub
    5. PEA Size Classification
    6. Imperiled Species Priorities by Hub
    7. Listed Species Priorities by Hub
    8. At-risk Aquatic Species by Watershed
    9. Critical Aquatic Biodiversity Watersheds

C. Threats
    1. Landscape Viability Context Index
    2. Urban Growth Pressure Model

D. Recreation Potential
    1. Influence of Urban Areas
    3. Influence of Public Lands
    3. Influence of Water Based Recreation
    4. Influence of Points of Interest

E. Hub Function & Structure
    1. Internal Gaps/ Hub Density
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    4. Hub Land Use Context Index
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    6. External Context: Percent PEA
    7. External Context: Percent SEA
    8. Hub Total Area Index
    9. Hub Core Area Index
    10. Hub Core Roadless Area Index
    11. Perimeter of Circle to Perimeter of Patch (Hub)
    12. Perimeter to Area Ratio
    13. Amount of Roads per Hub

III. Linkage Prioritizations
Separating Linkages into Discrete Segments

A. Internal Context Analyses
    1. Internal Context: Percent PEA
    2. Internal Context: Percent SEA
    3. Internal Context: Percent of Primary and Secondary Roads
    4. Internal Land Use Context

B. External Context Analyses
    1. External Context: PEAs
    2. External Context: SEAs
    3. External Context: Land Use

C. Width Analysis
    1. Perimeter to Area Ratio
    2. Density

D. Hub Ranks
    2. Prioritizing Linkages by Hub Priority Rank

IV. Creation of MUAs

Introduction

All prioritization analyses were completed using ESRI's ArcInfo GRID, versions 7.2.1 Patch 2 and 8.1, and ESRI's Arcview with Spatial Analyst Extension, version 3.2. The analyses were completed at the University of Florida's Geoplan Center. When applicable, a reference file is listed, which refers to specific commands or AMLs (Arc Macro Language) used to complete the methods. Any command names listed in the methods below are for ArcInfo GRID.

I. REGIONAL PRIORITIZATIONS

A. ECOSYSTEM SERVICES:

1. Surficial Aquifer Areas Vulnerable to Pollution

DRASTIC summary index scores for the region ranged from 32 to 226. The scores were reclassified into priority ranks from 1 to 10 based on natural breaks. The higher the index score, the greater the susceptibility to pollution. The reclassification scheme is as follows:

Priority Rank	*DRASTIC Summary Score*
1	32 - 79
2	80 - 96
3	97 - 108
4	109 - 118
5	119 - 132

Priority Rank	*DRASTIC Summary Score*
6	133 - 151
7	152 - 170
8	171 - 187
9	188 - 207
10	208 - 226

<u>2. Size & Proximity to Wetlands</u>
Reference file: prio_wet_prox.aml

1. Wetlands (r4_wetlands90) are first grouped into 9 size classes. The classes were determined by first taking the natural log of the counts. This yielded 13 classes, of which the five smallest classes were lumped into a single category (181 acres and less) . These classes were considered small at the regional scale and hence, lumping of the classes was logical because such amount of detail is not necessary for this large scale analysis.

Size Classification for Wetlands

Size Class	*Area (in Acres)*
1	1 - 181
2	182 - 489
3	490 - 1,333
4	1,334 - 3,625
5	3,626 - 9,839
6	9,840 - 26,917
7	26,918 - 73,223
8	73,224 - 250,157
9	250,158 - 2,668,066

2. Each wetland size class was then buffered by successive increments of 90 meters. For example, Class 1 was buffered by 90m, Class 2 was buffered by 180m, Class 3 was buffered by 270m; etc. Originally, the total buffer distance was determined to be 1km. But when split between the 9 size classes, 1000 meters does not divide evenly with 90m cells. Hence, increments of 90m were

used, and the maximum buffer distance is 810 - the result of 9 size classes with successive 90 m increments. See table below.

Ranking System for Wetlands Size Classes & Buffers

	Size Classes & Corresponding Buffer Amounts								
Ranks	***1 Buffer 90 meters***	***2: Buffer 180 m***	***3 Buffer: 270 m***	***4 Buffer: 360 m***	***5 Buffer: 450 m***	***6 Buffer: 540 m***	***7 Buffer: 630 m***	***8 Buffer: 720 m***	***9 Buffer: 810 m***
1st Buffer Increment *	2	3	4	5	6	7	8	9	10
2nd Buffer Increment		2	3	4	5	6	7	8	9
3rd Buffer Increment			2	3	4	5	6	7	8
4th Buffer Increment				2	3	4	5	6	7
5th Buffer Increment					2	3	4	5	6
6th Buffer Increment						2	3	4	5
7th Buffer Increment							2	3	4
8th Buffer Increment								2	3
9th Buffer Increment									2

*Buffer Increments of 90 meters

3. Surface Water Source Priorities

Surface water intake points were prioritized using population numbers associated with each surface water source point. Overlapping points were managed to make sure that the point with the largest population served was used to determine the weight. Also redundant populations served by the same utility company were divided by the total number of surface water source points. Each point was buffered by approximately 5 miles. The buffered points were weighted based on the natural log of the population served which was reclassed into 10 classes as follows:

Natural log of population	Rank
1.5	2
6	3
7	4
8	5
9	6
10	7
11	8
12	9
13	10

All other cells outside the 5 mile buffers were assigned a rank of 1.

4. Ground Water Source Priorities

Ground water source points were all buffered by approximately 1 mile. The buffers were then separated into 9 180 meter increments classed from 10 to 2 with the increment closest to the groundwater source point given the highest rank with progressively lower ranks further from the source point. All cells outside the 1 mile buffer were given a rank of 1.

5. Major and Wild and Scenic River Buffers

Major rivers were the same as those used in the riparian corridor analysis in the development of the Southeastern Ecological Framework. Major rivers and wild and scenic rivers were combined into one grid. This rivers grid was buffered in nine 270 meter increments for a total of 2430 meters. The increments were then ranked 10 to 2, with the open water and the closest buffer interval lumped into the highest rank of 10 and then each interval further out ranked 9 to 2. All cells beyond 2430 meters were assigned a value of 1.

6. Coastal Storm Protection Areas

Intact natural and semi-natural land cover within coastal areas can be important for minimizing storm damage related to coastal storms and especially hurricanes. As a surrogate for more specific FEMA data on coastal surge and flood areas, an analysis was created identifying all landcover in coastal areas prioritized by the size of the area. Natural and semi-natural cover classes from the NLCD (National Land Cover Dataset) within 10 kilometers of coastal water bodies were identified. Coastal water bodies were identified using 1:100,000 USGS hydrology data and included ocean, gulf, and any estuarine waters. All water bodies and primary roads (using primary class roads from 1:100,000 Tiger roads) were removed. These areas were then separated into 9 priority size classes ranging from 2 to 118,773 acres using equal intervals with the largest areas receiving the highest ranks. All other areas within the region were assigned a rank of 1. The ranking assignments were:

Priority Rank	*Acres of Native Coastal Habitat*
1	None
2	2 - 14,848 acres
3	14,849 - 29,694
4	26,695 - 44,541
5	44,542 - 59,387
6	59,388 - 74,234
7	74,235 - 89,080
8	89,081 - 103,927
9	103,928 - 118,773
10	118,774 - 133620

7. Shellfish Harvest Area Buffers

Approved coastal shellfish harvest areas (CSAs) must meet certain water quality standards to remain open to harvest. Although water quality within estuaries is dependent on all freshwater inflows, immediate buffer zones adjacent to estuaries harboring shellfish harvest waters are also important for maintaining water quality. This prioritization analysis identifies all areas designated as approved or conditionally approved shellfish harvest areas. Adjacent buffers areas were ranked in 625 meter intervals using the following delineation:

Priority Rank	*Distance away from CSA(meters)*
1	gt 5000 meters
2	4376 - 5000 meters
3	3751 - 4375 meters
4	3126 - 3750 meters
5	2501 - 3125 meters
6	1876 - 2500 meters
7	1251 - 1875 meters
8	626 - 1250 meters
9	lt 625 meters
10	Within a shellfish harvest area

B. BIODIVERSITY

1. Conservation lands size classes and proximity

1) Substituted conservation lands from the Tennessee GAP Program for our original conservation lands in Tennessee.

1) Combined National Estuarine Research Reserves with conservation lands.

1) Removed all open water (defined as water from r4_hypoly or water from r4_mrlc90).

1) Conservation land was then grouped by size classes by transforming cell counts using natural log. The following groupings were created:

Natural log 1-5 = 1
Natural log 6 = 2
Natural log 7 = 3
Natural log 8 = 4
Natural log 9 = 5
Natural log 10 = 6
Natural log 11 = 7
Natural log 12-14 = 8

1) Each of these size groups was then buffered and ranked based on size. Larger conservation areas were buffered the greatest distance and ranked highest. All Size classes were buffered in 540 meter increments. The following ranking system was used:

	Size Class 1	Size Class 2	Size Class 3	Size Class 4	Size Class 5	Size Class 6	Size Class 7	Size Class 8
	buffer distance	buffer distance	buffer distance	buffer distance	buffer distance	buffer distance	buffer distance	buffer distance
	540 meters	1080 meters	1620 meters	2160 meters	2700 meters	3240 meters	3780 meters	4320 meters
Ranks								
conservation land	3	4	5	6	7	8	9	10
1st buffer increment	2	3	4	5	6	7	8	9
2nd buffer increment		2	3	4	5	6	7	8
3rd buffer increment			2	3	4	5	6	7
4th buffer increment				2	3	4	5	6
5th buffer increment					2	3	4	5
6th buffer increment						2	3	4
7th buffer increment							2	3
8th buffer increment								2

2. Interior Forests

A. Interior Forest Identification

1) Reclassified 90 meter MRLC into two classes (temp1):
    a. land uses with edge effects == 1
        low intensity residential
        high intensity residential
        high intensity commercial
        bare rock/soil
        quarries/mines
        transitional/clearcuts
        orchard
        grassland
        pasture/hay
        row crops
        small grains
        other grasses
    a. land uses/cover with no/low associated edge effects == No Data
        all other MRLC classes

2) Regiongrouped temp 1 to identify only patches 10 acres or larger (edge_patches1)

3) Buffered edge_patches1 where 10-99 acres was buffered by 100 meters, 100-999 acres was buffered by 300 meters and > 1000 acres was buffered by 1000 meters using Eucdistance.

3) Buffered primary, secondary, and tertiary (all other roads other than jeep trails) by 300, 200, and 100 meters respectively.

5) All negative edge effects modeled in steps 3 and 4 were then combined into one grid.
Forest was identified using MRLC data (upland deciduous, upland mixed, upland evergreen, woody wetlands).

6) Negative edge effects were then "subtracted" from forest areas.

7) The remaining "interior" forest was regiongrouped.

8) Regiongrouped interior forest was separated into 10 size classes:
1 == < 100 acres (and all other cells)
2 == 100-500 acres
3 == 500-1000 acres
4 == 1000-2500 acres
5 == 2500-5000 acres
6 == 5000-10,000 acres
7 == 10,000-25,000 acres

8 == 25,000-50,000 acres
9 == 50,000-100,000 acres
10 == > 100,000 acres

A. Forest Interior/Density Alternative

1) Step 1-7 above still apply.

1) Intensive land use density was determined using the Cat123 grid's class 3 land use and a 11 X 11 90 meter cell (app. 1 square kilometer) neighborhood.

1) Forest density was determined using the MRLC-based forest grid and the same focal sum neighborhood function.

1) Areas with less than 25% intensive land use and 75% or greater forest density were identified.

1) All areas containing interior forest that also met the density thresholds for both intensive land use and forest density were identified.

1) These areas of interior, dense forest without significant influence of intensive land uses were regiongrouped.

1) The regiongrouped blocks of forest were separated into 10 size classes:
1 == < 100 acres (and all other cells)
2 == 100-500 acres
3 == 500-1000 acres
4 == 1000-2500 acres
5 == 2500-5000 acres
6 == 5000-10,000 acres
7 == 10,000-25,000 acres
8 == 25,000-50,000 acres
9 == 50,000-100,000 acres
10 == > 100,000 acres

3. Old growth and significant longleaf pine forest stands

The PEA data layers for old growth stands and significant longleaf pine stands were used as the basis of the prioritization layer. The PEA data was developed using the Eastwide Forest Areas Inventory Dataset.

Old growth stands are defined as stands that are at least 100 years old. For each state, plots with stand ages of 100 years or greater were selected. Since each plot was represented by a single point, plots were then buffered with radii calculated from the "expanded acreage" attribute item. Expanded acreage represented the total area that the plot was supposed to represent, so the radius of a circle with that acreage was calculated, and the point was buffered using the calculated radius as the buffer distance. Individual state coverages were then gridded, merged into a region 4 grid, and resampled to 90m.

That resulting grid was then checked with MRLC forest classes to check if the buffered area overlapped with forest areas identified by MRLC.

Significant Longleaf pine stands are defined as stands plots with stand ages of 50 years or greater and with at least 50% longleaf pine and that were not plantations. For each state, plots with stand ages of 50 years or greater and with at least 50% longleaf pine and that were not planted were selected. Since each plot was represented by a single point, plots were then buffered with radii calculated from the "expanded acreage" attribute item. Expanded acreage represented the total area that the plot was supposed to represent, so the radius of a circle with that acreage was calculated, and the point was buffered using the calculated radius as the buffer distance. Individual state coverages were then gridded, merged into a region 4 grid, and resampled to 90m. That resulting grid was then checked with MRLC forest classes to check if the buffered area overlapped with evergreen forest areas identified by MRLC.

4. Imperiled Species Priorities

Imperiled species richness was created using data produced by the Association for Biodiversity Information and The Nature Conservancy. As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). Their imperiled species analysis used the Environmental Protection Agency's EMAP hexagons (648.7 square kilometers) as a base unit to summarize the distribution of imperiled species across the United States. Imperiled species were defined as species that are either critically imperiled (G1) or imperiled (G2) using the natural heritage G rank classification system. This data contained the number of imperiled species found in each EMAP hexagon. The original shapefile was turned into a 90 meter grid within Region 4. The number of imperiled species was reclassed using equal area intervals as follows:

Priority Rank	*# of G1/ G2 Species*
1	0
2	1
3	2
4	3
5	4
6	5
7	6 - 7
8	8 - 9
9	10 - 12
10	13 - 26

Cells having no imperiled species were not included in the equal area slicing and were assigned a rank of 1 after other cells were partitioned by equal area and ranked.

5. Listed Species Priority Areas

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). Their analysis of federally listed species used the Environmental Protection Agency's EMAP hexagons (648.7 square kilometers) as a base unit to summarize the occurrence of listed species across the United States. This data contained the number of listed species found in each EMAP hexagon. Shapefile was turned into a 90 meter grid within Region 4. The number of species was reclassed using equal area intervals as follows:

Priority Rank	*# of Listed Species*
1	0
2	1
3	2
4	3
5	4
6	5
7	6
8	7 - 8
9	9 - 11
10	12 - 22

Cells having no imperiled species were not included in the equal area slicing and were assigned a rank of 1 after other cells were partitioned by equal area and ranked.

6. At-risk Aquatic Species by Watersheds (HUCs)

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). This analysis of aquatic biodiversity was based on assessing the number of G1, G2, G3 aquatic species found with watersheds represented by the U.S. Geologic Survey's eight digit Hydrologic Cataloguing Unit (HUC). The original shapefile was turned into a 90 meter grid within Region 4. The number of at risk aquatic species by HUC was reclassed using equal area intervals as follows:

Priority Rank	***# At-risk aquatic Species***
1	0
2	1
3	2
4	3 - 4
5	5 - 6
6	7 - 8
7	9 - 10
8	11 - 12
9	13 - 16
10	18 - 48

Cells having no imperiled species were not included in the equal area slicing and were assigned a rank of 1 after other cells were partitioned by equal area and ranked.

7. Critical Watersheds for Aquatic Biodiversity

As part of the book, Precious Heritage: the Status of Biodiversity in the United States, the Association for Biodiversity Information and The Nature Conservancy developed several analyses directly relevant to prioritizing areas based on their potential significance for conserving biodiversity (Stein et al. 2000). The critical watersheds analysis identified all of the watersheds (based on eight digits HUCs) needed to contain all fish and mussels species found in the natural heritage database. This included identification of at least two watersheds for each species to ensure some redundancy and the inclusion of at least one watershed for each of 63 eccoregions in the continental United States. The prioritization analysis based on the critical watershed analysis was a simple reclassification, where all critical watersheds were assigned a rank of 10 and all other areas within the region were given a 1.

8. Black Bear Habitat Suitability

There are 11 SUA grids that comprise the final black bear habitat MUA.

8.1 Straight primary, secondary and tertiary habitat grid

1. Original NLCD was created at 30m x 30m. The resampling technique from 30m to 90m is as follows:

ARC/INFO GRID function BLOCKMAJORITY was used to find the majority value (the value that appears most often) for 3 x 3 blocks of cells. When a majority value existed, the 3 x 3 cell block was assigned this value and resampled to 90m. Otherwise resampling defaulted to nearest-neighbor assignment.

Select NLCD habitats and rank based on habitat based on black bear presence and use of habitats (see Cox et al. 1994).

NLCD Description	NLCD Value	Potential Habitat Rank
Primary Habitat		
Evergreen Forest	41	1
Deciduous Forest	42	1
Mixed Forest	43	1
Woody Wetlands	91	1
Secondary Habitat		
Shrubland	55	2
Transitional	33	2
Tertiary Habitat		
Grassland/Herbaceous Wetland	71	3
Emergent/Herbaceous Wetland	92	3

Habitat SUA Grid Values:

Value	**Description**
1	Not Identified Potential Black Bear Habitat
3	Tertiary Potential Black Bear Habitat (NLCD = 71, 92)
7	Secondary Potential Black Bear Habitat (NLCD = 51, 33)
10	Primary Potential Black Bear Habitat (NLCD = 41, 42, 43, 91)

8.2 Potential Core Black Bear Habitat

1. Select primary habitat grid created above.
2. Run a REGIONGROUP to determine habitat patch sizes.
3. Select lands greater than 37 acres in size (per Mykytka and Pelton 1989).
4. Buffer these lands by 1 kilometer using the EUCDISTANCE command.
5. Select all primary and secondary habitat patches that fall within the 1 kilometer buffer.
6. The resultant grid is now the **Primary potential habitat grid**.
7. Prepare the TBA_URBAN grid for resampling by running a BLOCK MAJORITY on the polygon-based dataset. The TVA_URBAN grid is a dataset of urban areas in the Southeastern US.
8. Resample up to 90 meters cell size to match the NLCD grid.
9. Remove all areas that exist within the TVA_URBAN grid from the Primary potential habitat grid.

10. Prepare the Hydrography dataset for resampling by running a BLOCKMAX on the arc-based dataset. The R4_HYPOLY dataset is a project grid created for this project.
11. Resample to 90 meters cell size to match the NLCD grid.
12. Run a neighborhood analysis in a 3 x 3 rectangular neighborhood, FOCALSUM, to measure the density of the habitat patches to be considered as core areas in 1 square kilometer neighborhood. Lands with 89% density of primary potential habitat or greater were selected (8 / 9 cells).
13. A REGIONGROUP is now run to determine the area of contiguous patches of habitat in order to select lands greater than 100, 000 acres.
14. Then, we make sure that the areas just defined fall in close proximity to the areas identified in r4_bbsitesf that is based on actual bear population data and home ranges. Any primary habitat areas that are also existing conservation lands and greater than100K acres and within 100KM of r4_bbsitesf are kept.

Core Habitat SUA Grid Values:

Value	**Description**
1	Lands not considered for this purpose
10	Potential Core Black bear habitat

8.3 Distance from Potential Core Black Bear Habitat

1. Create a proximity grid through the EUCDISTANCE function.
2. Rank lands based on proximity to Black bear core areas.

Distance from Habitat SUA Grid Values:

Value	**Description**
1.	Lands not considered for this purpose
2.	Lands between 90 and 100 Kilometers from Potential Core Black BearAreas
3.	Lands between 70 and 80 Kilometers from Potential Core Black Bear Areas
4.	Lands between 60 and 70 Kilometers from Potential Core Black Bear Areas
5.	Lands between 50 and 60 Kilometers from Potential Core Black Bear Areas
6.	Lands between 40 and 50 Kilometers from Potential Core Black Bear Areas
7.	Lands between 30 and 40 Kilometers from Potential Core Black Bear Areas
8.	Lands between 20 and 30 Kilometers from Potential Core Black Bear Areas
9.	Lands between 10 and 20 Kilometers from Potential Core Black Bear Areas
10.	Lands less than 10 Kilometers From Potential Core Black Bear Areas

8.4 Ranking roadless areas based on the percentage of Primary potential habitat contained within the various size-classed roadless patches

1. Use SEA_RDLESS (roadless areas 2500 acres or greater) and R4_RDLESS (roadless areas 5000 acres or greater) previously defined for SEF project.
2. Run a REGIONGROUP on R4_RDLESS to determine roadless patches greater than 10,000 acres.
3. COMBINE the three separate roadless area grids with the Primary potential habitat grid.
4. Determine the percent of Primary potential habitat per roadless area grid through tabular alterations.

Roadless Areas SUA Grid Values:

Value	**Description**
1	Not Identified Potential Black Bear Habitat
2	Roadless areas 2500 acres or greater with 10-40% primary potential black bear habitat
3	Roadless areas 2500 acres or greater with 40-70% primary potential black bear habitat
4	Roadless areas 2500 acres or greater with greater than 70% primary potential black bear habitat
5	Roadless areas 2500 acres or greater with 10-70% primary potential black bear habitat
6	Roadless areas 2500 acres or greater with 40-70% primary potential black bear habitat
7	Roadless areas 2500 acres or greater with greater than 70% primary potential black bear habitat
8	Roadless areas 10,000 acres or greater with 10-40% primary potential black bear habitat
9	Roadless areas 10,000 acres or greater with 40-70% primary potential black bear habitat
10	Roadless areas 10,000 acres or greater with greater than 70% primary potential black bear habitat

8.5. Habitat Diversity

1. Classify NLCD habitat into four categories: forested wetlands, forested uplands, freshwater and saltwater marshes, and low stature open brush lands.

Habitat Category	NLCD Value	NLCD Description
Forested uplands	41	Evergreen forest
	42	Deciduous forest
	43	Mixed forest
Forested wetlands	91	Woody wetlands
Freshwater and saltwater marshes	71	Grassland/herbaceous
	92	Emergent/herbaceous
Shrub and brushland	55	Shrub and brushland
	33	Transitional

2. Run a FOCALVARIETY with a 28 x 28 neighborhood (approximately one square mile)
1. Rank lands based on variety of habitat categories.

Habitat Diversity SUA Grid Values:

Value	**Description**
1	Not Identified Potential Black Bear Habitat
4	Single habitat class present
6	Two habitat classes present
8	Three habitat classes present
10	Four habitat classes present

8.6 Land use intensity

1. Use R4_CAT123, a categorized ranking of lands based on disturbance and/ or land use intensity (see reclass table below).
2. Run a BLOCKMAJORITY on FL-HYLUSE (a polygon-based dataset) to prepare for a resample.
3. Resample up to 90 meters cell size to match the NLCD grid.
4. Lands that occur as Tree plantations/tree crops/tree regeneration (b/w 4400 - 4499) list as Category 0 (natural lands/negligible disturbance)

Reclass Tables:

NLCD		CATEGORY RANK
11	Water	0
21	Low Intensity Residential	3
22	High Intensity Residential	3
23	High Intensity Commercial	3
31	Bare Rock/Soil	1
32	Quarries/Mines	2
33	Transitional/Clearcuts	1
41	Deciduous Forest	0
42	Evergreen Forest	0
43	Mixed Forest	0
51	Deciduous Shrub	1
61	Orchard	2
71	Native Grassland	1
81	Pasture/Hay	2
82	Row Crops	2
83	Small Grains	2
85	Other Grasses	2
91	Woody Wetlands	0
92	Herbaceous Wetlands	0
SAMAB		
110	Water	0
210	Low Intensity Residential	3
220	High Intensity Residential	3
230	High Intensity Commercial	3
310	Bare Rock/Soil	1
320	Quarries/Mines	2
330	Transitional/Clearcuts	1
410	Deciduous Forest	0
411	Northern Hardwood Forests	0
412	Mixed Mesophytic Hardwood Forests	0
413	Oak Forests	0
414	Bottomland Hardwood Forests	0
420	Evergreen Forest	0
425	White Pine / Hemlock Forests	0
426	Montane Spruce-Fir Forests	0
427	Southern Yellow Pine Forests	0
430	Mixed Forest	0
438	White Pine/Hemlock/Hardwood Forests	0
439	Mixed Pine/Hardwood Forests	0
510	Deciduous Shrub	1
610	Orchard	2
710	Native Grassland	1
810	Pasture/Hay	2

820	Row Crops	2
830	Small Grains	2
850	Other Grasses	2
910	Woody Wetlands	0
920	Herbaceous Wetlands	0
WMD		
1000-1599	Commercial, Residential, Industrial	3
1600-1649	Mining	2
1650	Reclaimed Mining Land	1
1660-1710	Mining Holding Ponds, Institutional, & Educational Facilities	2
1720-1790	Other Institutional Facilities	3
1810	Swimming Beaches	1
1820	Golf Courses	2
1830-1890	Intensive Recreational Facilities	3
1990-1950	Open, Disturbed Lands	1
2000-2111	Agriculture, Improved Pasture Land	2
2120-2130	Unimproved & Woodland Pastures	1
2140-2260	Row, Field, Crops	2
2300-2330	Feeding Operations	3
2400-2590	Nurseries, Vineyards, & Specialty Farms	2
2600	Fallow Agriculture	1
3000-3500	Rangeland	1
4000-4210	Upland Coniferous & Upland Hardwood Forest	0
4220	Brazilian Pepper (exotic)	2
4230	Oak-Pine-Hickory Forest	0
4240	Melaleuca (exotic)	2
4250-4360	Upland Hardwood Forest	0
4370	Australian Pine (exotic)	2
4380-4390	Upland Hardwood Forest	0
4410-4460	Tree Plantations or Tree Crops	0
5000	Open Water	0
6000	Wetlands	0
7000	Disturbed Land	1
7100-7340	Beaches, Natural Sand or Exposed Rock	0
7400-7930	Disturbed Land, Borrow, Spoil, Fill, & Burned Areas	1
8000-8880	Transportation, Communication, & Utilities	3
9000	Seagrasses	0

Then, the grid is reclassified to conform to the 1-10 valuation of the other single utility indices.

Land Use Intensity SUA Grid Values:

Value	Description
No data	Residential or Urban (previously 3)
1	Extractive or Agricultural (previously 2)
5	Bare or Exposed Areas, Deciduous Shrub, or Grassland (previously 1)
10	Water, Forests, or Wetlands (previously 0)

8.7. Distance from intensive land uses

1. Select all lands listed as Category 3 and create new grid.
2. Run a REGIONGROUP to select Category 3 patches 100 acres or greater.
3. Run a EUCDISTANCE to determine proximity to defined patches of Category 3 lands.
4. Rank lands based on distance away from defined Category 3 lands.

Distance from Intensive Land Uses SUA Grid values:

Value	Description
1	Lands not considered for this purpose
2	Lands between 90 and 100 Kilometers from Category 3 lands
3	Lands between 70 and 80 Kilometers from Category 3 lands
4	Lands between 60 and 70 Kilometers from Category 3 lands
5	Lands between 50 and 60 Kilometers from Category 3 lands
6	Lands between 40 and 50 Kilometers from Category 3 lands
7	Lands between 30 and 40 Kilometers from Category 3 lands
8	Lands between 20 and 30 Kilometers from Category 3 lands
9	Lands between 10 and 20 Kilometers from Category 3 lands
10	Lands less than 10 Kilometers from Category 3 lands

8.8. Distance from primary roads

1. Primary roads from EPA's road grid (R4_RDGRD) were selected to create an individual dataset.
1. Run a BLOCKMAX on the linear-based dataset to prepare for a resample.
2. Resample up to 90 meters cell size to match the NLCD grid.
3. Run a EUCDISTANCE to determine proximity to primary roads.
4. Rank lands based on distance away from primary roads.

Distance from Primary Roads SUA Grid value:

Value	**Description**
1	Lands not considered for this purpose
2	Lands between 90 and 100 Kilometers from Primary roads

3	Lands between 70 and 80 Kilometers from Primary roads
4	Lands between 60 and 70 Kilometers from Primary roads
5	Lands between 50 and 60 Kilometers from Primary roads
6	Lands between 40 and 50 Kilometers from Primary roads
7	Lands between 30 and 40 Kilometers from Primary roads
8	Lands between 20 and 30 Kilometers from Primary roads
9	Lands between 10 and 20 Kilometers from Primary roads
10	Lands less than 10 Kilometers from Primary roads

8.9. Conservation lands (10 if existing, otherwise a 1)

1. Use R4_CLAN (a dataset of all public and private conservation lands in the southeast, existing and proposed conservation lands were identified. Data sources are as follows:

(1) US Environmental Protection Agency - Forest Service Ownership Boundaries
(2) NASA / University of California at Santa Barbara {1996} - Comprehensive Managed Areas Spatial Database
(3) US Geological Survey - Federal and Indian Lands
(4) US Forest Service {1995-1998} - Alabama Forest Service Ownership Boundaries
(5) University of Florida GeoPlan Center {1994-1998} - Florida Conservation Areas Database
(5) GA Natural Heritage Program {1998} - Georgia Department of Natural Resources Lands
(7) GA Gap Project {1999} - Public and Private Conservation Lands
(8) US Geological Survey - Kentucky Wildlife Management Areas
(9) US Geological Survey - Kentucky State Managed Forests
(10) US Geological Survey; KY Department of Parks Facilities Guide {1991-1997} - Kentucky State Parks
(11) US Forest Service {1994-1996} - Mississippi National Forest Ownership Boundaries
(12) US Geological Survey {1997} - Mississippi National Park Boundaries
(13) MS Department of Wildlife, Fisheries, and Parks {1997} - Mississippi State Park Boundaries
(14) MS Department of Wildlife, Fisheries, and Parks {1997} - Mississippi Wildlife Management Areas
(15) US Geological Survey - South Carolina Nation Forests, Parks, Refuges, Reservations and Wildlife Management Areas Boundaries
(16) The Conservation Fund - North Carolina Conservation Areas
(17) US Environmental Protection Agency - North Carolina Lands Owned by The Nature Conservancy

Conservation Lands SUA Grid values:

Value	Description
1	Lands not considered for this purpose
10	Existing or proposed conservation lands

8.10. Road density grid

1. Use R4_NJPDENS7 (a road density grid created through LINEDENSITY with a unit scale factor of 1 mile to rank roads based on miles/sq. miles of roads).
2. Then, the grid is reclassified to conform to the 1-10 valuation of the other single utility indices.

Road Density SUA Grid values:

Value	Description
1	Greater than 3.0 miles/square mile
2	Greater than 2.5 and less than 3.0 miles/square mile
3	Greater than 2.0 and less than 2.5 miles/square mile
5	Greater than 1.5 and less than 2.0 miles/square mile
6	Greater than 1.0 and less than 1.5 miles/square mile
8	Greater than 0.5 and less than 1.0 miles/square mile
10	Less than or equal to 0.5 miles/square mile

8.11. Potential primary habitat in size classes

1. Use Primary potential habitat grid defined above.
2. Fragment habitat with primary roads (remove areas where roads exist)
3. Run a REGIONGROUP to determine patch sizes.
4. Rank based on size classes - 10,000 acres - 500,000 acres

Primary Habitat SUA Grid values:

Value	Description
1	Not Identified Potential Black Bear Habitat
5	Potential Primary Black Bear Habitat 10,000 acres or greater
7	Potential Primary Black Bear Habitat 50,000 acres or greater
8	Potential Primary Black Bear Habitat 100,000 acres or greater
9	Potential Primary Black Bear Habitat 250,000 acres or greater
10	Potential Primary Black Bear Habitat 500,000 acres or greater

8.12. Weighting the grids and creating the final MUA

1. Each grid was weighted based on knowledge of black bear biology and management and the scientific literature (Tom Hoctor, Pers. Comm.)

The SUA grids were weighted as follows:

1	*Input Dataset*
0.075	Potential Primary, Secondary and Tertiary Habitat
0.15	Potential Core Black bear habitat
0.15	Distance from Potential Core Black Bear habitat
0.05	Ranking roadless areas based on size classes and percentage of primary habitat contained within
0.05	Habitat Diversity
0.125	Category 123 lands
0.05	Distance from Cat3 lands
0.05	Distance from Primary roads
0.05	Conservation lands
0.05	Road density grid
0.20	Potential primary habitat in size classes

1. Add all weighted grids together (bb_all_sua).
2. Clip final product grid to Black bear location grid (actual black bear population locations with a 140 kilometer) (product grid: bb_buff_sua).
3. Clip the new grid to the Potential Primary habitat grid (product grid: bb_bufhab_sua).

9. Size Classification of PEAs

Reference file: prio_regional1.aml

Large water bodies (gt 1000 acres) were first excluded from PEAs. Large water bodies were defined as the following classes from NHD (National Hydrography Dataset): lake/pond, reservoir, sea/ocean. The remaining PEAs were then regiongrouped and grouped into the following classes:

Rank	***PEA Size***
1	not a PEA
2	lt 1,000 acres
3	1,000 - 4,999 acres

4	5,000 - 9,999 acres
5	10,000 - 24,999 acres
6	25,000 - 49,999 acres
7	50,000 - 99,999 acres
8	100,000 - 250,000 acres
9	250,000 - 500,000 acres
10	gt 500,000 acres

C. THREATS:

1. Context Analysis: Landscape Viability Index

This prioritization creates an index of landscape viability by combining four analyses: proximity to intensive land uses, proximity to major roads, density of intensive land uses, and road density.

A. Proximity to Large Areas (100 acres or greater) of Intensive Land Uses

1. Category 3 land uses, or intensive land use classes, such as commercial, residential, and transportation, were selected out of the cat123 dataset (a simplified land use dataset - see methods for "cat123" dataset for specific land use classes selected).

2. Contiguous category 3 land use regions were grouped together to evaluate sizes. All intensive land use areas greater than 100 acres were then selected out.

3. Euclidean distance was run on the regions of intensive land uses, and areas surrounding the land uses were ranked based on their proximity to the land use. The higher the rank, the closer proximity to intensive land uses.

Ranking of Areas in Proximity to Intensive Land Uses:

Rank	***Distance from Cat 3 Land Use (in meters)***
1	ge 5000
2	1001 - 5000
3	501 - 1000
4	101 - 500
5	le 100

B. Proximity to Major (Primary & Secondary) Roads

1. Primary and secondary roads were selected from TIGER/Line Road Files, and gridded at 90m.

2. Euclidean distance run on all primary & secondary roads, and areas surrounding the roads were ranked based on their proximity to the roads. The higher the rank, the closer proximity to roads.

Rank	***Distance from Primary & Secondary Roads***
1	ge 5000
2	1001 - 5000
3	301 - 1000
4	101 - 300
5	le 100

C. Density of Intensive Land Uses

1. Intensive land uses were separated into two categories - 2 & 3, in which 3 is the most intensive land uses such as commercial, residential, and transportation; and 2 is less intensive land uses such as extractive or agricultural. (See methods for cat123 dataset for more information).

2. A focal sum with a 18 x 18 neighborhood (1 square mile) was run on both categories of land uses. Areas were then ranked based upon the percentage of each type of land use within the square mile neighborhood. A higher rank, indicates a higher percentage /density of category 2 and 3 lands.

Rank	***Density of Category 2 Land Use***	***Density of Category 3 Land Use***
1	lt 10%	lt 2%
2	10 - 39%	2 - 9%
3	40 - 59%	10 - 19%
4	60 - 79%	20 - 29%
5	ge 80%	ge 30%

D. Road Density

1. A line density was run on all roads except jeep trails, and densities were reclassified as follows (a higher rank indicates a higher density of roads):

Rank	***Density of Primary & Secondary Roads (mi / sq.mi)***
1	le 0.5
2	0.5 - 0.99
3	1.0 - 1.99
4	2.0 - 2.99
5	gt 3

E. Combine Individual Analyses to Create Landscape Viability Context Index

Water bodies greater than 1000 acres were excluded from the final analysis. Then, the following five datasets were combined and averaged: Distance from Category 3 Land Use, Distance from Major Roads, Density of Category 2 Land Use, Density of Category 3 Land Use, and Road Density. The resultant grid yielded values from 1 - 4.8, in which a higher value indicates a lower landscape suitability. The values were then inverted to stay consistent with the other analyses, in which a higher number indicates a higher suitability / priority. The inverted values were reclassified into priority ranks from 1 to 10 based on equal interval, in which a higher rank indicates higher landscape suitability.

Priority Rank	***Index Score***
1	4.43 - 4.80
2	4.05 - 4.42
3	3.67 - 4.04
4	3.29 - 3.66
5	2.91 - 3.28
6	2.53 - 2.90
7	2.15 - 2.52
8	1.77 - 2.14
9	1.39 - 1.76
10	1 - 1.38

2. Urban Growth Potential Model

A. Distance to urban

(completed by Roger Tankersley, Jr. / Dennis Yankee Tennessee Valley Authority)

1. The first step was to create a GRID dataset of urban areas. Urban areas were defined as the following classes in the MRLC Landcover Dataset:

21	Low intensity residential
22	High intensity residential
23	High intensity commercial/industrial/transportation

2. The EUCDISTANCE function in Arc/Info GRID was used to compute the straight-line distance from every cell to the nearest urban area.

B. Distance to roads

(completed by Roger Tankersley, Jr. / Dennis Yankee Tennessee Valley Authority)

1. The first step was to transform the vector roads (Tiger 95 from ESRI Streetmap) database into raster GRID format, using the LINEGRID function with a resolution of 90 meters.

2. The EUCDISTANCE function in Arc/Info GRID was used to compute the straight-line distance from every cell to the nearest road.

C. Urban density

(completed by Roger Tankersley, Jr. / Dennis Yankee Tennessee Valley Authority)

Urban density was calculated as the number of cells in a 'sliding window' that were urban. Urban is defined as the following classes in the MRLC landcover classification database:

21	Low intensity residential
22	High intensity residential
23	High intensity commercial/industrial/transportation

An Arc/Info GRID containing only pixels defined as urban (defined as value '1') was used in the FOCALSUM command, which sums the number of pixels in the window. The result of that function is a GRID with sum values at every location, which was then divided by the total number of pixels in the window size, to arrive at a percent measure of urban at a given location on the ground.

D. Large scale urban density

(completed by John Richardson EPA Region 4)

Urban density was calculated as the number of cells in a 'sliding window' that were urban. Urban is defined as the following classes in the MRLC landcover classification database:

21 Low intensity residential
22 High intensity residential
23 High intensity commercial/industrial/transportation

This was done using a focal sum algorithm. Initially it was attempted as focal sum with a radius of 300 pixels. This was impractical due to the extremely long processing that it was taking. In order to speed it up, a blocksum on was done with a two step process, first with a 10 by 10 (300m by 300m) input, then resampled at 300m and the FOCALSUM run at a radius of 13 cells on the resampled 300m data.

```
Grid urban300sumx = blocksum(z:\region4\gridlib\mrlc_urban,rectangle,10,10,data)
Grid: urb_300sumx2 = resample(urban300sumx)
Grid: urban_fsx = focalsum(z:\temp\urb_300sumx2,circle,13,data)
```

E. Urban growth model - Combine all 4 layers

(completed by John Richardson EPA Region 4)

An Erdas Imagine model was developed with the Spatial modeler. The model combined all of the input layers with scaling for each of the layers :

distance to roads rescaled to 0 to 100 (unitless)
distance to urban rescaled to 0 to 100 (unitless)
urbandensity27 was divided by 5 (output values 0 to 20)
large scale urban (urbanfsx) scaled by 20*(log(urbanfsx)) output values 95 to 0

D. RECREATION POTENTIAL

1. Influence of Urban Areas

Hubs were divided into 10 individual groups based on population. A gravity model was developed for the ranked urban hubs with the mean population of each group used as the attraction or value for recreation potential. The results of the model were ranked 1-10 based using the natural breaks method. The calculations for the model are as follows:

$P_i = (\underline{W_j} / D_{ij})\log 10$

P_i = recreation potential at location i
W_j = attractiveness of location j
D_{ij} = distance between location i and j
= exponent for distance decay (2)

A log10 was applied to linearize the data. The mean values and corresponding ranks are as follows.

Mean Population	Rank
12,635	1
46,370	2
88,781	3
131,274	4
216,077	5
284,554	6
456,217	7
695,744	8
1,437,317	9
3,434,955	10

2. Influence of Conservation Lands

Conservation lands were divided into 10 individual groups based on acreage. A gravity model was developed for the ranked conservation lands with the mean acreage of each group used as the attraction or value for recreation potential. The equation for the model can be seen in the Influence of Urban Areas description. The results of the model were ranked 1-10 using the natural breaks method. The mean values and corresponding ranks are as follows.

Mean Acres	Rank
127	1
4,143	2
11,636	3
23,268	4
42,003	5
73,803	6
118,510	7
235,904	8
558,355	9
1,725,323	10

3. Water Based Recreation

Water bodies were divided into three individual groups based on their recreation potential. Coastal areas were given the highest recreational potential, with Wild and Scenic Rivers given the next highest and rivers, lakes and streams given the lowest value for recreational potential. A gravity model was developed for the ranked water features. The equation for the model can be seen in the Influence of Urban Areas description. The results of the model were ranked 1-10 based on the natural breaks method. The mean values and corresponding ranks are as follows.

Water Feature	Rank
Coastal	100
Wild and Scenic Rivers	50
Rivers, Lakes and Streams	10

4. Influence of Points of Interest

Points of interest were divided into three individual groups based on their recreation potential. . "Named" natural features were ranked the highest, nature based passive recreation features were ranked next and less passive nature based points of interest were ranked the lowest. A gravity model was developed for the ranked point of interest features. The equation for the model can be seen in the Influence of Urban Areas description. The results of the model were ranked 1-10 based on the natural breaks method. The mean values and corresponding ranks are as follows.

Point of Interest	Rank
City Parks, Historical Sites	100
Campgrounds, Parks, etc	50
Passive Recreation (Springs, Summits, Islands, etc)	10

II. HUB PRIORITIZATIONS

Hub Prioritizations Adapted From Regional Prioritizations

Some regional prioritizations were summarized by hub by taking the zonal mean of each, using the regional prioritizations as the value grid and the hub grid as the zone grid. The resultant grid from the zonal mean operation was a floating point grid, so it was converted to an integer grid. Four of the resultant grids did not have the full range of 1-10 values. For those, the resultant values from the zonal mean (floating point) were reclassified into 10 values. Those grids were: Surficial Aquifer Pollution

Vulnerability, Coastal Storm Protection Areas, Interior Forest Areas, and Proximity to Shellfish Harvesting Areas.

The following regional prioritizations were summarized by hub:

Ecosystem Services:
Shellfish Harvesting Areas
Major Rivers and Wild & Scenic Rivers
Wetlands: Size and Proximity
Surficial Aquifer Pollution Vulnerability
Coastal Areas Storm Protection

Recreation Potential
Influence of Urban Areas
Influence of Conservation Lands
Water Based Recreation
Influence of Points of Interest

Biodiversity:
Critical Aquatic Biodiversity Watersheds
Threatened & Endangered Species
Imperiled Species
At-Risk Aquatic Species
Conservation Lands: Size & Proximity
Interior Forest Areas
PEA Classes
Potential Black Bear Habitat

Threats
Context Analysis
Urban Growth Potential

A. HUB PRIORITIZATIONS: ECOSYSTEM SERVICES

1. Number of Stream Start Reaches per Hub

Reference file: STREACH.aml, ecoreach.aml, reachtoregion.aml

1. Run a LINEDENSITY of Stream start reach coverage
2. Find average stream reach density per hub (ZONALMEAN command).
3. Determine the range of values for each of the ecoregions.
4. Rank the hubs based on equal interval (range of values / # of classes [10]).

Ecoregion #	*Range of Stream Reach Densities*
63	0 - 21
65	0 - 29
66	2 - 33
67	2 - 30
68	4 - 29
69	6 - 29
70	2 - 23
71	0 - 27

72	2 - 25
73	1 - 23
74	1 - 27
75	0 - 18
76	0 - 5

2. Percent Wetlands per Hub

Reference file: rankthewethubs.aml

1. Create a wetlands grid based on Regional hydrography dataset (Land Use Context Index = 3).

2. Find percentage of SEAs per hub (COMBINE grids, and alter table to join back to the original Hub regiongroup grid).

3. Rank the Hubs based on percentage of wetlands. Percentages are reclassified using equal interval.

Rank	***Wetland Percent per Hub***
1	0 - 9.37%
2	9.38 - 18.75
3	18.76 - 28.13
4	28.14 - 37.51
5	37.52 - 46.89
6	46.90 - 56.27
7	56.28 - 65.65
8	65.66 - 75.03
9	75.04 - 84.41
10	84.42 - 93.79

3. Spatial Mix of Wetlands and Uplands

1. Use Wetlands and Uplands grids created above.

2. Determine hubs that have at least 20% wetlands or uplands.

3. Determine hubs that have at least 50% wetlands or uplands.

4. Identify hubs that have at least 20% of wetlands and at least 50% uplands (and vice versa).

5. Create grid of hubs that have a 20/50% spatial mix or a 50/20% spatial mix of uplands and wetlands.

Rank	*Spatial mix percentages*
1	Lands not considered
10	20% + wetlands/ 50% + uplands
10	20% + uplands/ 50% + wetlands

4. Surficial Aquifer Areas Vulnerable to Pollution by Hub

Reference file: prio_hubs_sua.aml

The regional prioritization for Surficial Aquifer Areas was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Surficial Aquifer Areas Vulnerable to Pollution.

5. Size & Proximity to Wetlands by Hub

Reference file: prio_hubs_sua.aml

The regional prioritization for size and proximity to wetlands was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Size & Proximity to Wetlands

6. Coastal Storm Protection Areas by Hub

Reference file: prio_hubs_sua.aml

The regional prioritization for coastal storm protection areas was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Coastal Storm Protection Areas.

7. Major and Wild & Scenic Rivers Buffers by Hub

Reference file: prio_hubs_sua.aml

The regional prioritization for major rivers and wild and scenic rivers was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Major and Wild & Scenic Rivers Buffers.

8. Shellfish Harvesting Areas Buffers by Hub

Reference file: prio_hubs_sua.aml

The regional prioritization for shellfish harvesting areas was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Proximity to Shellfish Harvesting Areas.

C. HUB PRIORITIZATIONS: BIODIVERSITY

1. Topographic Diversity

Reference AML: standard_dem2.aml, rankthedemhubs.aml

1. Run a ZONALSTD of to determine the standard deviation of the Digital Elevation Model (DEM) within each hub per ecoregion.

2. Determine the range of values for each of the ecoregions.

3. Rank the hubs based on equal interval (range of values / # of classes [10]).

Ecoregion #	*Range of DEM Standard Deviation Values*
63	0 - 11
65	0 - 117
66	4 - 311
67	3 - 214
68	7 - 135
69	22 - 172
70	16 - 65
71	3 - 100
72	1 - 12
73	1 - 26
74	1 - 27
75	0 - 19
76	0 - 4

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2. Size & Proximity to Conservation Lands
Reference file: prio_hubs_sua.aml

The regional prioritization for size and proximity to conservation lands was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Size & Proximity to Conservation Lands.

3. Black Bear Habitat Suitability Analysis
Reference file: prio_hubs_sua.aml

The regional prioritization for black bear habitat suitability was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Black Bear Habitat Suitability Analysis.

4. Interior Forests by Hub
Reference file: prio_hubs_sua.aml

The regional prioritization for interior forests was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Interior Forests.

5. PEA Size Classification
Reference file: prio_hubs_sua.aml

The regional prioritization for PEA size classification was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: PEA Size Classification.

6. Imperiled Species Priorities by Hub
Reference file: prio_hubs_sua.aml

The regional prioritization for imperiled species priorities was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Imperiled Species Priorities.

7. Listed Species Priorities by Hub

Reference file: prio_hubs_sua.aml

The regional prioritization for listed species priorities was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Listed Species Priorities.

8. At-risk Aquatic Species by Watershed

Reference file: prio_hubs_sua.aml

The regional prioritization for at-risk aquatic species by watershed was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: At-risk Aquatic Species by Watershed.

9. Critical Aquatic Biodiversity Watersheds

Reference file: prio_hubs_sua.aml

The regional prioritization for critical aquatic biodiversity watersheds was summarized by hub using the zonalmean command. Resulting values were used as the priority ranks per hub. For more details, see the full description for the regional prioritization in this appendix: Critical Aquatic Biodiversity Watersheds.

C. HUB RECREATION POTENTIAL

The recreation potential prioritization was created to identify recreation opportunities by hub. In order to identify opportunities, the influence of urban areas, conservation lands, water based recreation and points of interest were evaluated. These regional analyses were then summarized for hubs by calculating the average index value for each hub, using the zonalmean command. For more details, see the full description for the regional prioritization in this appendix: Regional Recreation Potential.

D. HUB THREATS

The regional threats analysis incorporate two related analyses that assess the threats from intensive land uses and roads that can both negatively affect ecological integrity existing natural and semi-natural lands, and the likelihood that such natural, semi-natural and agricultural lands will be converted to residential or urban land uses. These two regional analyses, Context Analysis and Urban Growth Potential, were then summarized for hubs by calculating the average index value for each hub, using the zonalmean command. For more details, see the full description for the regional prioritization in this appendix: Regional Threats.

E. HUB FUNCTION & STRUCTURE

1. Internal Gaps / Hub Density

Reference file: prio_hubs.aml

1. Focal sum with 11 x 11 neighborhood (approximately 1 square kilometer)

2. Take average of focal sum values per hub using zonal average command.

3. Reclassify hubs into size categories, based upon the natural log of the count. Resulting natural logs yielded eight values, from 8-15, from which eight size classes were made.

Size Class	*Hub Size (in Acres)*
1	5,000 - 9,826
2	9,827 - 26,640
3	26,641- 72,046
4	72,047 - 193,782
5	193,783 - 244,974
6	244,975 - 1,358,874
7	1,358,875 - 3,509,346
8	3,509,347 - 9,449,154

4. For each size class, focal sum averages when then reclassified into 1-10 ranks based on equal interval.

Focal Sum Values by Size Class & Associated Ranks

Size Class (Total Focal Sum Range)

Rank	***1:*** ***(64 -108)***	***2:*** ***(75 -113)***	***3:*** ***(85-115)***	***4:*** ***(98-117)***	***5:*** ***(102-117)***	***6:*** ***(109-117)***	***7:*** ***(108 -116)***	***8:*** ***(111-119)***
1	64 - 67	75 - 78	85 - 87	98 - 99	102 - 103	109	108	111
2	68 - 71	79 - 82	88 - 90	100 - 101	104 - 105	110	109	112
3	72 - 75	83 - 86	91 - 93	102 - 103	106	111	110	113
4	76 - 79	87 - 90	94 - 96	104 - 105	107 - 108	112	111	114
5	80 - 83	91 - 94	97 - 99	106 - 107	109	113	112	115
6	84 - 87	95 - 98	100 - 102	108 - 109	110 - 111	-	-	-

7	88 - 91	99 - 102	103 - 105	110 - 111	112	114	113	116
8	92 - 95	103 - 106	106 - 108	112 - 113	113 - 114	115	114	117
9	96 - 99	107 - 110	109 - 111	114 - 115	115	116	115	118
10	100 - 108	111 - 113	112 - 115	116 - 117	116 - 117	117	116	119

2 & 3. Internal Context of Hubs: Percent PEA/SEA per Hub

Reference file: prio_hubs.aml

1. Combine optimized hubs with PEAX (priority ecological areas after exclusion) using the COMBINE command. Combined optimized hubs with SEAX (significant ecological areas after exclusion) using the COMBINE command.

2. Calculate percentage of PEAX and SEAX (separately) per hub by dividing the number of peax and seax cells per total cells in linkage.

3. Reclassify percents into 1-10 ranks. The lower the rank, the lower the PEAX/SEAX percent. For PEAX per hub, there was no hub with less than 63% PEAX. For SEAX per hub, the variance was much greater, from 2% - 100%.

Rankings for Percent PEAX/SEAX per Hub

Rank	***Percent PEAX/ SEAX***
1	< 10 %
2	11 - 20 %
3	21 - 30 %
4	31 - 40 %
5	41 - 50 %
6	51 - 60 %
7	61 - 70 %
8	71 - 80 %
9	81 - 90 %
10	91 - 100 %

4. Hub Land Use Context Index

Reference file: spatial.aml

Land uses were grouped into 4 categories (categories 0,1,2,3), with category 0 representing natural land uses (water, forests, wetlands), category 1 representing semi-natural land uses (shrub, grasslands), category 2 representing moderate intensity land uses (agricultural, extractive), and category 3 representing highly intensive land uses (residential, commercial). This analysis uses only category 2 and 3 lands.

Values for the land use context index were calculated by assigning zones of influence for category 2 and 3 land uses, where the zones correspond to the intensity of disturbance caused by the land use. The intensity of disturbance is determined by both the intensity and the proximity to the land use.

The zones of influence or "effect" for the two categories of land use:

Category 2 Land Use: 3x3 cell rectangle around cat2 cell became value = 3, the 5x5 cell rectangle around the 3's became value 2, the 7x7 cell rectangle outside that became value = 1

Category 3 Land Use: 3x3 cell rectangle around cat3 cell value = 5, 5x5 cell rectangle value 4, 7x7 cell rectangle value 3, 9x9 cell rectangle value 2, and the 11x11 cell rectangle value 1.

The effect for each category of land use was calculated separately, and the two effects were combined so that the maximum value of each grid was the resultant value. The resulting range of values for the index was from 0 to 125, in which a higher value indicates higher land use intensities. This index was created for the entire region for use in evaluating regional, hub, and linkage land use context. For this prioritization in particular, the index values were averaged per hub. The averaged index values were then inverted to stay consistent with the other analyses, in which a higher value indicates a higher priority area (in this case a high value indicates a low priority area). Inverted values were finally reclassified into priority ranks from 1 to 10 based on equal intervals, in which a hub with lower land use intensities receives a higher priority rank.

5. External Context of Hubs: Land Use Context

Reference file: Externalandpeas3.aml, Rankthecat123hubs.aml

1. Create textfile of hub number, minimum and maximum coordinates of all hubs.

2. Setwindow to the x and y minimum and maximum coordinates per hub to create a proximity grid of 5 kilometers on a hub by hub basis.

3. Buffer area is combined with the Land Use Context Index (See methods above).

4. Find average cat123 ranking per buffer area (ZONALMEAN command).

5. Rank the Hubs based on equal interval zonal mean values.

Rank	*Zonal Mean Values*
1	0 – 10
2	11 – 21
3	22 – 32
4	33 – 43
5	44 – 54
6	55 – 65
7	66 – 76
8	77 – 87
9	88 – 98
10	99 - 109

6. External Context of Hubs: PEAs

Reference file: Peax_seax.aml, rankthepeahubs.aml

1. Create a text file of hub number, minimum and maximum coordinates of all hubs.

2. Set the analysis window to the x and y minimum and maximum coordinates per hub to create a proximity grid of 5 kilometers on a hub by hub basis.

3. Buffer area is combined with the PEAX grid (for information on PEAX grid, see the Appendix C: Data Lists for SEF Delineation).

4. Find percentage of PEAs per buffer area (COMBINE grids, and alter table to join back to the original Hub regiongroup grid).

5. Rank the Hubs based on percentage of PEAs. Percentages are reclassified based on natural breaks.

Rank	*PEA percentage Values*
1	1.6 - 6.8%
2	6.9 - 10.5%
3	10.6 - 13.4%
4	13.5 - 16.4%

5	16.5 - 19.8%
6	19.9 - 23.4%
7	23.5 - 27.3%
8	27.4 - 32.1%
9	32.2 - 39.4%
10	39.5 - 62%

7. External Context of Hubs: SEAs

Reference file: Peax_seax.aml,ranktheseahubs.aml

1. Create a text file of hub number, minimum and maximum coordinates of all hubs.
2. Set the analysis window to the x and y minimum and maximum coordinates per hub to create a proximity grid of 5 kilometers on a hub by hub basis.
3. Buffer area is combined with the SEAX grid (For more information on the SEAX grid, see the Appendix C: Data Lists for SEF Delineation.)
4. Find percentage of SEAs per buffer area (COMBINE grids, and alter table to join back to the original Hub regiongroup grid).
5. Rank the Hubs based on percentage of SEAs. Percentages are reclassified based on natural breaks.

Rank	*SEA percentage Values*
1	0.3 - 7.6%
2	7.7 - 13.2 %
3	13.3 - 17.6%
4	17.7 - 21.5%
5	21.6 - 25.3%
6	25.4 - 29.2%
7	29.3 - 33.9%
8	34.0 - 39.3%
9	39.4 - 46.2%
10	46.3 - 63.9%

8. Hub Total Area Index

Reference file: spatial.aml

Total Area Index values were determined by reclassifying total hub acreages to priority ranks from 1 to 10, where a higher rank corresponds to a larger hub area.

Assigned Ranks for Hub Total Area Index

Rank	***Hub Acreage***
1	lt 500 acres
2	500 - 1,500 acres
3	1,501 - 2,500 acres
4	2,501 - 5,000 acres
5	5,001 - 10,000 acres
6	10,001 - 50,000 acres
7	50,001 - 100,000 acres
8	100,001 - 500,000 acres
9	500,001 - 1,000,000 acres
10	gt 1,000,000 acres

9. Hub Core Area Index

Reference file: spatial.aml

1. Each hub was first shrunk by 500 meters (i.e., its outer edges were drawn-in 500 meters).

2. The areas remaining after the shrink are regiongrouped.

3. The thickest /deepest point in the remaining areas is found using the ZONALMAX command in grid. That distance was used as the diameter, from which the radius was calculated, and finally the area of a circle was calculated using that radius.

4. These core areas were reclassified into priority ranks from 1 to 10, where a higher rank corresponds to a larger core area.

Assigned Ranks for Hub Core Area Index

Rank	***Hub Acreage***
1	lt 500 acres
2	500 - 1,500 acres
3	1,501 - 2,500 acres
4	2,501 - 5,000 acres
5	5,001 - 10,000 acres
6	10,001 - 50,000 acres
7	50,001 - 100,000 acres
8	100,001 - 500,000 acres
9	500,001 - 1,000,000 acres
10	gt 1,000,000 acres

10. Core Roadless Area Index

Reference file: spatial.aml

1. Roads were excluded from hubs (set to no data)

2. Remaining hub areas were regiongrouped.

3. The thickest /deepest point in the remaining areas is found using the ZONALMAX command in grid. That distance was used as the diameter, from which the radius was calculated, and finally the area of a circle was calculated using that radius.

4. These areas were reclassified using the following scheme:

Assigned Ranks for Core Roadless Area Index

Rank	***Hub Acreage***
1	lt 500 acres
2	500 - 1,500 acres
3	1,501 - 2,500 acres
4	2,501 - 5,000 acres
5	5,001 - 10,000 acres

6	10,001 - 50,000 acres
7	50,001 - 100,000 acres
8	100,001 - 500,000 acres
9	500,001 - 1,000,000 acres
10	gt 1,000,000 acres

11. Perimeter of Circle to Perimeter of Patch (hub) Ratio

Reference file: spatial.aml

1. First, the area and perimeter of each hub were found.

2. Then, the Perimeter-of-Circle-to-Perimeter-of-Patch(hub) ratio was calculated using the equation:

$$\text{PCircle : PPatch} = \frac{2p \ * \ \text{sqrt(ACircle} / p)}{\text{PPatch}}$$

3. The ratio values are then reclassified into priority ranks from 1 to 10 based on equal interval, in which a higher rank corresponds to a lower ratio or better hub shape.

12. Corrected Perimeter to Area Ratio

Reference file: spatial.aml

1. Corrected-perimeter-to-area ratio is calculated using an equation found in "Principles and Methods in Landscape Ecology" by Almo Farina. The equation is as follows:

$$\text{Corrected Perimeter:Area} = (0.282 * \text{perimeter}) / \text{sqrt\_area}).$$

2. Corrected-perimeter-to-area ratios were converted into priority ranks from 1 to 10 by using the reclassification scheme:

Rank	***Calculated P:A Ratio***
1	gt 28
2	25-27
3	22-24
4	19-21
5	16-18

6	13-15
7	10-12
8	7-9
9	4-6
10	1-3

13. Amount of Roads Per Hub

Reference file: spatial.aml

Amount of roads per hub was calculated by dividing the number of primary and secondary road cells per hub by the total number of cells per hub. The hubs were then given rankings from 1-10, where a low ranking indicates a high percentage of road cells per hub and a high ranking indicates a low percentage.

Rank	*% Road Cells per Hub*
1	gt 10%
2	7 - 9.99
3	5 - 6.99
4	4 - 4.99
5	3 - 3.99
6	2 - 2.99
7	1 - 1.99
8	.5 - .99
9	0 - .49
10	0

Note: This index is sensitive to the cell size of the input grids. We used a 90 meter cell size, in which most of the roads were represented with a one-cell width. Generally, the larger the cell size, the more roads will be represented. However, since this is a relative scale, we are mainly concerned with which hubs are better depending upon which have "more" or "less" roads.

III. LINKAGE PRIORITIZATIONS

Separating Linkages into Discrete Segments
Reference file: separate_links.aml

1. Take buffered links from /auto/epa1/linkage/links/, and check with SEF (those buffered links have not been cleaned and optimized);

2. Erase optimized hubs.

3. Regiongroup result from above (#2) and delete areas smaller than five cells.

4. Include only segments that connect two different hubs.

A. INTERNAL CONTEXT ANALYSES

1. Percent Priority Ecological Areas per Linkage

Reference file: prio_links.aml

1. Peax (priority ecological areas after exclusion) and the linkages were overlayed using the COMBINE command. The result from this function yielded the number of peax cells per each linkage, from which the percentage of peax per linkage was calculated.

2. Percents were reclassified into 1-10 ranks based on equal interval of range. Ranges for each linkage type were as follows: General: 0-61%; Upland: 0-42%; Riparian: 0-97%

Ranking for Percent PEA by Linkage Type

	Percent PEAX		
Rank	***General***	***Upland***	***Riparian***
1	0 - 6%	0 - 4%	0 - 10%
2	7 - 12%	5 - 8%	11 - 20%
3	13 - 18%	9 - 12%	21 - 30%
4	19 - 24%	13 - 16%	31 - 40%
5	25 - 30%	17 - 20%	41 - 50%
6	31 - 36%	21 - 24%	51 - 60 %
7	37 - 42%	25 - 28%	61 - 70%
8	43 - 49%	29 - 32%	71 - 80%
9	50 - 55%	33 - 36 %	81 - 90%

10	56 - 61%	37 - 42%	91 - 97%

2. Percent Significant Ecological Areas per Linkage

Reference AML: prio_links.aml

1. SEAX (significant ecological areas after exclusion) and the linkages were overlayed using the COMBINE command. The result from this function yielded the number of seax cells per each linkage, from which the percentage of seax per linkage was calculated.

2. Percents were reclassified into 1-10 ranks based on equal interval of range. Ranges for each linkage type were as follows: General: 0-87%; Upland: 0-94%; Riparian: 0-99%

Ranking for Percent SEA by Linkage Type:

Percent SEAX

Rank	***General***	***Upland***	***Riparian***
1	0 - 8%	0 - 10%	0 - 10%
2	9 - 17%	11 - 20%	11 - 20%
3	18 - 26%	21 - 30%	21 - 30%
4	27 - 34%	31 - 40%	31 - 40%
5	35 - 43%	41 - 50%	41 - 50%
6	44 - 52%	51 - 60%	51 - 60%
7	53 - 60%	61 - 70%	61 - 70%
8	61 - 69%	71 - 80%	71 - 80%
9	70 - 77%	81 - 90%	81 - 90%
10	78 - 87%	91 - 94%	91 - 99%

3. Percent of Primary & Secondary Roads per Linkage

Reference file: prio_links.aml

1. Primary and secondary roads were overlaid with the linkage segments using the COMBINE command. The result from this function yielded the number of primary and secondary road cells per each linkage, from which the percentage of road cells per linkage was calculated.

2. Percentages were reclassified into 1-10 ranks based on natural breaks. The smaller the % of roads, the higher the rank.

Range of Roads Percentages per Linkage:

Percent Roads

Rank	*General*	*Upland*	*Riparian*
1	17 - 29%	16 - 18%	20 - 34%
2	14 - 16%	14 - 15%	16 - 19%
3	12 - 13%	12 - 13%	14 - 15%
4	11.00%	11.00%	12 - 13%
5	9 - 10%	9 - 10%	9 - 11%
6	7 - 8%	7 - 8%	7 - 8%
7	5 - 6%	6.00%	5 - 6%
8	3 - 4%	3 - 5%	3 - 4%
9	1 - 2%	1 - 2%	1 - 2%
10	0.00%	0.00%	0.00%

4. Contextual Land Use Index

Reference file: prio_links.aml

1. Find average cat123 effect ranking per linkage. (zonalmean, using linkage segments as zone grid, and cat123_effect grid as value grid)

2. Average cat index values are reclassified into 1-10 ranks based on natural breaks. Values were reclassified as the following:

Focal Sum Values

Rank	*General*	*Upland*	*Riparian*
1	77 - 95	63 - 86	87 - 111
2	67 - 76	46 - 62	74 - 86
3	58 - 66	41 - 45	65 - 73
4	51 - 57	36 - 40	56 - 64
5	45 - 50	31 - 35	47 - 55
6	37 - 44	25 - 30	39 - 46

7	29 - 36	19 - 24	30 - 38
8	22 - 28	13 - 18	20 - 29
9	14 - 21	3 - 12	10 - 19
10	0 - 13	0 - 2	0 - 9

B. EXTERNAL CONTEXT ANALYSES

1. PEA Context of Linkages

Reference AML: prio_links_cntxt.aml

Iterative process which evaluates one linkage at a time:
1. One kilometer buffer is created around the linkage (EUCDISTANCE command)

2. Buffer area is with combined PEAX (priority ecological areas after exclusion) grid using the COMBINE command. Then the percentage of the buffer area that is PEAX is calculated.

3. Percentages are reclassified into 1-10 ranks based on equal interval of the range. Ranges of PEAX percents were as follows: General linkages: 7-87%; Upland: 23-92%; Riparian: 4-85%

Ranking of Percent PEAX per Linkage Buffer

Rank	***General***	***Upland***	***Riparian***
1	7 - 14%	23 - 29%	4 - 11%
2	15 - 22%	30 - 36%	12 - 19%
3	23 -30%	37 - 43%	20 - 27%
4	31 - 38%	44 - 50%	28 - 35%
5	39 - 46%	51 - 57%	36 - 43%
6	47 - 54%	58 - 64 %	44 - 51%
7	55 - 62%	65 - 71%	52 - 60%
8	63 - 70%	72 - 78%	61 - 68%
9	71 - 78%	79 - 85%	69 - 76%
10	79 -87%	86 - 92%	77 - 85%

2. SEA Context of Linkages

Reference file: prio_links_cntxt.aml

Iterative process which evaluates one linkage at a time:
1. One kilometer buffer is created around the linkage (EUCDISTANCE command)

2. Buffer area is combined SEAX grid using the COMBINE command. Then the percentage of the buffer area that is SEAX is calculated.

3. Percentages are reclassified into 1-10 ranks based on equal interval of the range. Ranges of SEAX percents were as follows: General: 3-90%; Upland: 10-77%; Riparian: 2-86%.

Ranking of Percent SEAX per Linkage Buffer

Rank	***General***	***Upland***	***Riparian***
1	3 - 10%	10 - 15%	2 - 9%
2	11 - 19%	16 - 22%	10 - 17%
3	20 - 28%	23 - 29%	18 - 26%
4	29 - 36%	30 - 35%	27 - 34%
5	37 - 45%	36 - 41%	35 - 43%
6	46 - 54%	42 - 49%	44 - 51%
7	55 - 62%	50 - 55%	52 - 59%
8	63 - 71%	56 - 62%	60 - 67%
9	72 - 80%	63 - 69%	68 - 76%
10	81 - 90%	70 - 77%	77 - 86%

3. Land Use Context of Linkages

Reference file: prio_links_cntxt.aml

Iterative process which evaluates one linkage at a time:
1. One kilometer buffer is created around the linkage (EUCDISTANCE command)

2. Buffer area is combined with the CAT123 Effect grid (See methods for cat123 effect from spatial characterizations).

3. Find average cat123 ranking per buffer area (ZONALMEAN command).

4. Average CAT123 values are reclassified into 1-10 ranks based on natural breaks. The lower the CAT123 value, the better the land use context. Range of average CAT123 values are as follows: General linkages: 1-80; Riparian: 1-80; Upland: 1-79

Rank	*General*	*Upland*	*Riparian*
1	81 - 90	57 -79	87 - 106
2	69 - 80	51 - 56	80 - 86
3	58 - 68	46 - 50	72 - 79
4	50 - 57	38 - 45	62 - 71
5	44 - 49	31 - 37	53 - 61
6	37 - 43	25 - 30	45 - 52
7	30 - 36	17 - 24	35 - 44
8	23 - 29	11 - 16	23 - 34
9	8 - 22	4 - 10	11 - 22
10	1 - 7	0 - 3	4 - 10

C. WIDTH ANALYSES

1. Density Analysis of Linkages

Reference file: prio_links_width.aml

1. Focal sum on all linkages with a 11x11 neighborhood (approximately 1 square kilometer). The maximum possible value for the 11 x 11 neighborhood focal sum is 121, which would equal a neighborhood with 100% linkage cells (an area with no holes). A value of 60 would equal a neighborhood with approximately 50% linkage cells.

2. Calculate average focal sum value for the linkage using zonal average command.

3. Reclassify average focal sum values into 1-10 ranks based on natural breaks. The range of average focal sum values was as follows: General: 40 - 115; Upland: 44-112; Riparian: 18 - 109.

Ranking of Average Focal Sum Values by Linkage Type:

Rank	*General Average Focal Sum Values*	*Upland Average Focal Sum Values*	*Riparian Average Focal Sum Values*
1	40 - 54	44 - 55	15 - 33
2	55 - 73	56 - 73	34 - 53
3	74 - 79	74 - 80	54 - 65
4	80 - 86	81 - 86	66 - 73
5	87 - 91	87 - 91	74 - 81
6	92 - 95	92 - 96	82 - 87
7	96 - 100	97 - 99	88 - 92
8	101 - 105	100 - 102	93 - 97
9	106 - 110	103 - 106	98 - 102
10	111 - 115	107 - 112	103 - 109

2. Width Measurement: Corrected Perimeter to Area Ratio

Reference file: prio_links_width.aml

1. Area of all linkages is calculated with the zonalgeometry command.

2. The perimeter to area ratio is calculated using the following equation:
Corrected Perimeter:Area = (0.282 * perimeter) / sqrt_area)

3. Ratio values are reclassified into 1-10 ranks based on natural breaks. A lower ratio indicates a better linkage shape, and hence is given a higher rank. Ratio ranges are as follows: General linkages: 1.5 - 8.82; Upland: 1.89 - 15.07; Riparian: 2.16 - 15.61.

Ranking of Perimeter to Area Ratio Values by Linkage Type

Rank	*General P:A Ratio*	*Upland P:A Ratio*	*Riparian P:A Ratio*
1	6.03 - 8.82	11.86 - 15.07	12.46 - 15.61
2	4.63 - 6.02	8.04 - 11.85	9.89 - 12.45
3	3.70 - 4.62	6.61 - 8.03	7.89 - 9.88
4	3.30 - 3.69	5.20 - 6.6	6.74 - 7.88
5	3.01 - 3.29	4.33 - 5.19	5.94 - 6.73
6	2.74 - 3.00	3.71 - 4.32	5.07 - 5.93

7	2.48 - 2.73	3.17 - 3.7	4.23 - 5.06
8	2.25 - 2.47	2.79 - 3.16	3.60 - 4.22
9	1.96 - 2.24	2.32 - 2.78	2.95 - 3.59
10	1.5 - 1.95	1.89 - 2.31	2.16 - 2.94

D. HUB PRIORITY

1. Prioritizing Linkages by Hub Priority Rank

Reference file: prio_links_hubrank.aml

1. Expand linkages by 1 cell.

2. Combine expanded linkage grids with regiongrouped hub grid to see which hubs correspond to which linkages.

3. Join final hub ranks (hub_mua_all) to combined grid result from step 2.

4. Find average of connected hub ranks for each linkage. The averages were then reclassified into 1-10 ranks based on natural breaks:

Rank	*General Avg Hub Rank*	*Upland Avg Hub Rank*	*Riparian Avg Hub Rank*
1	1 - 1.5	1 - 1.3	1 - 1.5
2	1.51 - 2	1.31 - 2	1.51 - 2.33
3	2.01 - 2.5	2.01 - 2.75	2.34 - 3
4	2.51 - 3	2.76 - 3.5	3.01 - 3.66
5	3.01 - 3.75	3.51 - 4.5	3.67 - 4
6	3.76 - 4.5	4.51 - 5.5	4.01 - 5
7	4.51 - 5.5	5.51 - 6	5.01 - 6
8	5.51 - 6.5	6.01 - 7	6.01 - 7
9	6.51 - 7.5	7.01 - 8	7.01 - 8.5
10	7.51 - 10	8.01 - 9	8.51 - 10

For Linkage MUA --> if plan on taking out links that only connect parts of the same hub, then use segments under /epa1/prio/links/ (has an item for # of hubs), and filter out all links where numhubs == 1, and then reclassify using equal area

Linkage MUAs

	General	Upland	Riparian
Rank	***Avg SUA Rank***	***Avg SUA Rank***	***Avg SUA Rank***
1	2.3 - 4.4	2.7 - 3.8	2.9 - 3.9
2	4.5 - 4.7	3.9 - 4.4	4.0 - 4.5
3	4.8	4.5 - 4.8	4.6
4	4.9 - 5.0	4.9 - 5.1	4.7 - 4.9
5	5.1	5.2 - 5.5	5.0 - 5.1
6	5.2 - 5.3	5.6 - 5.9	5.2 - 5.4
7	5.4 - 5.6	6.0	5.5 - 5.6
8	5.7 - 5.8	6.1 - 6.2	5.7 - 6.0
9	5.9 - 6.2	6.3 - 6.6	6.1 - 6.5
10	6.3 - 7.7	6.7 - 6.8	6.6 - 8.0

IV. CREATION OF MULTIPLE UTILITY ASSIGNMENTS (MUAs)

MUAs were created by taking the average of all SUAs in each prioritization category. The MUAs were ranked using equal area in order to spatially distribute the values into ten equivalent geographic classes, in which each class is representative of 10% of the total land area in the SEF. The highest priority sites can then be considered those areas which fall into the top ten percent.

Five regional MUAs, six hub MUAs, and one linkage MUA were created. Four MUAs that were clipped to the SEF boundary were also created. MUAs are listed below, with the corresponding input SUAs. Weighting of input SUAs was used only when noted.

A. REGIONAL PRIORITIZATION MUAs

1. Regional Ecosystem Services MUA

Surficial Aquifer Areas Vulnerable to Pollution
Size & Proximity to Wetlands
Surface Water Source Priorities
Ground Water Priorities

- Major and Wild & Scenic Rivers Buffers
- Coastal Storm Protection Areas
- Proximity to Shellfish Harvesting Areas

2. Regional Biodiversity MUA
   - Size & Proximity to Conservation Lands
   - Interior Forests
   - Old Growth and Significant Longleaf Pine Forest Stands
   - Imperiled Species Priority Areas
   - Listed Species Priority Areas
   - At-risk Aquatic Species by Watersheds (HUCs)
   - Critical Watersheds for Aquatic Biodiversity
   - Black Bear Habitat Suitability Analysis
   - PEA Size Classification

3. Regional Threats MUA
   - Context Analysis
   - Urban Growth Pressure Model

4. Regional Recreation Potential MUA

The Influence of Urban Hubs, Influence of Conservation Lands, Water Based Recreation and Influence of Points of Interest SUAs were combined to create a Recreation Potential MUA. The SUAs were weighted and then added together. SUA grids and associated weights are as follows.

SUA	Weight
Influence of Urban Hubs	0.1
Influence of Conservation Lands	0.4
Water Based Recreation	0.2
Influence of Points of Interest	0.3

5. Final Regional MUA

A final regional MUA was created by averaging the four regional MUAs:

- Regional Ecosystem Services MUA
- Regional Biodiversity MUA
- Regional Threats MUA
- Regional Recreation Potential MUA

B. HUB PRIORITIZATION MUAs

1. Hub Function / Structure MUA

- Total Area Index
- Core Area Index
- Roadless Area Index
- Perimeter of a Circle to Perimeter to a Hub
- Perimeter to Area Ratio
- Amount of Roads per Hub
- Contextual Rating
- Hub Density/ Internal Gaps
- External Contextual Analysis: Land Use
- External Contextual Analysis: PEA
- External Contextual Analysis: SEA
- Internal Context of Hubs: PEA
- Internal Context of Hubs: SEA

2. Hubs Ecosystem Services MUA

	Weight
Stream Start Reaches by Hub	0.21
Surficial Aquifer Vulnerability to Pollution	0.21
Size & Proximity to Wetlands	0.21
Proximity to Shellfish Harvesting Areas	0.08
Coastal Storm Protection Areas	0.08
Major and Wild & Scenic Rivers	0.21

The Hub Ecosystem Services MUA was weighted in order to counteract the coastal areas bias in the MUA analysis. Two of the six ecosystem services SUAs, proximity to shellfish harvesting areas and coastal storm protection, are heavily coast oriented. When combining these two datasets with the rest of the SUAs, the resulting MUA shows a heavy priority bias towards the coasts. Coastal areas are important for ecosystem services, however the resulting coastal bias is more an outcome of data availability, rather than an accurate depiction of priority ecosystem services areas. Hence, ecosystem services have not been comprehensively represented, but the weighting scheme used provides for the most accurate depiction of ecosystem services with the data available. Ideal future datasets would include air quality, carbon sequestration rates, areas upstream of drinking water intake points, and complete 100 and 500 year floodplain data (only parts of the region have been completed).

3. Hub Biodiversity MUA

- Topographic Diversity
- Size & Proximity to Conservation Lands
- Black Bear Suitability Analysis
- Interior Forest Areas
- PEA Size Classification
- Imperiled Species Priorities

Threatened and Endangered Species Priorities
At-risk Aquatic Species Priorities
Critical Aquatic Biodiversity Watersheds

4. Hub Threats MUA

Landscape Viability Analysis
Urban Growth Model

5. Hub Recreation MUA

6. Final Hub MUA

The final Hub MUA was created by averaging the five hub MUAs listed below:

Hub Function / Structure MUA
Hubs Ecosystem Services MUA
Hub Biodiversity MUA
Hub Threats MUA
Hub Recreation MUA

C. LINKAGE PRIORITIZATION MUA

Internal Context: Percent PEA
Internal Context: Percent SEA
Internal Context: Percent of Primary and Secondary Roads
Internal Land Use Context
External Context: PEAs
External Context: SEAs
External Context: Land Use
Perimeter to Area Ratio
Density
Hub Ranks

D. SEF PRIORITIZATION MUA

Prioritization was first completed for the entire region to evaluate all the ecological priorities and threats that occur region-wide. However, the primary purpose of the prioritization phase of the SEF Project was to identify areas within the SEF that are a higher priority for protection and attention. Hence, the four regional MUAs created were clipped to the boundaries of the SEF to isolate framework areas for evaluation.
They are as follows:

SEF Ecosystem Services MUA
SEF Biodiversity MUA
SEF Threats MUA
SEF Recreation Potential MUA

Appendix F: Mississippi Delta Framework Technical Methods

Primary Ecological Areas (PEAs)

Below is the list of PEAs used in the Delta Framework. Following each name is an explanation of how each was made and the commands and software used to create them. All GRIDS were projected in the EPA R4 Albers projection.

LC_90m (Land Cover at 90m resolution)
All Land Cover Grids used in the DF are based on the MRLC (Multi-Resolution Land Cover, now called NLCD) from LANDSAT 7, dated 1992-1993.

First did a Neighborhood Statistics analysis in AV to resample to LC in a majority fashion. I used a 3x3 cell majority of a rectangle –to resample LC at 90m cells by the majority LC in each cell, then MapCalculated the output grid (Command: [MRLC_Delta] *1.AsGrid), to reclassify at 90m.

More notes on MajorityFilter: I set the parameters to "True" to get a 90m output grid that has sampled all 8 surrounding cells (first true parameter) and to ensure the output must have at least half (4 of 8) cells in one LC type to be designated that type (second "true" parameter). Decided to use the "half" parameter b/c it was a conservative way to get forest blocks that were at least 1/2 forest, not just a plural majority (2 or 3 out of 9, but the most of one LU). See Help topic: Majority Filter for details.

--

1. PEA_RDLESS (Roadless Areas)
Rationale: This grid was made to identify large roadless areas. These areas are considered valuable for ecological processes and wildlife habitat because they are largely undeveloped and undisturbed, and often have whole ecosystems still relatively intact. Based on 1992-93 MRLC.
Step 1: ROADS_30M: Input layer was a roads coverage clipped to the Delta area from ESRI Street Maps, based on TIGER 1995 roads coverage. These original coverages can be found on either website. Cut original coverage to fit boundaries of DF; saved as Delta_rds_r4.shp. Converted Delta_rds_r4.shp to 30m grid in AV.
Step 2: ROAD_SUM:
Command (Arc) GRID: ROAD_SUM = BLOCKMAJORITY (ROADS_30m, rectangle, 3, 3, data)
This sets the resampling of ROADS in a 3 (30m) cells x 3 (30m) cells rectangle to the majority field.
Step 3: ROADSUM_90m: Created a 90m summary grid of roads from Road_Sum. In AV MapCalculator.
Command: [ROAD_SUM]*1.AsGrid (I multiplied it times itself at 90m to resample.)

Step 4: ROADLESS_90m: Then Reclassified ROADSUM_90M values in AV to set roads = 0 and roadless areas = 1, creating a converted or "roadless" grid, where value 1 = roadless areas.
Step 5: ROADLESS: In AV MapCalculator <u>Command</u>: ([Roadless_90m] * [Lc_90m . Toggle]) to get roadless areas with majority natural cover. Majority natural cover means that the Landsat data was resampled from 30 to 90m using the BLOCKMAJORITY <u>Command</u>. This <u>Command</u> reassigns the value of the new 90m cell to whichever LC type was dominant in that cell. LC classes used as "natural" are (in Toggle field turned to 1): 41, 42, 43, 51, 71, 91, 92. (*See MRLC Classes for details*.)
Step 6: PEA_RDLESS: (Primary Eco Area of Roadless Areas)
Regiongrouped ROADLESS in AV MapCalculator. <u>Command</u>: ([roadless].regiongroup (true, true, 0)
then ReClassed ROADLESS to get only natural roadless areas of 5000+ acres. (1 = 2500+ pixin "Count" field, 0 = all else).
*This Grid was then converted into BLK_Forest, large forested roadless blocks; itself not a PEA.

<u>2. PEA_POTBBHAB</u> (Potential Black Bear Habitat)
Used criteria for black bear habitat supplied by the Louisiana Black Bear Conservation Committee to model for potential black bear habitat in the Delta (forested areas of 10,000 or more, distanced from urban areas and major roads).
Step 1: Used FOREST_BLOCKS (forest incl forested wetlands ge 10,000 acres) as habitat base.
Step 2: Ran the exclusions to eliminate areas of high road density and inappropriate land use. (Appropriate road density = areas of less than 2 miles of roads per 1 square mile area. Inappropriate land uses were defined as MRLC categories 21, 22, 23, 81, 82, and 83—urban and intense agriculture.)
Step 3: Excluded areas within 0.5 miles of a major (Class 1) road.
Step 4: Reclassified the grid to cut the polygons into 10,000 acre hubs (ge 5,000 pixels).

<u>3. PEA_BBHAB</u> (Actual known Black Bear Habitat)
Took the PEA_POTBBHAB grid and crossed it with the black bear habitat boundaries supplied by the LA Black Bear Conservation Committee to get actual, known occupied black bear ranges (All_bbhab).
<u>Command</u> (in AV): MapCalculator: ([PEA_POTBBHAB] * [All_bbhab])

<u>4. PEA_BCAS_POT</u> (Bird Conservation Areas, Potential)
<u>Rationale:</u> To identify potential migratory bird nesting and feeding areas in the MS flyway, based on Fish and Wildlife criteria (Charlie Baxter's work). Migratory birds are critical species in the Delta and a good indicator of ecological health. The result was forested areas of low road density and at least 1km from ag lands in groups of at least 10,000 acres to serve as potential habitat according to FWS criteria.
Step 1: Set Analysis Props to 30m, Converted BCA shapefile from FWS into a grid.
Step 2: Ran Neighborhood Statistics of a Rectangle – Majority at 3x3 cell size on BCA_30m to get a majority filter 90m output in which each 90m cell designated BCA is at least half BCA.

Step 3: Then MapCalculated the [NbrMajGrid]*1.AsGrid to reclassify at 90m.
Step 4: ReClassified LC_90m as Ag only, then ran Find_Distance on it. Did this to identify areas in proximity to agriculture lands to be excluded from BCA habitat, as birds that nest in ag areas often compete with migratory birds and therefore do not make good migratory bird habitat.
Step 5: ReClassed of ag buffer grid to identify areas ge 1km from ag lands.
Step 6: In AV, MapCalculated [AG_BUFF_RC] * [FOREST_BLOCKS] to get only 10k acre forest blocks that output value of 2, to be at least 1km from ag.

5. PEA_BCA2 (Bird Conservation Areas, version 2)
Same process as above, but cut to FWS BCA boundaries to serve as actual habitat

6. PEA_REFTRKNG (Reforest Tracking Areas)
These are places where reforestation efforts are occurring on public lands. Source: US FWS Joint Venture program. Simply reprojected and converted refors_trkng_sys.shp to a grid.

7. PEA_WRP: (Wetlands Reserve Program)
These are the 2000 WRP areas for each state except TN (TN was not available in digital format). WRP is a wetlands reserve program run by the NRCS. Data was collected from the NRCS state field office.
I simply compiled all the states' shapefiles and converted them into 30m grid.

8. PEA_PUBLANDS: (Publicly Managed Lands)
This is a compilation of managed areas, state and federal, from various (but not all) sources. The lands shown here were the ones digitized and publicly available in the fall of 2000. It is a combination of the following database layers:

Federal Lands from the USGS Fed Land database (avail on the USGS website). Includes lands from all major public agencies, including Forest Service, Park Service, Corps of Engineers, etc.
Joint Venture State Wildlife Management Areas
Joint Venture National Wildlife Refuges
LA Wildlife Management Areas (Source: LA GAP program)
LA GAP areas of the MAV (MS Alluvial Valley) (Source: LA GAP program)
AR Wildlife Management Areas (Source: AR CAST program)
AR Stewardship Areas (Source: AR CAST program)
AR Game and Fish Commission Wildlife Management Areas
MS GEMS Program areas (Gulf Ecological Management areas)
State NRCS WRP areas (2000)

9. PEA_HABDIVER (Habitat Diversity)

Rationale: This grid identifies areas of multiple habitat types in one area. These are valued more highly than areas of a single land cover type.

Step1: Selected the following land cover types from 30 m MRLC grid to be used:
1 = 51 Decid shrub, 52 Evgr Shrub, 53 Mixed Shrub, 71 Grassland/Herbaceous
2 = 91 Woody Wetlands
3 = 92 Emergent Herbaceous Wetlands
4 = 42 Evergreen Forest
5 = 43 Mixed Forest
6 = 41 Deciduous Forest
Step 2: Calculated a focal variety of those land cover types in a 27 cell window to find how many of each type were in each cell.
Command: (Arc) GRID: Habvar2 = focalvariety(Habdiv, rectangle, 27, 27, data)
Step 3: ReClassified each cell as having 0-6 habitat types
Step 4: Calculated at least 90% habitat coverage in a 27 window:
Command: (Arc) GRID: HABDIV4 = focalsum(habdiv.index, rectangle, 27, 27, data)
Step 5: Crossed areas of high diversity with areas of at least 90% natural habitat coverage.
Command: (AV) MapCalculated: ([Habvar3] * [Habdiv4 . Habdiv]) to get grid of habitat variety classes
in areas of 90% coverage only.
Step 6: Excluded areas of urban and agriculture lands.
Step 7: Selected only areas with 3 or more habitat types to be "High Diversity" areas.
Command: (AV) MapCalc: ([Habdiv_90per] * [Agtrans_mask . mask] *[Urban_mask1 . mask])
Added field, "HighDiv," in which values ge 3 = 1, 0-2 = 0.

10. PEA_2WETLANDS

This grid is simply the herbaceous and forested wetlands extracted from the MRLC Land Use database. Type 1 wetlands are the woody wetlands (MRLC class 91), and Type 2 wetlands are the herbaceous wetlands (MRLC Class 92). It is at a 30m resolution, and like the MRLC, dates 1992-1993.

PEA_COMBO3 (PEA Combination grid, version 3)

Rationale: This is all PEA's combined as a prelude to creating the Hubs. It's also a very useful matrix, as each PEA can be pulled put separately, or they can be viewed in any desired combination.
Command: (Arc) Grid: **PEA_COMBO3** = combine(pea_bbhab, pea_potbbahb, pea_rdless, pea_bca2, pea_publands, pea_wrps, pea_refortrk, pea_habdiv.highdiv, pea_wetland)

PEAX development

Rationale: To exclude areas of high road density and urban land use

Step 1: Generate exclusion mask
use **pea_allmsk (generated from PEA_COMBO3)** to generate **PEAX** deleting an incompatable land use, high rd density
focal sum **mrlc_urban90** with 3x3 9x9 and 27x27 window
add field xclude to output of each 1= exclude
region group **mrlc_urban90** then select groups over 100 acres, buffer and select within 270 m of that
output to **urbana100x**
or together the excluded areas from

```
2001 09 28 1500   2   109     0jrr01 h:\temp\calc1 = (((((p:\ms_delta\jr_redo\urban100x) OR (p:\ms_delta\jr_redo\urbsum81.Xclude)) OR (p:\ms_delta\jr_redo\urbsum729.xclude)) OR (p:\ms_delta\jr_redo\urbsum9.xclude)) OR (p:\ms_delta\jr_redo\cat10_mask.Xclude)) OR (p:\ms_delta\grids\rd_dens_rc.Xclude)
```

rename to **xclude_mask**
Step 2: Mask PEA layer with exclusion mask
mask **pea_allmsk** with **xclude_mask** to give **PEAX**

```
2001 09 28 1516   2    95     0jrr01 h:\temp\calc1 = (p:\ms_delta\jr_redo\xclude_mask.invert) * (p:\ms_delta\jr_redo\pea_allmsk)
```

Step 3: Region group to exclude areas less than 5000 acres
region group **PEAX** to give **PEAX_RG**
Input grid=PEAX
NoDiagNbrs=false
Cross Class=true
ExcludedValue=0

```
2001 092 81 522   2    82     0jrr01 h:\temp\RgnGrp2 = RegionGroup(p:\ms_delta\jr_redo\peax,#,EIGHT,CROSS,0)
```

Final HUB development
Rationale: To select PEAX greater than 5000 acres
Step: Calculate acres for each group in **RgnGrp2** then select hubs with Acres greater than 5000.

Hub Optimization

generate cat10mxk =cat10_mask 0=nd 1=1 mask of catagory 1 and 0 land cover =1 all other = nodata

```
2001 09 28 1604   1    60     0jrr01 h:\temp\rclss7 = SETNULL((h:\temp\grid4) EQ (1),h:\temp\grid4)
```

reclassify peax 1 =1; 0 = nodata to **hubs_1** non optimized hubs

optimized hubs ran cost distance on hubs_1 with cat_1cost and mask set to not_exclude (inverse of exclusion zone-- xclude_mask) ==> temp file

```
2001 10 011303   9  -329     0jrr01 h:\temp\grid4 = CostDistance(p:\ms_delta\jr_redo\hubs_1,p:\ms_delta\costsurf\cat_1cost,#,#,5000)
```

reclassified temp file for 0-1000 as optimized hubs

```
2001 10 01 1328   1    56     0jrr01 h:\temp\rclss8 =
CON(ISNULL(h:\temp\grid4),0,h:\temp\grid4)
```

output to hubs_opt

recoded exclude mask to not exclude for a mask of areas not excluded in the exclusion process
output not_exclude

```
2001 10 01 1253   1    57     0jrr01 h:\temp\rclss8 = SETNULL((h:\temp\grid4) EQ
(0),h:\temp\grid4)
```

intersected cat1_cost (natural lands) with not_exclude to give include_both
this is natural lands not in the exclusion zone

```
2001 10 01 1334   2  -305     0jrr01 h:\temp\calc3 = (p:\ms_delta\jr_redo\not_exclude) *
(p:\ms_delta\costsurf\cat_1cost)
```

output to include_both

reclassify hubs_1 nodata =1 1 =nodata set up mask for holes in hubs to optimize (temp file)
Region grouped the holes; selected only those less than 25000 acres (grid4)
then filled with landcover cat 1 or 0

hubs_opt2 optimized hubs by method of U of F

```
([Reclass of Hubs_1] = 0).con ( ([Grid4 . Optmsk] * [Cat10_mask] ), [Reclass of
Hubs_1] )
2001 10 02 1508   4  -186     0jrr01 h:\temp\calc4 = CON((h:\temp\rclss9) EQ
(0),(h:\temp\grid4.Optmsk) * (p:\ms_delta\jr_redo\cat10_mask),h:\temp\rclss9)
```

Linkage Process/ Cost Surface and Links

Background

The creation of the cost surface used to delineate the corridors in the Delta Framework was based largely on the cost surface parameters used in the SE Ecological Framework (SEF), developed by the University of Florida (UFL). Parameters were customized to what was considered appropriate for the MS Delta.

Purpose

A cost surface is an input file that gives values to various GRIDS that are used as inputs into

ArcView extension that creates two output grids. These grids are then used as inputs for the program that creates the corridors, using the values of the two new input grids to determine the corridor's path. Two grids were created for each and every corridor, and each corridor run separately, as the software didn't allow multiple runs. This preliminary work of assigning values was done in ArcInfo, and the corridor delineation was run in ArcView 3.1 using the Cost Surface extension.

Process

The process has been broken down into steps, and the actual command strokes given in the "Command" lines. I used all PEA's and SEA's, as well as some individual grids (like the Land Cover's reclassification, CAT_123) as inputs. This means that all these grids had a value, or a "say", in where the corridors could link the hubs.

Cost Surface

Step 1: Combined all SEAs into one grid called SEA_COMB (SEA Combination).
Command: (Arc) GRID: COMBINE pot_bbhab, rdless, bca_pot, sig_rip

Step 2: Combined all PEA's into one grid called PEA_COMBO3.
Command: (Arc) Grid: PEA_COMBO3 = combine(pea_bbhab, pea_potbbahb, pea_rdless, pea_bca2, pea_publands, pea_wrps, pea_refortrk, pea_habdiv.highdiv, pea_wetland)

**** See Data Layer list for full names of Grids, and explanation of CAT_123 values.***

Step 3: Created Grid called Intrinsic with the three basic input grids.
Command: (Arc) Grid: INTRINSIC = GRID: intrinsic = con(pea_combo3 > 1, 10, con (sea_comb = 1, 7, con(cat_123 = 0, 5, con (cat_123 = 1, 3, 1))))

so values are:
1 = no value
3 = CAT 1 LU
5 = CAT 0 LU
7 = SEAs
10 = PEAs

Step 4: Created ReClass of RC_ripdist (riparian distance; ie, distance from streams) as last input.
RC_ripdist grid:

Orig value	New value	Distance (meters)

1 =	10	0-180m
2 =	7	180-270m
3 =	5	270-810m
4 =	3	810-1620m
5 =	1	ge 1620m

Made initial cost surface grid in three parts (b/c Arc can only take so many characters in a command line at once).

Part I: CS_GDSTUFF: ("Cost Surface – Good Stuff")

Command: (Arc) Grid:

```
cs_gdstuff = con(intrinsic == 10 & rc_intact == 10 & rc_ripdist2
ge 7, 1, con(intrinsic == 10 & rc_intact == 10, 2, con(intrinsic == 10 & rc_intact == 7 &
rc_ripdist2 ge 7, 3, con(intrinsic == 10 & rc_intact == 7, 4, con(intrinsic == 7 & rc_intact
== 10 & rc_ripdist2 ge 7, 5, con(intrinsic == 7 & rc_intact == 10, 6, con(intrinsic == 7 &
rc_intact == 7 & rc_ripdist2 ge 7, 7, con(intrinsic == 7 & rc_intact == 7, 8, 0))))))))
```

PartII: CS_GDSTUFF2:

```
cs_gdstuff2 = con(intrinsic == 5 & rc_intact == 10 & rc_ripdist2 ge 7, 9, con(intrinsic ==
5 & rc_intact == 10, 10, con(intrinsic == 5 & rc_intact == 7 & rc_ripdist2 ge 7, 11,
con(intrinsic == 5 & rc_intact == 7, 12, con(intrinsic == 3 & rc_intact == 10 &
rc_ripdist2 ge 7, 13, con(intrinsic == 3 & rc_intact == 10, 14, con(intrinsic == 3 &
rc_intact == 7 & rc_ripdist2 ge 7, 15, con(intrinsic == 3 & rc_intact == 7, 16, 0))))))))
```

Part III: CS_GDSTUFF3:

```
cs_gdstuff3 = con(cs_gdstuff gt 0, cs_gdstuff, con(cs_gdstuff2 gt 0, cs_gdstuff2,
con(intrinsic == 10 & rc_ripdist2 ge 7, 17, con(intrinsic == 10, 18, con(intrinsic == 7 &
rc_ripdist2 ge 7, 110, con(intrinsic == 7, 20, con(intrinsic == 5 & rc_ripdist2
ge 7, 21, con(intrinsic == 5, 22, con(intrinsic == 3 & rc_ripdist2 ge 7, 23, con(intrinsic
== 3, 24, 0))))))))))
```

CS_GDSTUFF4: all three cost surfaces above combined into one long CON statement.

TOTALCOST1 = con(lc_90m == 11, 10000, con(prim_roads == 1, 20000, 0))
TOTALCOST2 = con(cat_12390 == 2 & sigrip_buff == 1, 800, 0)
TOTALCOST3 = con(cat_12390 == 2, 8000, 0)
TOTALCOST4 = con(cat_12390 == 1 & (ms_urban_grow ==

TOTALCOSTFIN = total cost surface, all put together, optimized and filled in. Optimized and filled in means that holes (some urban pixels) and others were identified and either added or eliminated. See process below.

Notes on TOTALCOSTFIN for DEF:

Calculated cost surface using Imagine model named "total_cost_2.gmd" and the graphic image "total_cost.img".

Part I:
This part created the Grid for natural areas and all the possible exclusions in ERDAS Imagine.

```
conditional { (($n19_ms_urban_grow ge 500) or ($n20_city_bndrs == 1) or
($n22_sec_rds  == 1) or ($n23_rd_dens_rc  == 4) or ($n21_urb_density == 1)) 1} ==>
n17_memory
```

Part II:

```
CONDITIONAL {
 ($n10_noroad_urban == 1) -99,
 ($n5_lc_90m == 11) 10000 ,
 ($n8_prim_roads == 1) 20000,
 ($n9_cat_12390 == 2 and $n3_sigrip_buff ==1) 800,
 ($n9_cat_12390  == 2) 8000,
 ($n9_cat_12390  == 1 and $n17_memory) 70,
 ($n9_cat_12390  == 0 and $n17_memory) 60,
 ($n9_cat_12390 == 1 and $n19_ms_urban_grow ge 200) 50,
 ($n9_cat_12390  == 0 and$n19_ms_urban_grow ge 200) 40,
 ($n14_cs_gdstuff4) $n14_cs_gdstuff4 }
```

This left a number of 0 values across the matrix.

Ran the following model on total_cost.img to get rid of 0 values in cost grid(model name = total_cost_add.gmd):

```
CONDITIONAL {( $n1_total_cost ne 0) $n1_total_cost,
 ($n1_total_cost ==0 and $n2_mrlc_urban90 ==1 ) -99,
($n1_total_cost ==0 ) FOCAL MAJORITY ($n1_total_cost ,$n6_Low_Pass, )
 }   --- run focal majority only where 0 exists on non urban land
```

This cleaned up all of the urban as zero but still left a few 0's(1774)

Ran nibble process in Arc on totalcostadd in order to delete 1774 zero values
total_cost_add.nibble(total_cost_add = 0).setnull(total_cost_add),true)
h:\temp\calc4 = NIBBLE(z:\temp\totalcostadd,h:\temp\grid2,DATAONLY)
recode temp file -99 to nodata ==> p:\ms_delta\costsurf**totalcostfin**
    h:\temp\rclss2 = SETNULL((h:\temp\grid2) EQ (0),h:\temp\grid2)

Result was **TOTALCOSTFIN**. Used this with the **HUBS_OPT** grid as the two inputs: **TOTALCOSTFIN** was the values of the cost surface the corridors ran over, and **HUBS_OPT** were the starting and ending points the corridors ran between.

Links

This describes the actual process in ArcView of creating the individual ecological corridors between the hubs using the input grids created above. Links were created in ArcView 3.2 using the Cost Surface Extension (spcstdst.avx). **HUBS_OPT** was used as the input grid, and **TOTALCOSTFIN** used as the input for the Distance and Direction grids. Each link was made individually. Combined all individual links into a shapefile called **clip_link.shp**.

The links were made one by one using ArcView.
Step 1: A mask was made that included only the area between the hubs being linked. This was done to confine the analysis to only the area being linked
Step 2: Run the cost distance extension and define the to and from nodes for the link.
Step 3: Save the linkage Shapefile
This process was run for a total of approximately 500 links (22,200 km). An analysis of the links was made and links with high amounts of agriculture and/or very thin links were removed from the set. Approximately 56% on the links were removed leaving about 9,600km of total single cell linkage.

OPTIMIZING LINKS

This process "optimized" the links to extend corridors to all compatible land uses from the single –celled original corridors created in the Link process.

Step 1: Converted clip_links.shp to **clip_links** grid

Step 2: Reclassified CAT_12390 as
0 = 1,
1 = 10,
2 = 50, and
3 = nodata and saved as CAT_123COST.

Step 3: In MapCalculator, ran costsurface
Command: AV: **Clips_link.costsurface (nil, nil, 50,000)**
("nil"s are allocation grids we didn't need, and 50,000 was a top ceiling value to mitigate how many cells it would connect to the links. Saved as **Link_cost**.

Step 4: Then clipped LINK_COST to the hubs (because links bled into hubs) in MapCalculator:
Command: AV: hubs_opt.toggle*link_cost (*toggle was inverse values, 0,1*)
Saved as ms_delta\grids\links**LINK_COST2**.

Step 5: Then reviewed it and decided that values 1-5000 were best suited to general links, so ReClassified Links_cost2 into 1-5000 = 1, all else 0, saved as grids\links**NATURAL_LINKS.**

(ReClassed CLIP_LINKS to 1,0 grid so would run calculations. Also had to reclassify link and cost surface links to eradicate No Data as was poking holes in framework. Saved as **ONECELL_LINKS**).

Put onecell_links and natural_links together into: **Nat_links2.**

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Final Delta Ecological Framework
Rationale**:** To combine the optimized hubs with the links
DEF_v2 generated by adding together the hubs_opt2 and natlinks2
2001 10 02 1542 2 132 0jrr01 h:\temp\calc4 = CON((p:\ms_delta\jr_redo\hubs_opt2) EQ (1),p:\ms_delta\jr_redo\hubs_opt2,p:\ms_delta\grids\links\nat_links2)

DEF_v4 is the unoptimized Delta Framework

Final optimization steps for def v4
1. region group holes, \
2 select holes < 50000 acres
3 fill with natural land cover any holes contiguous with framework
4 add back in PEA public lands that are contiguous with framework
5 region group and delete any lone chunks less than 5000 acres
6 smooth using cost distance

Step 1-- 2001 10 04 1116 2 -313 0jrr01 h:\temp\calc5 = RegionGroup(p:\ms_delta\jr_redo\def_v4,#,FOUR,WITHIN,1)
Step 2-- 2001 10 04 1159 4 242 0jrr01 h:\temp\calc6 = (h:\temp\calc5.optmask) * (1) mask of holes less than 50000 acres
Step 3 & 4--
(([Def_v4]) or ([Pea_combine . Pea_publands]) or ([Map Calculation 2]))* [Cat10_mask]

2001 10 04 1414 4 -215 0jrr01 h:\temp\calc8 = ((p:\ms_delta\jr_redo\def_v4) OR ((p:\ms_delta\jr_redo\cat10_mask) * (p:\ms_delta\jr_redo\pea_combine.Pea_publands))) OR ((p:\ms_delta\jr_redo\cat10_mask) * (h:\temp\calc6))
DEF_v4 addback

output calc8 (map calculation 3) is the DEF with holes filled and public lands added back in. This also added small pieces from the public lands and some disconnected pieces in the middle of the holes

Step 5--region group to get rid of the small pieces
2001 10 04 1431 1 94 0jrr01 h:\temp\calc9 = RegionGroup(h:\temp\calc8,#,FOUR,WITHIN,0)

select only those pieces with area greater than 5000 acres
2001 10 04 1439 3 156 0jrr01 h:\temp\calc10 = (h:\temp\calc9.Link) * (1)

output to **DEF_V4 gt 5000**

Set up cost distance for only cat 1 land classes and calculate distance from **DEF_V4 gt 5000**

```
( ([DEF V4 gt 5000] = 0).SetNull ([DEF V4 gt 5000]).costdistance([Cat_1cost], NIL,
NIL, 5000))
```

output to **DEF_v4optdis**

Step 6:select core def_v4optdis =0 and buffer out to 500 meter to smooth for final optimization. A few of the places
that were excluded were added back in but mostly the buffering is in natural previously not included or excluded.

AV Map calculator ([def_v40optdis] < 500).con (1.AsGrid, 0.AsGrid)

```
2001 10 05 1121   5   121     0jrr01 h:\temp\calc8 =
CON((p:\ms_delta\jr_redo\def_v4optdis) LT (500),1,0)
```

output as **DEF_final**

Combined DEF_Final with nat_links2, SEA (rclss2) and PEA(rcls1)

```
200110121042   3   150     0jrr01 p:\temp\Combin1 =
COMBINE(p:\ms_delta\jr_redo\def_final,p:\ms_delta\grids\links\nat_links2,p:\temp\rclss
2,p:\temp\rclss1)
```

output to **DEF_combo**

Renamed **DEF_combo** output attributes and types output to **DEF_Combo2**

Appendix G: Cost Surface for Modeling Upland Linkages for Murray County, Georgia Ecological Network

UPLAND COST SURFACE VALUES

Value	Description
1	Uplands within large, intact habitat areas and PEAs
2	Uplands within areas of high density habitat and PEAs
3	Other uplands that are within PEAs
4	Uplands within large, intact habitat areas and SEAs
5	Uplands within areas of high density habitat and SEAs
6	Other uplands that are in SEAs
7	Uplands within large, intact habitat areas
8	Uplands within areas of high density habitat
9	Other uplands
18	Natural and Semi-natural Land Cover (not uplands or water, from Categories 0 & 1 from Simplified Land Cover Dataset) within large intact habitat areas
20	Natural and Semi-natural Land Cover (not uplands or water from (Categories 0 & 1 from Simplified Land Cover Dataset) within areas of high density habitat
25	Other Natural and Semi-natural Land Cover that is not uplands or water
50	Uplands with edge effects, within city boundaries, within high density urban areas, within areas of high road density
60	Natural and Semi-natural Land Cover (Categories 0 & 1 from Simplified Land Cover Dataset) with edge effects, within city boundaries, within high density urban areas, or within areas of high road density
80	Wetlands
90	Water
100	Primary roads
No Data	Category 2 and 3 Land Cover from Simplified Land Cover Dataset
No Data	All other cells

Simplified Land Cover Dataset: Tennessee Valley Authority's (TVA) Multi-Resolution Land Cover (MRLC) Dataset and Southern Appalachian Assessment (SAA) Land Cover Dataset were simplified into 4 categories: Categories 0, 1, 2, and 3.

Category 0 Land Cover represents Natural Land Cover (water, forests, or wetlands), consisting of the following MRLC land cover classifications: Water (11), Deciduous Forest (41), Evergreen Forest (42), Mixed Forest (43), Woody Wetlands (91), Herbaceous Wetlands (92); and the following SAA Land Cover classifications: Woody Wetlands (910), Herbaceous Wetlands (920), Water (110), Deciduous Forest (410), Northern Hardwood Forests (411), Mixed Mesophytic Hardwood Forests (412), Oak Forests (413), Bottomland Hardwood Forests (414), Evergreen Forest (420), White Pine / Hemlock Forests (425), Montane Spruce-Fir Forests (426), Southern Yellow Pine Forests

(427), Mixed Forest (430), White Pine / Hemlock / Hardwood Forests (438), Mixed Pine / Hardwood Forests (439)

Category 1 Land Cover represents Semi-natural Land Cover consisting of the following MRLC land cover classifications: Bare Rock/Soil (31), Transitional/Clearcuts (33) Deciduous Shrub (51), Native Grassland (71); and the following SAA Land Cover classifications: Bare Rock/Soil (310), Transitional/Clearcuts (330), Deciduous Shrub (510), Native Grassland (710).

Category 2 Land Cover represents extractive or agricultural land uses consisting of the following MRLC land cover classifications: Orchard (61), Pasture/Hay (81), Row Crops (82), Small Grains (83), Other Grasses (85), Quarries/Mines (32); and the following SAA Land Cover classifications: Quarries/Mines (320), Orchard (610), Pasture/Hay (810), Row Crops (820), Small Grains (830), Other Grasses (850).

Category 3 Land Cover represents intensive land uses (residential or commercial) consisting of the following MRLC land cover classifications: Low Intensity Residential (21), High Intensity Residential (22), High Intensity Commercial (23), and the following SAA Land Cover classifications: Low Intensity Residential (210), High Intensity Residential (220), and High Intensity Commercial (230)

Uplands: Uplands were defined as the following Multi-Resolution Land Cover Classes: Natural Forested Upland (non-wet): Deciduous Forest (41), Evergreen Forest (42), Mixed Forest (43), Deciduous Shrubland (51), Evergreen Shrubland (52), Mixed Shrubland (53); Natural Shrubland: Deciduous Shrubland (51), Evergreen Shrubland (52), Mixed Shrubland (53); and Herbaceous Upland Natural/Semi-Natural Vegetation: Grassland/Herbaceous (71).

Edge effects: Edge effected areas include: Urban, residential, commercial, and industrial areas (category 3 from Simplified Land Cover Dataset) greater than 100 acres; and primary roads buffered by 100 meters.

High density urban areas: Urban areas were derived from the TVA's urban density analyses. Density was calculated as the percentage of cells in a sliding window (also referred to as a neighborhood) that were urban. Urban was defined as the following classes in the MRLC landcover classification database: Low Intensity Residential (21), High Intensity Residential (22), Hith Intensity Commercial/Industrial/Transportation (23). The density analyses were calculated for three neighborhood sizes: 3 x 3, 9 x 9, and 27 x 27 neighborhoods with 30 meter cells, respectively 2 acres, 18 acres, and 162 acres. Areas that are greater than 40% urban land uses at each of three scales were considered to be high density urban areas.

High Density Habitat Areas: These areas were derived from TVA's habitat density analyses. Density was calculated as the percentage of cells in a sliding window (also referred to as a neighborhood) that were natural habitat. Habitats were defined as the following classes in the MRLC landcover classification database: Deciduous Forest (41), Evergreen Forest (42), Mixed Forest (43), Deciduous Shrubland (51), Woody Wetlands (91), Herbaceous Wetlands (92). The density analyses were calculated for three neighborhood sizes: 3 x 3, 9 x 9, and 27 x 27 neighborhoods with 30 meter cells, respectively 2 acres, 18 acres, and 162 acres. Areas that are greater than 80% natural habitats at each of three scales were considered to be high density habitat areas.

<u>Large, intact habitat areas</u>: Large, intact areas were defined as contiguous natural habitat areas greater than 2,500 acres. Natural habitat areas were defined as the following classes from the MRLC Land Cover classification database: Open Water (11), Deciduous Forest (41), Evergreen Forest (42), Mixed Forest (43), Woody Wetlands (91), Emergent Herbaceous Wetlands (92). First, a density analysis was done at two neighborhood sizes, 9x9 and 27x27 with 15 meter cells. Areas that were at least 90% habitat at both scales, and that were greater than 2,500 acres were considered to be large, intact habitat areas.

Appendix H: Conservation Tools and Strategies

Following is a brief list of government tools, strategies, and voluntary programs for conservation:

Governmental Tool Box

Administrative Tools[1]

- **Dedications** - Dedications are requests from a local government that a developer dedicate a negotiated portion of their land as open space as a condition for building approval.

- **Impact Fees** - These are fees charged to the developer to help pay for infrastructure and public amenities costs necessitated by the new development. Impact fees may be used for off-site improvements such as funding for a new school, or for on-site improvements, such as building roads or funding road improvements.

- **Development Incentives** - An example development incentive is offering higher densities to landowners or developers who wish to set aside large portions of their land as open space. Transfer of development rights would be one way to develop at higher densities.

- **Development Disincentives** - Disincentives discourage traditional "cookie cutter" development designs by imposing a density reduction for developers who do not incorporate open space protection goals.

- **Deed Restrictions** - Deed restrictions constrain the use of one's property and are recorded on the property's deed. Deed restrictions may be placed on new developments or with current landowners.

Zoning Tools[1]

- **Agricultural and Forest Districts** - The purpose of these districts is to help preserve blocks of agricultural and forest lands. These districts usually require that an area be kept in agricultural or forest use for the length of the agreement.

- **Planned Unit Developments (PUDs) -** PUDs offer more flexible development practices than traditional zoning, while still meeting overall community density and land use goals. PUDs encourage open space preservation through the use of mixed use, massed, or clustered development practices that result in smaller individual lot sizes. Provisions within the PUD can require developers to preserve part of the development for open space. Local governments can create a

PUDs zoning district or permit a PUD in a regular zoning district on a site by site basis.

- **Open Space Districts** - Open space districts are created to protect natural areas and/or unique features. These districts usually allow the same overall amount of development, but use clustering, density limitations, and other development restrictions to preserve open space and restrict development to a smaller area. The focus of open space districts (i.e. agriculture, forests, wetlands, parks) is flexible depending upon the desires of the local community.

- **Overlay District** - These districts are used to impose additional development restrictions in a certain area because a unique feature warrants protection. For instance, a floodplain overlay district can be used to further restrict development in the floodplain, in additional to the zoning that currently exists in the floodplain.

Outright Purchase

Fee-simple Acquisition

Fee-simple acquisition is direct and outright purchase of a piece of property. This option can insure protection of a sensitive area, but is often difficult because it requires landowners who are willing to sell their land as well as sufficient funds available for purchase.

Voluntary Programs

Conservation Easments

A conservation easement is a voluntary legal agreement made by a landowner to restrict the land uses permitted on his or her property. It is a flexible option that can be tailored to suit the goal of the easement and the desires of the landowner. Landowners can choose to restrict one or more land uses, or to permit only particular land uses on the property, for a specified period of time. The purpose of the easement is flexible. Its purpose can be to protect sensitive habitat, to keep the land in forestry or agricultural land uses, for aesthetics, etc. Some example types of easements include conservation, agricultural, historic preservation, scenic, and more. Also, the landowner can choose to only include a portion of his or her land in the easement.

Furthermore, landowners can benefit financially from conservation easements through reduced income taxes and estate taxes. A conservation easement is considered a tax-deductible charitable gift and can be used to reduce the landowner's taxable income. Also, conservation easements can reduce estate taxes, which can help families who wish to pass land to their relatives. If a landowner dies and wishes to pass his or her land to their family, the land is subject to an estate tax, which is often so high that the land must be sold to pay the tax. Conservation easements can reduce estate taxes and consequently help families keep their land.

Federal Conservation Programs

The U. S. Department of Agriculture's Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA), both offer conservation programs which local governments and landowners can benefit from technical and financial resources. The following list is just a few of the conservation programs offered through NRSC and FSA.

Natural Resources Conservation Service (NRCS) Programs

Wildlife Habitat Incentive Program (WHIP): WHIP is a voluntary program that aims at protecting wildlife habitat primarily on private lands. NRCS provides technical assistance and some financial assistance to improve wildlife habitats. WHIP agreements generally last from 5 to 10 years.

> **State of Georgia WHIP**: The Georgia WHIP focuses on priority habitats, such as longleaf pine ecosystems and early successional plant habitats, and management practices, including wildlife upland and wetland habitat management, prescribed burning, riparian buffers, and more. For more information, contact, Jim Dial at (706) 546-2114.

Farmland Protection Program (FPP): The FPP is a voluntary program that aims at keeping productive farmland in agricultural land uses. It provides funding for conservation easements that purchase development rights on agricultural lands.

Wetlands Reserve Program (WRP): The WRP is a voluntary program that offers financial assistance to landowners wishing to protect wetlands on their property. Usually, the landowner enters an agreement with the USDA to restore and protect the wetland, while limiting the use of the land. The program offers agreements of varying lengths, from 10 years to permanent.

Forestry Incentive Programs (FIP): The FIP promotes good forest management practices on privately owned, non-industrial forest lands in an effort to reduce wind and soil erosion, enhance water quality and wildlife habitat, and promote longevity of forest resources. Practices include tree planting, timber stand improvements, and natural regeneration. The FIP offers cost share assistance for participating landowners, with a limit of $10,000 per landowner and no more than 65% of total costs maybe paid.

A full list of NRSC programs can be found at:
http://www.nhq.nrcs.usda.gov/PROGRAMS/cpindex.html

Farm Service Agency Programs

Conservation Reserve Program (CRP): The CRP is a voluntary program for agricultural land owners. It offers technical and financial assistance to landowners who convert highly erodible and environmentally sensitive land to long-term resource-conserving cover for the purpose of improving soil conditions. CRP offers annual rental payments and cost share assistance, and agreements generally last from 10 to 15 years.

A full list of FSA programs can be found at:
http://www.fsa.usda.gov/dafp/cepd/conserva.htm

[1] Adapted from Evans, G.C. 1999. "Preserving Virginia's Heritage: Approaches for Protecting Open Space". Northern Virginia Soil & Water Conservation District, Thomas Jefferson Institute. Fairfax, VA. http://www.virginiaconservation.org/openspacepaper.htm#purchaseprogram.