ENVIRONMENTAL PLANNING IN FLORIDA

Mapping Wildlife Needs in Florida: The Integrated Wildlife Habitat Ranking System

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Abstract: The Florida Fish and Wildlife Conservation Commission is responsible for performing environmental reviews of major land developments in Florida that impact fish and wildlife resources and their habitat. In an effort to improve the efficiency and accuracy of these assessments, and to improve the coordination between agencies, the FWC developed a GIS-based habitat model that incorporates a wide variety of land cover, and wildlife species data. The Integrated Wildlife Habitat Ranking System ranks the Florida landscape based upon the needs of wildlife as a way to identify ecologically significant lands in the state, and to assess the potential impacts of land development projects. The IWHRS is provided as an ArcView (ESRI, Redlands, CA) project on a compact disc, which includes the results of the model, all of the data layers that went into the model, a wide variety of wildlife species location data, and a Florida landcover image. By using the capabilities of GIS, users can perform specific queries and investigations of the model results, the data layers that comprise the model, and the additional data provided on the CD, enhancing the utility of the model.

Introduction

Biologists with the Office of Environmental Services of the Florida Fish and Wildlife Conservation Commission (FWC) perform reviews of major land developments, such as highways, residential and commercial development, channel dredging, and other projects, that impact fish and wildlife resources and their habitats. These land use changes can adversely impact wildlife species listed by the FWC as threatened, endangered, or species of special concern, recreationally and commercially important fish and wildlife resources, wildlife habitats, and public lands. FWC biologists evaluate project design to estimate the total area that will be impacted, assess the type and level of impacts, and then make recommendations to the project designers on ways to avoid, minimize, or mitigate those impacts.

Providing input during the early planning stage of major land developments, followed by in-depth coordination and cooperation between land development planners and resource agencies, is the key to successfully influencing land use decisions on land development projects. Accurate, detailed information on habitat quality and the spatial distribution of fish and wildlife resources within the project area must be readily available and accessible to resource biologists and land developers. Additionally, major resource issues must be quickly and clearly defined and potential solutions fully investigated before final project implementation, in order to avoid future problems with state and federal permits and second-party court challenges.

To improve the efficiency and accuracy of environmental assessments, a tool was needed to allow for a rapid assessment of the fish and wildlife resource and habitat features in the state of Florida. This tool would permit a landscape-scale evaluation of a proposed project to assess environmentally important lands to fish and wildlife species that might adversely be affected.

Geographic information systems (GIS) provide an ideal tool for regional or statewide assessments of landscapes, habitat model development and application, and modeling the potential distribution of species and habitats (Conner and Leopold 1998, Stoms et al. 1992). GIS has emerged as a tool to assist in the resolution of land use conflict and the management of natural resources (Brown et al. 1994). Given appropriate digital habitat and wildlife data, these data can be used to identify environmentally sensitive lands, allow GIS users to put their project in a landscape perspective, and allow habitat quality and wildlife needs to be simulated as a function of proposed management (Conner and Leopold 1998).

The FWC used the tools of GIS to improve environmental assessments and help bridge the gap between wildlife agencies and land developers by developing the Integrated Wildlife Habitat Ranking System (IWHRS). The IWHRS is a GIS-based habitat model that incorporates a wide variety of land cover, and wildlife species data to identify ecologically significant lands within the state of Florida and rank the Florida landscape based on the needs of wildlife.

Methods

All GIS work was conducted in raster format using the spatial analyst extension of the ArcView software package (ESRI, Redlands, CA). The pixel size used for the analysis was 30 x 30m, and the model's extent was the political boundary of the State of Florida.

The IWHRS is composed of 10 data layers that model important ecological aspects of wildlife species in Florida. The data layers used in the model were constructed by utilizing various preexisting GIS datasets. The datasets were selected by their ability to accurately represent the natural vegetation of the study area, represent areas currently protected for wildlife, model wildlife habitats and locations, and identify lands critical to wildlife (table 1). Five principal datasets were used: (1) FWC land cover and vegetation data, (2) FWC wildlife models, (3) public land boundaries, (4) conservation and recreation lands (CARL) boundaries, (5) and save our rivers (SOR) lands boundaries. To construct the data layers of the IWHRS, the preexisting datasets were manipulated to extract those features needed by the data layers.

Model Layers

Landscape Diversity

This layer identifies areas of habitat diversity in the state of Florida. It is important when identifying areas of ecological significance to consider diversity of the landscape, which can have effects on species diversity. A landscape composed of a mosaic of different kinds of habitats will provide suitable conditions for the growth of a variety of different species (Huston 1996). For example, bird diversity has been shown to be positively correlated to structural complexity or species diversity of trees, and in aquatic environments, diversity associated with structural species, such as corals or sponges, is strongly associated with diversity of fish and invertebrates (Huston 1996).

To construct the data layer for landscape diversity, the FWC land cover image was reclassified by using a variety neighborhood statistic in ArcView with a radius of one mile. The variety neighborhood statistic identifies the number of different land cover types within the user-defined radius of a pixel. The variety of habitat types within a one-mile radius ranged from 1-16 (out of a possible 22 land cover categories).

Roadless Habitat Patch Size

The influence of roads on wildlife is well documented. In a review, Trombulak and Frissell (2000) identified seven general impacts that roads have on wildlife: mortality from road construction, mortality from collisions with vehicles, modification of animal behavior, alteration of the physical environment, alteration of the chemical environment, spread of exotics, and increased use of areas by humans. Furthermore, roads create a barrier to wildlife movement, can alter animal communities, reduce biological diversity, and increase the threat of extinction (Alexander and Waters 2000). We represented the effects of roads on wildlife in the model by identifying continuous habitat patches in the state of Florida and ranking them based on size.

Table 1
Description of the datasets used to construct the data layers of the Integrated Wildlife Habitat Ranking System

Data Set	**Description**
Statewide Land Cover	A map of 22 total land cover types: 17 natural vegetation types, 3 disturbed vegetation types, 1 barren land class, and 1 water class. The map was constructed by the FWC based on 1985-1989 Landsat Thematic Mapper imagery. See Kautz et al. (1993) for a complete description of data set construction.
Wildlife Species Models	Distribution maps on 130 species based on available occurrence records, land cover data, species' range information, habitat requirements, home range size, dispersal capabilities, and other life-history characteristics (Cox and Kautz 2000, Cox et al. 1994)
Public Land Boundaries	Database from the Florida Natural Areas Inventory (Jue et al. 2001). Includes boundaries and statistics for more than 1,400 federal, state, local, and private managed areas, all provided directly by the managing agencies. National parks, state forests, wildlife management areas, local and private preserves are examples of the managed areas included.
Conservation and Recreation Lands Boundaries	Lands identified to conserve and protect unique natural areas, endangered species, unusual geologic features, wetlands, and archaeological and historical sites. The lands acquired under the program are maintained as parks, recreation areas, wildlife management areas, wilderness areas, forests and greenways. Funding source comes primarily through the sale of bonds.
Save our Rivers Lands Boundaries	Using monies from the Water Management Lands Trust Fund and Preservation 2000, the SOR program enables the water management districts to acquire lands necessary for water management, water supply and the conservation and protection of water resources including wildlife.

To construct the data layer for roadless habitat patch size, the FWC land cover image was reclassified so that only categories representing native habitat were identified and grouped into continuous patches. To ensure that all major roads were accurately represented as sectioning the landscape, a major road GIS coverage was overlaid onto the reclassified FWC landcover image.

Due to the size and scale of analysis, a minimum habitat patch size of $0.15km^2$ was used. Mykytka and Pelton (1989) found that habitat patches >$0.152km^2$ (37 acres) were important components of black bear habitat in the Osceola National Forest. The Florida black bear represents an integral species in the model whose history of roadkills is well documented (Gilbert and Wooding 1996, Wooding and Brady 1987). If a habitat patch was smaller than $0.15km^2$, it was not included in the analysis and scored 0.

Habitat patches were ranked using the quartile method due to the large size range of the parcels (from $0.15km^2$ to $6{,}059km^2$). The scoring is as follows:

0. < $0.15\ km^2$
1. $0.15km^2$ – $2.12km^2$
2. $2.12km^2$ – $9.65km^2$
3. $9.65km^2$ – $24.05km^2$
4. $24.05km^2$ – $52.25km^2$
5. $52.25km^2$ – $94.50km^2$
6. $94.50km^2$ – $170.30km^2$
7. $170.30km^2$ – $298.00km^2$
8. $298.00km^2$ – $562.50km^2$
9. $562.50km^2$ – $3{,}030.50km^2$
10. > $3{,}030.50km^2$

Strategic Habitat Conservation Areas (SHCA)
SHCA's are the result of a study by Cox et al. (1994) that identified privately owned lands in Florida needed to adequately protect over 40 vertebrate species of wildlife, high quality rare habitats of Florida, roosting areas for bats, wetlands important to wading birds, and land important to the survival of 105 globally rare plant species.

If an area was identified as an SHCA, and is currently unprotected, it was given a value of 1 in the SHCA data layer; all other areas had a value of 0.

Listed Species Locations
The enactment of the Endangered Species Act in 1973 was the most comprehensive and powerful piece of environmental legislation enacted by the United States (Orians 1993). Congress passed this legislation to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." With that in mind, we included a layer in the model that reflects the locations and diversity of listed wildlife species maintained by the state of Florida. The FWC officially lists imperiled wildlife species in the state of Florida and recognizes three categories: endangered, threatened, or of special concern. The state imperiled species list serves as a means for the state to protect wildlife, and set conservation priorities specific to the state of Florida (Dan Sullivan, personal communication).

Using potential habitat models for listed species in Florida, the data layer was classified based on the presence, number, and level of imperiled status for listed species present. The ranking scheme of the coverage is given below:

1. 1 species of special concern
2. 2 – 3 species of special concern
3. 4 – 5 species of special concern
4. 6 – 7 species of special concern
5. 8 – 9 species of special concern
6. 1 threatened species
7. 2 – 3 threatened species
8. 4 – 5 threatened species
9. 6 – 7 threatened species
10. > 0 endangered species

Species Richness
The protection of biodiversity is important for a wide variety of reasons, such as ecological, economical, medical, aesthetical, recreational, scientific, and ethical. Biodiversity is the foundation of any healthy ecosystem and helps an ecosystem persist. Numerous studies have reinforced the link between species richness and community function (Naeem et al. 1994, Tilman 1996, Hooper and Vitousek 1997).

To model biodiversity for the species richness data layer, we utilized the potential habitat models of 130 focal species that were created in Cox et al. (1994) and Cox and Kautz (2000) and merged each model together into one coverage. A pixel's value represents the number of species identified as having potential habitat at that site. The range of values was 0 (representing no species) to 26 species overlapping in a single pixel.

Black Bear Potential Habitat Model
The Florida black bear is one of only two large carnivore wildlife species remaining in Florida. The wide ranging nature of the black bear, their habitat characteristics, and large home ranges identifies them as an "umbrella species." Umbrella species are species at the top of food chains with large home ranges. By protecting the habitat needs of these species, a large number of other species are protected as well (Savard et al. 2000). For this reason, we included the black bear habitat model as an individual layer in the IWHRS.

The model was obtained from Cox et al. (1994). Habitat scores were based on proximity to existing conservation areas, size of roadless areas, diversity of cover types, and the presence of specific cover types. For the black bear potential habitat model data layer, the range of values was from 1-10, with 10 being the most favorable habitat for black bears.

Public Lands
Public lands managed for the benefit of fish and wildlife resources provide the most essential protection of fish and wildlife species and are the only way to ensure that lands needed for fish and wildlife will remain for years to come. The public lands layer includes the boundaries for more than 1,400 federal, state, local, and private managed areas, all provided directly by the managing agencies. National parks, state forests, wildlife management areas, local and private preserves are all examples of the managed areas included. The data layer was derived from the April 2001 Florida Natural Areas Inventory (FNAI) database (Jue et al. 2001).

To construct the public lands data layer, all public lands identified in the FNAI database were given a value of 1; all other areas were classed 0.

Distance to Public Lands
Protecting areas surrounding existing public lands serves to enhance the conservation value of the entire area (Sayer 1991). Additionally, protecting areas surrounding existing public lands protects the park or protected area from outside disturbance (Martino 2001, Reid and Miller 1989). For wide-ranging species, building upon existing public lands helps to protect areas large enough to sustain stable populations of the species.

The distance to public lands data layer was constructed by performing a find distance query in ArcView on the public lands coverage. From the results, the range of values was divided into 10 discreet categories using equal intervals. Values assigned to pixels were inversely proportional to the distance to public lands, (e.g., a pixel with a value of 10 falls in the closest interval to public land, 9 is the next interval outward from public land, and so forth until the outermost interval). The ranking system of the coverage is given below:

1. > 29.88km from public land
2. 26.56km – 29.88km from public land
3. 23.24km – 26.56km from public land
4. 19.92km – 23.24km from public land
5. 16.6km – 19.92km from public land
6. 13.28km – 16.6km from public land
7. 9.96km – 13.28km from public land
8. 6.64km – 9.96km from public land
9. 3.32km – 6.64km from public land
10. < 3.32km from public land

Florida Greenways
There is general consensus among conservation biologists that landscape-level connectivity has the potential to enhance population viability for many species, and that most of our current species have evolved in well-connected landscapes (Gilpin and Soule 1986, Noss 1987). Additionally, vegetated riparian corridors are important contributors to improved water quality in streams (Karr and Schlosser 1978, Schlosser and Karr 1981), and hedgerows and shelterbelts have been shown to inhibit soil erosion (Forman and Baudry 1984).

To include landscape connectivity in the current model, we utilized the results of the Florida Greenways Project. The Florida Greenways project was an analysis of potential ecological connectivity using land-use data, such as important habitats for target species, priority ecological communities, wetlands, roadless areas, floodplains, and important aquatic systems to identify areas with priority conservation significance and potential landscape linkages (Hoctor et al. 2000).

Florida Greenways lands were given a value of 1 in the data layer; all others were given a value of 0.

Conservation and Recreation Lands/Save Our Rivers (CARL/SOR)
CARL lands seek to conserve and protect unique natural areas, endangered species, unusual geologic features, wetlands, and archaeological and historical sites. The lands acquired under the program are maintained as parks, recreation areas, wildlife management areas, wilderness areas, forests and greenways. Funding source comes primarily through the sale of bonds. Using monies from the Water Management Lands Trust Fund and Preservation 2000, the SOR program enables the water management districts to acquire lands necessary for water management, water supply, and the conservation and protection of water resources, and wildlife.
We included these lands because they were identified as ecologically important and are actively being pursued for public acquisition and protection. For the CARL/SOR data layer, lands identified on these lists were given a value of 1 where all other areas were given a value of 0.

Model Construction
Prior to the model calculation, the model data layers needed to be standardized so that all layers were equally represented in the model calculation. In order to standardize each layer, a total value range for each layer of 0 - 1 was imposed. Scores for each layer were either binary or scaled. For binary layers, this resulted in the value of 1 representing the landscape feature the coverage is modeling, and a value of 0 representing all other areas. For scaled layers, a pixel's value was calculated by normalizing the range of values found in the data set by the maximum value. For example, if black bear potential habitat model had a range of values from 0 - 10, the coverage was divided by 10, resulting in a new range of values from 0 - 1.

The final image was constructed by simply adding all standardized data layers together. The resulting values assigned to the pixels were proportional to its importance to wildlife (e.g., the higher the value of a pixel, the more important it is to wildlife).

Results

Figure 1 shows the results of the model. Florida is fortunate that many areas of important native ecological communities remain statewide. Assuming that lands identified in the IWHRS with a value of 6 or greater constitute at least intermediate quality habitat for wildlife, 5.75 million hectares of a statewide total 14.5 million hectares were identified as providing at least intermediate quality habitat (having an IWHRS value of 6 or greater). This reveals that over 1/3 of the total land mass of Florida provides some level of ecological significance to wildlife species. Of concern is that currently 2.4 of these 5.75 million hectares are not in public ownership under any type of formal conservation protection.

The model identified the importance of the currently protected habitat areas in Florida as well as identifying many unprotected areas. Overlaying the existing public lands in Florida (figure 2) shows that there are many good quality lands not under any type of conservation protection. Some of these areas include (a) lands along the northern portion of the Apalachicola National Forest, (b) lands in Tate's Hell Swamp, (c) lands in the big bend region, (d) lands along the western border of Osceola National Forest, (e) lands surrounding Ocala National Forest and (f) Withlacoochee State Forest, (g) lands SE of Orlando, (h) lands north of Avon Park AFB, (i) lands surrounding Fisheating Creek, and (j) lands north of Big Cypress/Fakahatchee Strand (figure 2).

Discussion

Florida currently has an estimated population of 16.7 million people and hosts over 39 million tourists each year (Duda 1987). From 1990 to 2000 Florida experienced an average population growth rate of 2.26 percent, adding over 2.9 million people to the state (U.S. Census 2003). The projected population growth estimates has the Florida population surpassing New York as the third largest state, being over the 20 million mark by 2025.

The large population growth is a major factor in rural land development. It is estimated that until the year 2020, roughly 130,000 acres per year will be converted to urban from rural uses (Reynolds 1999). The projected population growth and accompanying land development needs put wildlands in jeopardy. It is imperative that those lands critical to preserving Florida's wildlife are not dramatically impacted by development pressures.

The IWHRS serves an important role in helping users identify areas important to wildlife that should be conserved, and assess impacts that a land development project might have on the surrounding area. The IWHRS allows any user to quickly and easily visualize a variety of species and habitat considerations for wildlife, and perform queries and investigations of those considerations to see how they interact. With this information, better informed decisions can be made on land development projects which will help to meet the needs of wildlife in Florida.

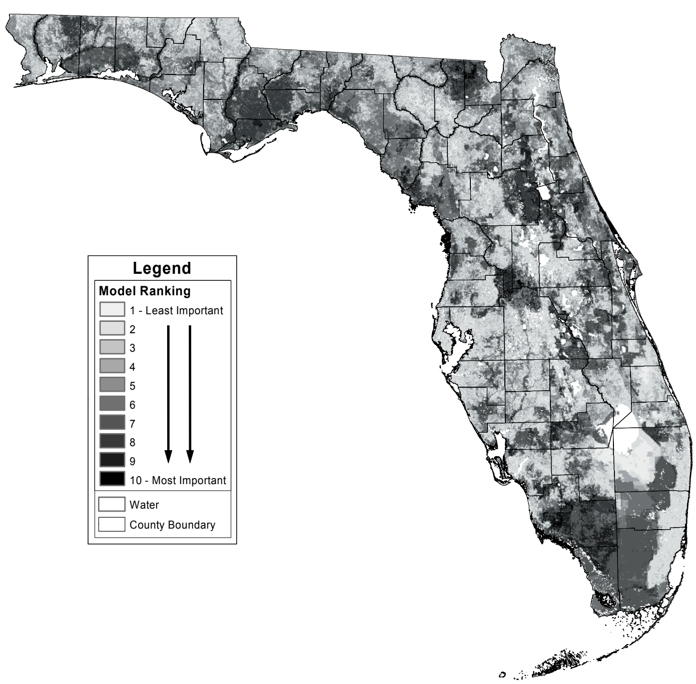

Fig. 1. The final model calculation of the Integrated Wildlife Habitat Ranking System.

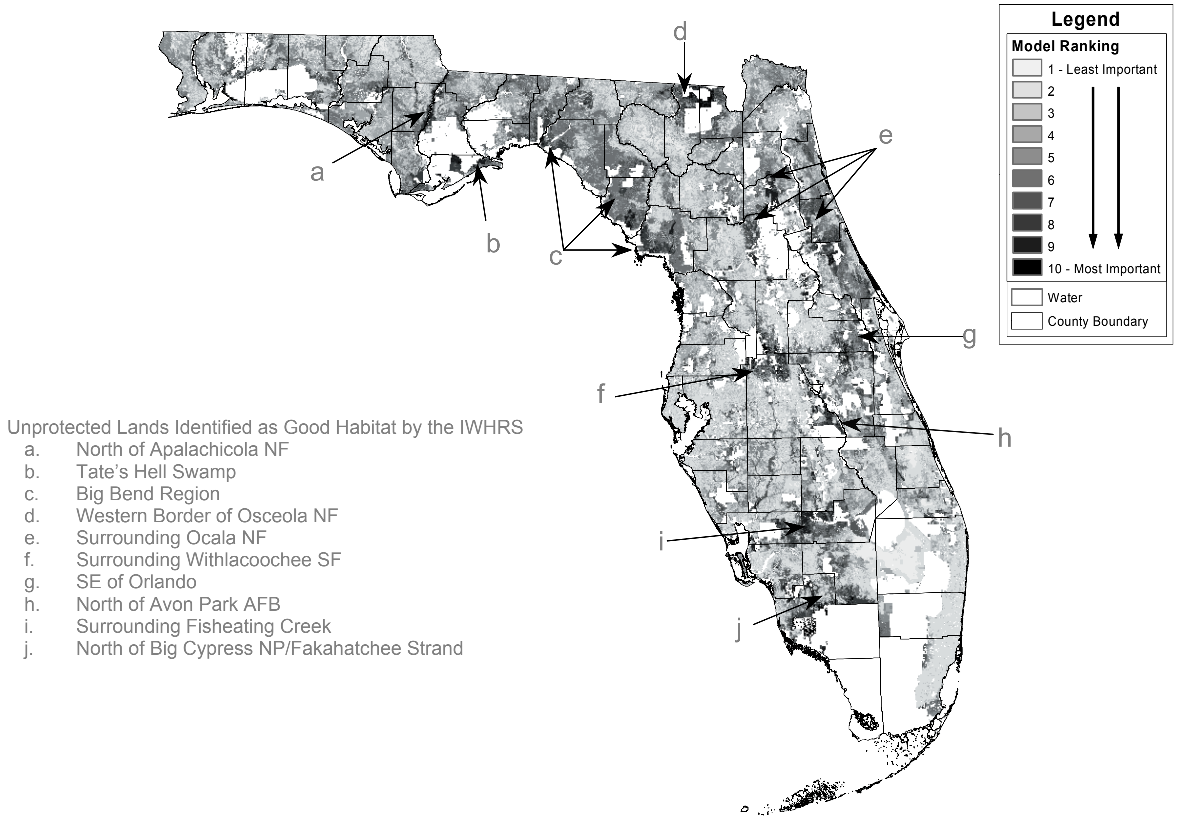

Fig. 2. Final model calculation of the Integrated Wildlife Habitat Ranking System with public lands in white.

CD Format

We provide the results of this model, the data layers that contributed to the model, and a wide variety of additional spatial, species location, and species habitat model data to the public as an ArcView project on a compact disc (CD). By providing the data in this format, users have the full capabilities of a GIS to perform further analysis or inquiries with the data.

Users can customize and recalculate the model to better fit the task at hand, and users can add or remove data layers to recalculate the model. This improves the utility of the IWHRS by giving it the flexibility to suit the needs of specific projects or queries. Additionally, as new or better data become available, users can replace old data layers and update the model. This will keep the IWHRS as current and accurate as the data available.

Using the identify tool in ArcView, users can identify individual pixel values of the model result, and any model layer. This allows full inquiry of the model's data layers, and identification of the values of individual model layers at specific locations or regions in Florida, to get a clear understanding of the importance of each data layer at specific locations.

Users can use the additional data included on the CD to overlay spatial data, species location data, and species habitat models to further identify areas important to individual species of wildlife. Furthermore, users can add any other data not included on the CD and use these data with the model or individual data layers.

Model Uses

We designed the IWHRS to serve as a rapid assessment tool to help manage the assessments of development projects. Using a desktop computer with ArcView (ESRI, Redlands, CA), one can quickly evaluate habitat quality of potential development project site locations and the surrounding areas to identify those projects requiring the most attention and coordination with the FWC.

The FWC is using this information for coordination with many agencies including the Florida Department of Transportation (FDOT), the Florida Department of Community Affairs, county governments, and other state and local groups to assist in determining ways to avoid or minimize land development project impacts.

FWC biologists are using the IWHRS to assist with reviews of FDOT projects, including new highway construction or expansions, and dredge and fill associated with bridge construction. We use the IWHRS to evaluate and compare multiple alignments, and assess direct, secondary, and cumulative impacts to important habitat systems and wildlife resources. The model is especially useful in performing larger, landscape level assessments of linear projects such as highways. FWC initial project reviews center on identifying the array of issues which should be addressed by FDOT in the project development and environmental study phase such as impacts to listed species, public lands, and habitat connectivity. This natural resource information forms the basis for an FWC letter to regulatory agencies on recommendations on ways to avoid or minimize impacts. Additionally, The FWC also uses the scored IWHRS maps to identify appropriate parcels for mitigation through public land acquisition. For example, the IWHRS was used in a recent project involving the expansion of Interstate Highway 4 in Volusia County where the FWC used the IWHRS to identify important habitat areas for the acquisition of $8.17 million of public lands for mitigation by the FDOT and the St. John's River Water Management District.

Limitations

A GIS model is only as accurate as the data that go into it. The information provided by the IWHRS model is based on data from numerous sources. As with most GIS data, deficiencies exist, and users must be aware of these deficiencies when utilizing the data. For the IWHRS we utilized the best available data to construct the model and feel that its results are of significant merit. Still, onsite surveys, literature reviews, and coordination with FWC biologists remain essential steps in documenting the presence or absence of imperiled species within the project area.

Six of the data layers (landscape diversity, roadless habitat patch size, SHCA, listed species, species richness, and the black bear potential habitat model) were constructed using the FWC landcover image. The FWC landcover image was created from 1985-1989 Landsat Thematic Mapper imagery. Obviously, the Florida landscape has changed somewhat from the late 1980's until now, but the landcover changes during that time could not be reflected in the model.

The species models that composed the SHCA, listed species, species richness, and black bear potential habitat model layers were originally constructed at a 100-m resolution. For the current analysis, these layers were resampled to a 30m resolution to conform to the other data layers. This resampling did not result in any gain in information; it merely brought these layers to the same resolution of the other layers. As a result, these layers do not provide data at a true 30-m resolution, and habitat features smaller than the original 100-m resolution might not have been identified. This coarse resolution was necessary at the time of potential habitat model creation due to limitations with computer disk space and processing times.

Future Work to Be Completed

The IWHRS will continue to be updated and supported as new data become available and as long as there is a need for the information. Currently, the FWC is in the process of updating its land cover image with Landsat Thematic Mapper imagery from the years 2001 – 2003. When completed, all layers in the IWHRS utilizing this data layer will be updated. The FWC has also been working on constructing a new statewide black bear habitat model utilizing the most current data layers and improved statistical methods. As new data become available they will be incorporated into the model to update and improve its accuracy and currency.

Biographical Sketch: Mark Endries received a B.S. in Biology and an M.S. degree in ecology from the University of Wisconsin-Oshkosh. Mark's interests lie in applying the technology of GIS to assist with and improve habitat protection planning and wildlife conservation. Mark has been an employee of the Florida Fish and Wildlife Conservation Commission for three years. Currently, Mark serves as the Division of Wildlife GIS program coordinator for the Florida Fish and Wildlife Conservation Commission.

Terry Gilbert received a BS in wildlife ecology and forestry from the University of Florida, and an M.S. from Auburn University in wildlife management and fisheries biology. As a wildlife biologist with the Office of Environmental Services of the Florida Fish and Wildlife Conservation Commission, Terry has worked for the past 28 years to address avoidance, minimization and mitigation measures for impacts to wildlife populations and habitat systems on projects such as highways, high-speed rail, and airports. Terry also routinely works on projects dealing with conservation land acquisition, mining and habitat restoration, and large-scale development projects including channel dredging, and commercial and residential construction.

Randy Kautz has been an employee of the Florida Fish and Wildlife Conservation Commission's Office of Environmental Services for the past 26 years. Since 1984, Mr. Kautz has been the leader of the Habitat Protection Planning section, where he has been responsible for developing and implementing programs aimed at the conservation of the habitats of rare and imperiled fish and wildlife in Florida. Mr. Kautz supervises the use of GIS technology to identify Florida lands in need of habitat protection, the publication of guidelines for the protection of endangered species habitat on lands proposed for development, and the dissemination of conservation data to other agencies and the public.

References

Alexander, S. M. and N. M. Waters. 2000. The Effects of Highway Transportation Corridors on Wildlife: a Case Study of Banff National Park. Transportation Research Part C 8 (2000) 307-320.

Brown, S., Schreier, H., Thompson, W. A. and I. Vertinsky. 1994. Linking Multiple Accounts with GIS as Decision Support System to Resolve Forestry/Wildlife Conflicts. *Journal of Environmental Management* 42: 349-364.

Conner, L. M. and B. D. Leopold. 1998. A Multivariate Habitat Model for Female Bobcats: A GIS Approach. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 52: 232-243.

Cox, J., Kautz, R., MacLaughlin, M. 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 Freshwater Fish Commission, Tallahassee, Florida.

Cox, J. A. and R. S. Kautz. 2000. Habitat Conservation Needs of Rare and Imperiled Wildlife in Florida. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Duda, M. D. 1987. Floridians and Wildlife. Sociological implications for wildlife conservation in Florida. Nongame Wildlife Program Technical Report No. 2. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Forman, R. T. T. and J. Baudry. 1984. Hedgerows and Hedgerow Networks in Landscape Ecology. *Environmental Management* 8: 495-510.

Gilbert, T. and J. Wooding. 1996. An Overview of Black Bear Road Kills in Florida 1975-1995. *Proceedings of the Transportation Related Wildlife Mortality Seminar*. Florida Department of Transportation, Tallahassee, Florida.

Gilpin, M. E. and M. E. Soule. 1986. Conservation Biology: The Science of Scarcity and Diversity. Sinsuer Associates, Inc, Sunderland, MA.

Hoctor, T. S., Carr, M. H. 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.

Hooper D. U. and P. M. Vitousek. 1997. The Effects of Plant Composition and Diversity on Ecosystem Processes. *Science* 277: 1302-1305.

Huston, M. A. 1996. *Biological Diversity: The Coexistence of Species on Changing Landscapes*. Cambridge University Press: New York, NY. 681 pp.

Jue, S., Kindell, C., and J. Wojcik. 2001. Florida Managed Areas (FLMA) - April 2001. Retrieved April 2001 from http://www.fnai.org/gis_data.cfm Online. Internet.

Karr, J. R. and I. J. Schlosser. 1978. Water Resources and the Land-water Interface. *Science* 201:229-234.

Kautz, R. S. and J. A. Cox. 2001. Strategic Habitats for Biodiversity Conservation in Florida. Conservation *Biology* 15(1): 55-77.

Kautz, R. S., Gilbert, D. T. and G. M. Mauldin. 1993. Vegetative Cover in Florida Based on 1985-1989 Landsat Thematic Mapper Imagery. *Florida Scientist* 56: 135-154.

Martino, D. 2001. Buffer Zones around Protected Areas: A Brief Literature Review. *Electronic Green Journal* 15: 1-15.

Mykytka, J. M. and M. R. Pelton. 1989. Management Strategies for Florida Black Bears Based on Home Range Habitat Composition. *International Conference of Bear Research and Management* 8: 161-167.

Naeem, S., Tompson, L. J., Lawler, S. P., Lawton, J. H. and R. M. Woodfin. 1994. Declining Biodiversity Can Alter the Performance of Ecosystems. *Nature* 368: 734-37.

Noss, R. F. 1987. Corridors in Real Landscapes: A Reply to Simberloff and Cox. *Conservation Biology* 1(2) 159-164.

Oates, W. 1994. *Federalism and Government Finance*. Modern Public Finance, Harvard University Press, Cambridge MA.

Orians, G. H. 1993. Endangered at What Level? *Ecological Applications* 3(2): 206-208.

Reid, W. and K. Miller. 1989. Keeping Options Alive: The Scientific Basis for Conserving Biodiversity. World Resources Institute, Washington, DC.

Reynolds 1999. Urban Land Conversion and Competition for Rural Land Use. Staff Paper Series SP 99-15, University of Florida Institute of Food and Agricultural Sciences, Gainesville, Florida.

Savard, J. L., Clergeau, P. and G. Mennechez. 2000. Biodiversity Concepts and Urban Ecosystems. *Landscape and Urban Planning* 48: 131-142.

Sayer, J. 1991. Rainforest Buffer Zones: Guidelines for Protected Area Managers. IUCN – The World Conservation Union, Forest Conservation Programme. Gland, Switzerland.

Schlosser, I. J. and J. R. Karr. 1981. Water Quality in Agricultural Watersheds: Impact of Riparian Vegetation during Base Flow. *Water Research Bulletin* 17:233-240.

Stoms, D. M., Davis, F. W. and C. B. Cogan. 1992. Sensitivity of Wildlife Habitat Models to Uncertainties in GIS Data. *Photogrammetric Engineering and Remote Sensing* 6(58): 843-850.

Tilman, D. 1996. Biodiversity: Population versus Ecosystem Stability. *Ecology* 77: 350-363.

Trombulak, S. C. and C. A. Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. *Conservation Biology* 14(1): 18-30.

U.S. Census. Projections of the Total Populations of States. Retrieved May 1, 2003, from http://www.census.gov/population/projections/state/stpjpop.txt Online. Internet.

Wooding, J. B. and J. R. Brady. 1987. Black Bear Roadkills in Florida. *Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies* 41:438-442.