THE INTEGRATED WILDLIFE HABITAT RANKING SYSTEM 2009

Mark Endries[1], Terry Gilbert[2], and Randy Kautz[3]

[1]Florida Fish and Wildlife Conservation Commission
620 South Meridian St.
Tallahassee, FL 32399-1600

[2]URS Corporation
1625 Summit Lake Drive
Tallahassee, FL 32327

[3]Breedlove, Dennis and Associates, Inc.
2625 Neuchatel Drive
Tallahassee, FL 32303-2249

Exhibit INT418
June 26, 2012

ABSTRACT

The Florida Fish and Wildlife Conservation Commission (FWC) is responsible for the protection of the state's fish, wildlife and habitat resources. FWC biologists perform environmental reviews of major land development projects in Florida that potentially impact upland, wetland, and aquatic habitat systems that support commercially and recreationally important fish and wildlife resources, including listed species. In an effort to improve the efficiency and accuracy of these reviews, and to improve coordination among agencies, the FWC developed a Geographic Information Systems (GIS)-based assessment tool that incorporates a wide variety of land cover and wildlife species data. The Integrated Wildlife Habitat Ranking System (IWHRS) ranks the Florida landscape based upon the habitat 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 part of the FWC's continuing technical assistance to various local, regional, state, and federal agencies, and entities interested in wildlife needs and conservation in order to: (1) determine ways to avoid or minimize project impacts by evaluating alternative placements, alignments, and transportation corridors during early planning stages, (2) assess direct, secondary, and cumulative impacts to habitat and wildlife resources, and (3) identify appropriate parcels for public land acquisition for wetland and upland habitat mitigation purposes.

The IWHRS was originally created in 2001 and underwent a major revision in 2007 using updated datasets. In 2008 changes were made to five of the data layers (Listed Species Locations, Species Richness, Managed Lands, Distance to Managed Lands, and Florida Forever Board of Trustees/Save Our Rivers Lands) using data not available in 2007, and the Landscape Diversity layer was replaced with a Spatial Heterogeneity layer. In 2009, the binary Strategic Habitat Conservation Areas (SHCA) layer was replaced with a prioritized SHCA layer and all other layers except Spatial Heterogeneity and Landscape Connectivity were updated with data not available in 2008. This document describes the IWHRS 2009.

INTRODUCTION

FWC Biologists perform reviews of major land developments such as highways, residential and commercial developments, dredging for navigation channels and marinas, natural gas pipelines, phosphate and limestone mining, and other projects that impact fish and wildlife resources and their habitats. These land use changes can adversely impact species listed by the FWC as threatened, endangered, or species of special concern; recreationally and commercially important fish and wildlife resources; rare and sensitive 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 applicant or permitting agencies on potential 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 designers, 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 to resource biologists and land developers. Additionally, major resource issues must be quickly and clearly defined and potential solutions fully investigated before final project design and 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 rapid assessment of fish and wildlife resource and habitat features in the state of Florida. This tool would permit landscape-scale evaluation of a proposed project to assess its impact on lands important to fish and wildlife species.

Geographic Information Systems (GIS) provide an ideal tool for regional and statewide assessments of landscapes, development and application of habitat models, and modeling of the potential distribution of species and habitats (Conner and Leopold 1998, Stoms *et al.* 1992). GIS have also 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, to allow GIS users to view their project in a landscape prospective, and to 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 strengthen and enhance environmental assessments and to help bridge the information gap between wildlife agencies, land developers, and land use planners by creating 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.

The IWHRS was originally constructed in 2001. Since 2001, the landscape of Florida has changed, many of the principal datasets have been updated, new datasets have become available, and information on wildlife locations has continued to be gathered. While additional lands have been acquired for wildlife conservation, large areas of habitat have been lost to development. As a result, in 2007 the IWHRS underwent a major revision utilizing new and updated datasets (IWHRS 2007). In 2008, the IWHRS (IWHRS 2008) was modified by replacing the Landscape Diversity layer with a more refined Spatial Heterogeneity layer and the other layers were updated if new or updated datasets were available. The updated layers in the IWHRS 2008 include Listed Species Locations, Species Richness, Managed Lands, Distance to Managed Lands, and Florida Forever Board of Trustees/Save Our Rivers Lands. In 2009, The IWHRS (IWHRS 2009) was again modified by replacing the binary SHCA layer with a prioritized SHCA layer, incorporating into numerous datasets a 2008 developed lands dataset, and updating other datasets if newer data were available. The updated layers in the IWHRS 2009 include Roadless Habitat Patch Size, Listed Species Locations, Species Richness, Managed Lands, Distance to Managed Lands, Florida Natural Areas Inventory (FNAI) Habitat Conservation Priorities, and Florida Forever Board of Trustees/Save Our Rivers Lands. These updates maintain the IWHRS 2009 as a relevant natural resource tool given the rapid pace of land use change occurring across the Florida landscape. This document describes the IWHRS 2009.

METHODS

All GIS work was conducted in raster format using the Spatial Analyst extension of the ArcMap software package (ESRI, Version 9.3, 2008). The pixel size used for the analysis was 30 x 30 m, and the extent was the political boundary of the State of Florida.

Table 1. The 10 data layers used to calculate the IWHRS 2009.

Data Layers	
1.	Spatial Heterogeneity
2.	Roadless Habitat Patch Size
3.	Prioritized Strategic Habitat Conservation Areas (SHCA)
4.	Listed Species Locations
5.	Species Richness
6.	Florida Natural Areas Inventory (FNAI) Habitat Conservation Priorities
7.	Managed Lands
8.	Distance to Managed Lands
9.	Landscape Connectivity
10.	Florida Forever Board of Trustees/Save Our Rivers (FFBOT/SOR) Lands

The IWHRS 2009 is composed of 10 data layers that represent important ecological aspects for wildlife species in Florida (Table 1). The data layers used in the IWHRS 2009 were constructed by utilizing various preexisting GIS datasets (Table 2). 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 identify lands critical to wildlife. To construct the data layers of the IWHRS 2009, the preexisting datasets were manipulated to extract those features needed.

Table 2. Datasets used to construct the data layers of the IWHRS 2009.

Dataset	Description
Statewide Landcover	The land cover image created by the FWC using Landsat Enhanced Thematic Mapper satellite imagery collected in 2003. The classified image includes 43 land cover classes, including 26 natural and semi-natural vegetation types, 16 types of disturbed lands (e.g. agriculture, urban, mining), and 1 water class. For a complete description of classification methods and land cover classes please see Kautz et al. (2007) and Stys et al. (2004).
2008 Developed lands	The land cover image created by Avineon, Inc. (contracted by FWC) using Landsat Enhanced Thematic Mapper satellite imagery collected 2006 and 2007. The classified image includes 11 classes, including only those areas identified as “disturbed” or “non-natural”. This dataset was created to enhance our understanding of the distribution of these land cover types in Florida. An accuracy assessment was conducted by FWC staff in 2009. The data and associated report is available on FWC’s web page (Research/GIS and Mapping/Data and Maps| Terrestrial/Mapping Florida’s Altered Landscapes).
Wildlife Species Potential Habitat Maps	These FWC maps are based on known locations of species of wildlife, information on the land cover and vegetation types used by each species, and published or well documented information on the life-history requirements of the species. The potential habitat maps identify those areas statewide that could serve as potential habitat for an individual wildlife species.
Strategic Habitat Conservation Areas (SHCA)	SHCA are important habitat areas in Florida with no formal conservation protection that are needed to achieve population stability for listed, rare, and imperiled wildlife (Cox *et al.* 1994, Endries *et al.* 2009). Through population viability analyses, the lands identified as SHCA for a species, in conjunction with habitat occurring on existing conservation lands, are needed to provide the species with a minimum base of habitat for long-term persistence. We used the SHCA identified in The FWC Wildlife Habitat Conservation Needs in Florida report (Endries et al. 2009).

FNAI Conservation Needs Assessment Habitat Conservation Priorities.	The Conservation Needs Assessment is a geographic analysis of the distribution of certain natural resources and resource based land uses that have been identified by the Florida Forever Council and Florida Legislature as needing increased conservation attention (Florida Natural Areas Inventory 2007*b*). The Habitat Conservation Priorities layer prioritizes areas on the landscape that would protect both the greatest number of rare species and those species with the greatest conservation need. We utilized version 3.0 completed in 2008.
Florida Ecological Greenways Network Critical Linkages	The Florida Ecological Greenways Network identifies the opportunities to protect large, intact landscapes important for conserving Florida's biodiversity and ecosystem services (Hoctor et al. 2000). The Florida Greenways project is an analysis of potential ecological connectivity using land-use data to identify areas with conservation significance and potential landscape linkages. This dataset contains the Florida ecological greenways network and critical linkages prioritization results approved by the Florida Greenways and Trails Council in November 2005 (Florida Geographic Data Library 2007).
Managed Land Boundaries	The FNAI Florida Managed Areas (FLMA) database includes public and some private lands that the FNAI has identified as having natural resource value and that are being managed at least partially for conservation purposes (Florida Natural Areas Inventory 2007*c*). The Inventory database includes boundaries and statistics for more than 1,600 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. We utilized the FLMA database from March 2009.
Florida Forever Board of Trustees (FFBOT) Projects	Florida Forever is the nation's largest conservation land buying program. Collectively, the State of Florida has protected over 535,643 acres of land with $1.8 billion in Florida Forever funds through December 2006. Florida Forever lands are proposed for acquisition because of outstanding natural resources,

	opportunity for natural resource-based recreation, or historical and archaeological resources. However, these areas may not be currently managed for their resource value. This dataset contains boundaries of all FFBOT projects approved by the State's Acquisition and Restoration Council as of June 2009 (Florida Natural Areas Inventory 2009*a*).
Save Our Rivers (SOR) Lands Boundaries	Using monies from the Water Management Lands Trust Fund and Florida Forever, the SOR program enables the five Florida water management districts to acquire lands necessary for water management, water supply, and the conservation and protection of water resources including wildlife. Due to lack of more current information, we utilized the existing Save our Rivers database from the original IWHRS but removed any areas that are publicly owned.

Model Layers

Spatial Heterogeneity

This layer measures the spatial complexity and variability of habitat patches in the state of Florida. It is important when identifying areas of ecological significance to consider heterogeneity of the landscape, which may have significant effects on various ecosystem processes including predator-prey relationships (Pierce et al. 2000), population and metapopulation dynamics (Dempster and Pollard 1986, Dunning et al. 1992, Henein et al. 1998, Kie et al. 2002), community structure and biotic diversity (Holt 1984, Pianka 1992, Holt 1997), conservation biology (With 1997), and others. A landscape composed of a mosaic of habitats will provide suitable conditions for a variety of species (Huston 1996). For example, bird diversity has been shown to be positively correlated with 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).

The spatial heterogeneity analysis only includes natural land cover types from the FWC 2003 landcover image. Any open water, disturbed communities, agriculture, exotic plants, urban, and mining landcover categories were excluded. Due to computer processing limitations landcover classes were grouped to seven general categories (Table 3). We used the definition of spatial heterogeneity in categorical maps proposed by Li and Reynolds (1994). They define spatial heterogeneity as complexity in five components: (1) number of patch types, (2) proportion of each type, (3) spatial arrangement of patches, (4) patch shape, and (5) contrast between neighboring patches. To model these components in a GIS, we created an intermediate GIS data layer for each component of spatial heterogeneity.

Table 3. Classification of the FWC 2003 land cover image for the spatial heterogeneity analysis.

Classes	Description
1 – 2	Coastal Habitat
4, 5, 9	Pineland
3, 8, 10, 11	Hardwood Forest
7	Mixed Hardwood-Pine Forests
6	Dry Prairie
12, 13, 14, 23, 26	Herbaceous Wetland
15, 16, 17, 18, 19, 20, 21, 22, 24, 25	Woody Wetland

To represent the number of patch types we ran a Variety moving window analysis in ArcGIS using a 570 m (19 pixels) window. 570 m as a radius gets as close to a 100 ha circle as possible given 30 m pixel intervals in the landcover image. We then ran a Maximum Zonal Statistic in ArcGIS to obtain the maximum variety value for each patch. The resultant layer attributes each patch with the highest number of different patches within 570 m. To represent proportion of each type we used Fragstats and performed Simpson's Evenness Index (SIEI) landscape analysis. Then using zonal statistics in ArcGIS, we obtained the mean SIEI value for each patch. To represent the spatial arrangement of patches we used Fragstats and performed a patch analysis using the Mean Proximity Index. To represent patch shape we used Fragstats and performed a patch analysis using the Fractal Dimension analysis. To represent the contrast between neighboring patches we used Fragstats and performed a patch analysis using the Edge Contrast Index.

To obtain our final spatial heterogeneity layer we first transformed any of the intermediate data layers that were non-normally distributed. Next, we standardized the data ranges between the intermediate layers so that all were on a 0-1 scale and then added all layers together to obtain our measure of spatial heterogeneity. The range of values was divided into 10 discrete categories using a quantile methodology, the higher the value in the spatial heterogeneity layer the more heterogeneous the patch.

Roadless Habitat Patch Size

The influence of roads on wildlife is well documented. In a review, Trombulak and Frissell (2000) identified 7 general impacts that roads have on wildlife: (1) mortality from road construction, (2) mortality from collision with vehicles, (3) modification of animal behavior, (4) alteration of the physical environment, (5) alteration of the chemical environment, (6) spread of exotics, and (7) 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 IWHRS 2009 by identifying continuous habitat patches in the state of Florida bounded by roads and ranking them based on size.

We used the FWC 2003 land cover image to identify habitat statewide. We updated the 2003 land cover image with a 2008 developed lands dataset. The 2008 developed lands dataset was constructed using 2008 imagery and identifies all human altered areas using the FWC 2003 land cover classification scheme. To construct the data layer for roadless habitat patch size, the hybrid FWC 2003/2008 land cover image was reclassified so that only categories representing natural land cover habitat (values 1-26) were identified and grouped into single-value continuous patches. To ensure that all major roads were accurately represented as sectioning the landscape, the April 2008 version of the Florida Department of Transportation Roads Characteristics Inventory (RCI) dataset (Florida Department of Transportation 2008) was converted into a 30 m grid where all road networks were given a value of NoData and all other areas were given a value of 0. Next, an addition calculation was performed with the reclassed land cover image and RCI grid. The resulting grid represents native vegetation patches as a single value and all non-native vegetation and road areas as no data. We calculated the total area of each continuous patch by performing a region group analysis, which clusters each patch and identifies the total number (count) of pixels per patch.

Due to the size and scale of analysis, a minimum habitat patch size of 0.15 km^2 was used. Mykytka and Pelton (1989) found that habitat patches >0.152 km^2 (37 acres) were important components of black bear habitat in the Osceola National Forest. The Florida black bear is a species integral to the IWHRS 2009, and its history of roadkills is well documented (Gilbert *et al.* 2001, Wooding and Brady 1987). If a habitat patch was smaller than 0.15 km^2, it was not included in the analysis and scored 0.

Habitat patches were ranked using a 10 class quantile classification scheme due to the large size range of the parcels (from 0.15 km^2 to 3490 km^2). The quantile classification method identifies class cut-off values so that the total area of land in each class is approximately the same. Scoring was as follows:

0. < 0.15 km^2
1. 0.15 km^2 – 2.22 km^2
2. 2.22 km^2 – 8.87 km^2
3. 8.87 km^2 – 21.24 km^2
4. 21.24 km^2 – 43.69 km^2
5. 43.69 km^2 – 76.80 km^2
6. 76.80 km^2 – 124.87 km^2
7. 124.87 km^2 – 209.08 km^2
8. 209.08 km^2 – 442.89 km^2
9. 442.89 km^2 – 1070.73 km^2
10. > 1070.73 km^2

Strategic Habitat Conservation Areas (SHCA)

SHCA identify important habitat areas for species of wildlife with a deficiency in the amount of appropriate habitat protected by the current system of lands managed for conservation in Florida. We used the prioritized SHCA dataset in the Wildlife Habitat Conservation Needs in Florida report (Endries et al. 2009) and reclassified the five SHCA priority classes on a 0 – 10 scale as follows:

0. No SHCA
2. Priority 5 SHCA
4. Priority 4 SHCA
6. Priority 3 SHCA
8. Priority 2 SHCA
10. Priority 1 SHCA

Listed Species Locations

The US Endangered Species Act of 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 that reflects the locations and diversity of the state-listed terrestrial vertebrate wildlife species in the state of Florida. The FWC officially lists imperiled wildlife species in the state of Florida and recognizes 3 categories: endangered, threatened, and species of special concern. The state imperiled species list serves as a means for the state to protect wildlife and to set conservation priorities specific to the state of Florida.

Using wildlife potential habitat maps for listed species created by the FWC, 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:

0. No listed species present
1. 1 species of special concern
2. ≥ 2 Species of Special Concern
3. 1 Threatened species and ≤ 1 Species of Special Concern
4. 1 Threatened Species and ≥ 2 Species of Special Concern
5. 2 Threatened Species and ≤ 1 Species of Special Concern
6. 2 Threatened Species and ≥ 2 Species of Special Concern
7. ≥ 3 Threatened Species and ≥ 0 Species of Special Concern
8. 1 Endangered Species and ≥ 0 Threatened Species and ≥ 0 Species of Special Concern
9. 2 Endangered Species and ≥ 0 Threatened Species and ≥ 0 Species of Special Concern
10. ≥3 Endangered Species and ≥ 0 Threatened Species and ≥ 0 Species of Special Concern

Species Richness

The protection of biodiversity is important for a variety of reasons such as ecological, economical, medical, aesthetical, and recreational. 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, Wilsey and Potvin 2000).

To model biodiversity for the species richness data layer, we utilized the potential habitat maps of 95 wildlife species that were created by the FWC and merged all species maps into a single layer. A pixel's value represents a classification of the number of species identified as having potential habitat at that site. The range of values was 0 (representing no species) to 21 species overlapping in a single pixel. We classified the final layer using a 10 class quantile classification scheme. The classification values are given below:

0. No species present
1. 1 species
2. 2 species
3. 3 species
4. 4 species
5. 5 species
6. 6 species
7. 7 species
8. 8 species
9. 9 - 10 species
10. ≥11 species

FNAI Habitat Conservation Priorities

The FNAI conservation needs assessment layer contains six priority classes. The classes prioritize habitats throughout Florida based on number of rare species and those species with the greatest conservation need. We reclassified the six FNAI conservation needs assessment priority classes on a 0 – 10 scale as follows:

0. No priority
2. Priority 6 habitats
3. Priority 5 habitats
5. Priority 4 habitats
7. Priority 3 habitats
8. Priority 2 habitats
10. Priority 1 habitats

Managed Lands

Lands managed for the benefit of fish and wildlife resources provide the most essential protection of fish and wildlife species and are the one of the most important ways to ensure that those lands that are needed for fish and wildlife will remain in perpetuity. To construct the public lands data layer, all public lands identified in the FNAI FLMA database were given a value of 10; all other areas were classed 0.

Distance to Managed Lands

If one applies the theory of island biogeography (MacArthur and Wilson 1967) to managed lands by treating each block of managed land as an "island", then the predictions of island biogeography theory can be applied to land management in the following way:

1. Managed land tracts of larger area will host more species than those of smaller area because those of larger area are likely to provide a greater variety of habitat types.
2. Small, isolated managed land tracts will suffer higher rates of extinction than larger managed land tracts. Small "islands" generally support fewer individuals of each species present; therefore, each species is at greater risk of its numbers declining to zero.
3. Managed land tracts of small area close to very large managed land tracts will be more diverse and have lower extinction rates than those distant from very large managed land tracts. In general, the recolonization potential that large managed land tracts provide increases as the distance to the smaller managed land decreases.

These predictions suggest that the size of new managed lands and their proximity to existing managed areas can be critical to the maintenance of their species diversity and persistence. For example, protecting areas surrounding existing managed lands serves to enhance the conservation value of the entire area (Sayer 1991). Additionally, protecting areas surrounding existing managed lands protects the park or protected area from outside disturbance (Martino 2001, Reid and Miller 1989). For wide ranging species, building upon existing managed lands helps to protect areas large enough to sustain stable populations of the species.

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

1. > 20.25 km from managed land
2. 15.71 km – 20.25 km from managed land
3. 12.45 km – 15.71 km from managed land
4. 9.66 km – 12.45 km from managed land
5. 7.22 km – 9.66 km from managed land
6. 5.12 km – 7.22 km from managed land
7. 3.26 km – 5.12 km from managed land
8. 1.51 km – 3.26 km from managed land
9. 0.01 km – 1.51 km from managed land
10. 0 km from managed land

Landscape connectivity

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). Maintaining and restoring habitat connectivity can result in healthy ecosystem function, increased habitat, increased species richness and persistence, larger populations, optimal genetic interchange, reduced predation, and reduced human-caused death (Hilty *et al.* 2006). For example, 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). Habitat connectivity also has human benefits in the form of areas open to public access.

To include landscape connectivity in the IWHRS 2009, we utilized the results of the Florida ecological greenways network and critical linkages prioritization results (Florida Geographic Data Library 2007). We reclassified the six prioritization classes on a 0 – 10 scale as follows:

0. No linkage
2. Low priority linkage
3. Moderate-low priority linkage
5. Moderate priority linkage
7. High priority linkage
8. Very high priority linkage
10. Critical priority linkage

FFBOT/SOR Lands

Florida Forever Board of Trustees lands serve to conserve and protect unique natural areas, endangered species, unusual geologic features, wetlands, and archaeological and historical sites. Save Our Rivers lands conserves lands 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 FFBOT/SOR data layer, lands identified on either of these lists were given a value of 10 where all other areas were given a value of 0. Overlaps with existing managed areas were eliminated from the analysis.

IWHRS 2009 Construction

The final image was constructed by adding all 10 data layers together. The maximum calculated value was 87 out of a potential 100. Since the model only assesses upland and wetland terrestrial habitats, we used the FWC 2003 landcover image and reclassified all open water areas to have a value of zero. The final calculation was then classified using a 10 class scheme. The resulting value assigned to each pixel indicates its importance to wildlife (e.g. the higher the value of a pixel the more important it is to wildlife) (Table 4).

Table 4. Classification of the IWHRS calculation result.

IWHRS Class	Calculation Value Range
1	1 – 10
2	11 – 18
3	19 – 26
4	27 – 34
5	35 – 42
6	43 – 49
7	50 – 55
8	56 – 60
9	61 – 66
10	67 – 87

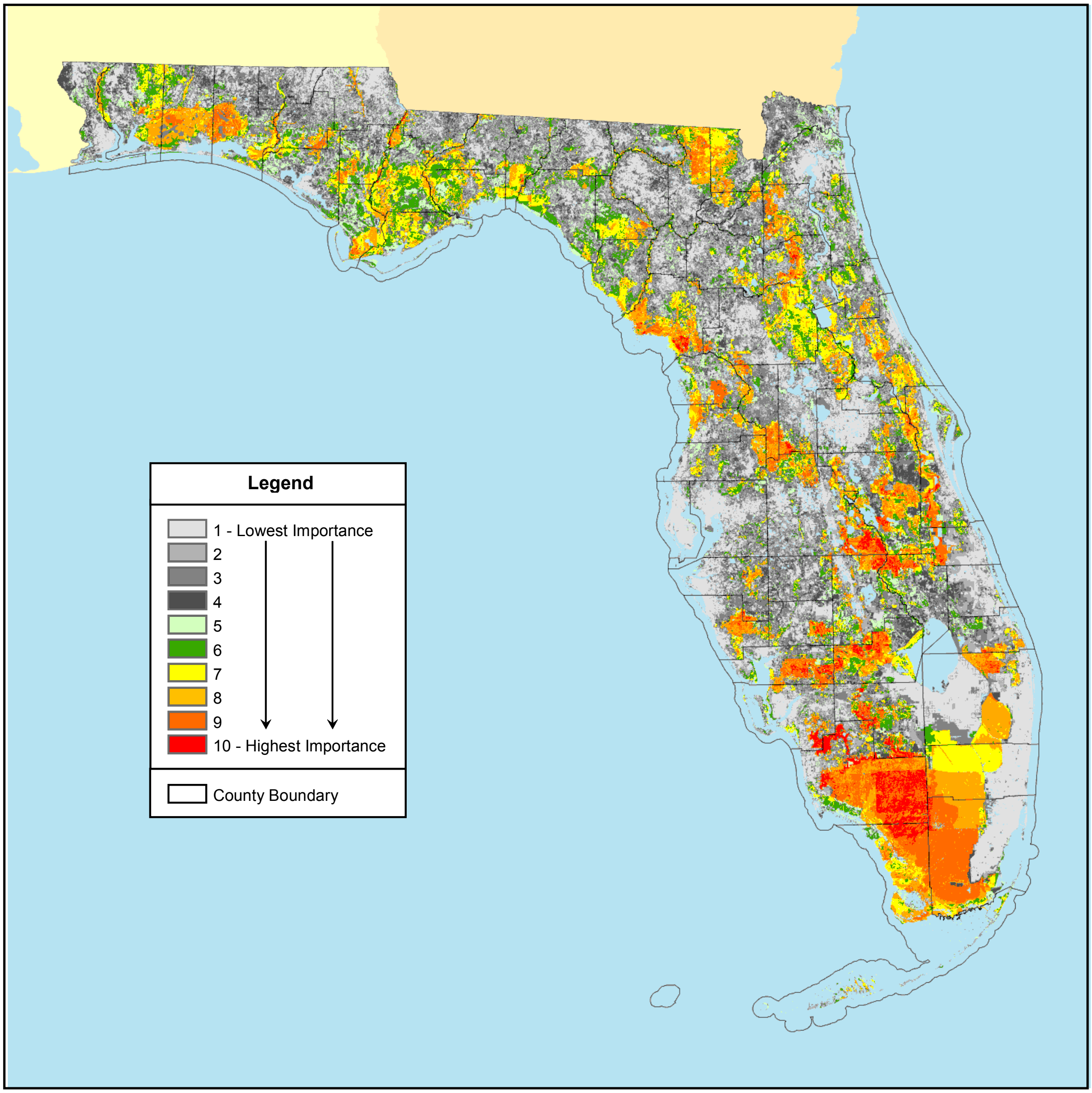

Figure 1. The final model calculation of the IWHRS 2009.

RESULTS

Figure 1 shows the result of the IWHRS 2009. Florida is fortunate that many areas of important native ecological communities remain statewide. Assuming that lands identified in the IWHRS 2009 with a value of 6 or greater constitute at least intermediate quality habitat for wildlife, 5.1 million hectares of a statewide total of 14.5 million hectares are identified. This reveals that over 1/3 of the total land mass of Florida continues to provide some level of ecological significance to wildlife.

The IWHRS 2009 identifies the importance of many lands currently managed for conservation in Florida, and it indicates the relative ecological values of many unprotected areas. Of the 5.1 million hectares of lands with a value of 6 or greater, 1.84 million of these hectares are not managed under any type of formal conservation protection.

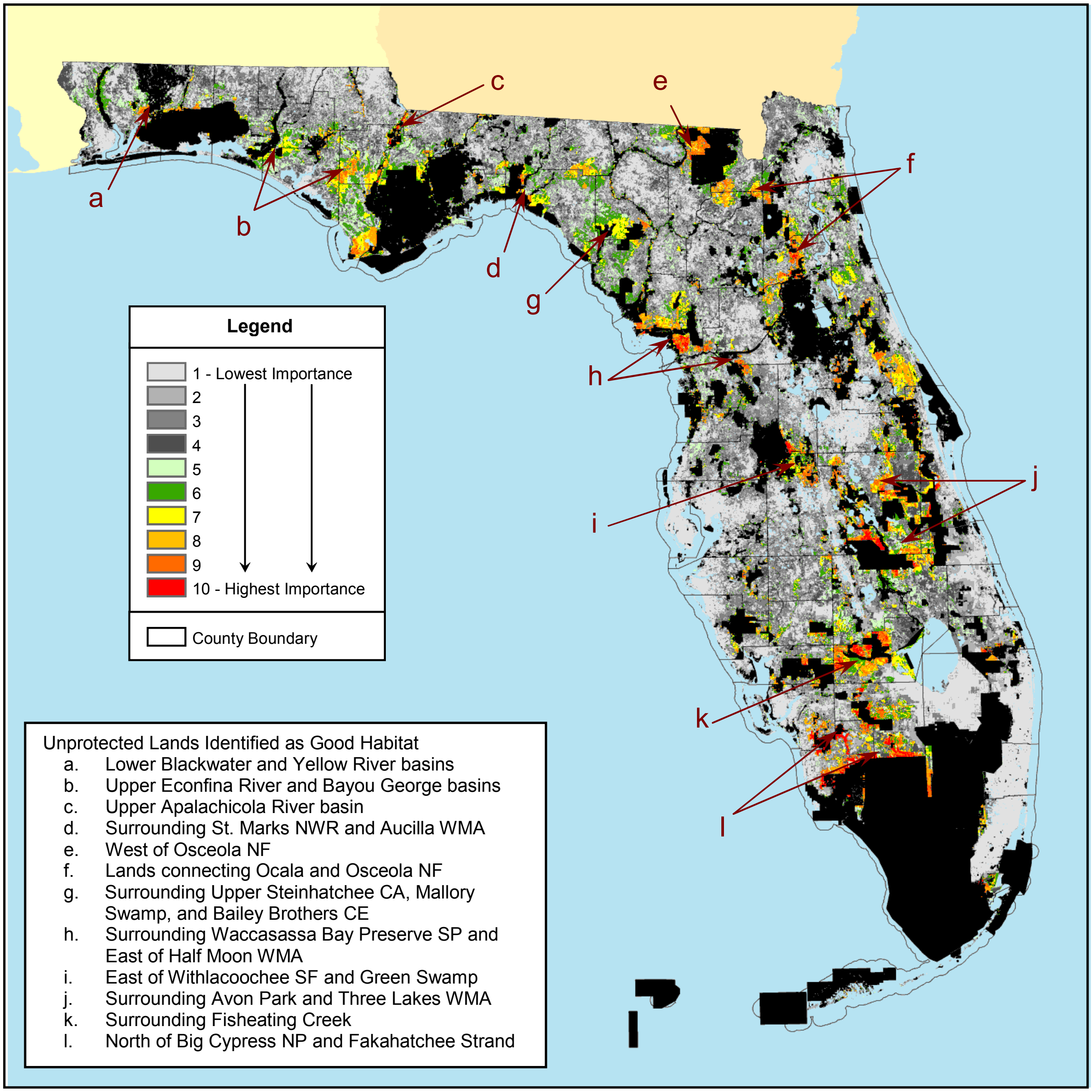

Figure 2. Final model calculation of the IWHRS 2009 with managed lands in black.

Overlaying the FLMA database on the IWHRS 2009 allows one to visually identify many good quality lands not under any type of conservation protection (Figure 2). Some of these areas include (a) the lower Blackwater and Yellow River systems and associated uplands that would further connect Blackwater State Forest with Eglin Air Force Base, (b) lands within the Upper Econfina and Bayou George basins, (c) lands along the upper Apalachicola River, (d) lands surrounding St. Marks National Wildlife Refuge and Aucilla and Big Bend Wildlife Management Areas, (e) lands along the western border of Osceola National Forest, (f) lands that would connect Ocala and Osceola National Forests through Camp Blanding, (g) lands surrounding Upper Steinhatchee Conservation Area, Mallory Swamp, and Bailey Brothers Conservation Easement, (h) lands surrounding Waccasassa Bay Preserve State Park and east of Half Moon Wildlife Management Area, (i) lands East of Withlacoochee State Forest and Green Swamp, (j) lands surrounding Avon Park and Three Lakes Wildlife Management Area , (k) lands surrounding Fisheating Creek, and (l) lands north of Big Cypress National Preserve and Fakahatchee Strand.

DISCUSSION

Florida currently has an estimated population of 18.5 million people (U.S. Census Bureau 2010) and hosts roughly 80 million tourists each year (VISIT FLORIDA Research 2010). From 2000 to 2009 Florida experienced an average population growth rate of 13.9%, adding over 2.5 million people to the state (U.S. Census Bureau 2010). Population growth projections have the Florida population surpassing New York making Florida the third largest state with over the 20 million people by 2015.

With population growth and tourism comes loss of natural habitat by conversion to urban and agriculture uses. Land use change measured over a 14-18 year period ending in 2003 calculated a 13.34% loss of natural and semi-natural land cover to urban (6.21%) and agricultural uses (7.14%)(Kautz et al. 2007). 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 jeopardizes the natural landscape of Florida. It is imperative that those lands critical to preserving Florida's wildlife are not dramatically impacted by development pressures.

IWHRS Uses

The IWHRS provides a measure of habitat quality over the entire land surface of Florida and is designed to serve as a rapid assessment tool to help manage impact assessment on development projects. The IWHRS serves a role in helping users identify habitat areas important to wildlife that should be conserved and assess impacts that land development projects could have on the surrounding area. With this information one can evaluate the habitat quality of potential development project site locations and surrounding areas to make informed decisions and identify those projects requiring the most attention and coordination with the FWC. Furthermore, the IWHRS can be used to identify appropriate parcels of land for mitigation through land acquisition.

Specific Examples of IWHRS Use

Since its inception in 2001 the IWHRS has become an integral tool used to assess proposed development projects and their impacts on the status of wildlife and biodiversity conservation statewide. It has proven valuable for assessing the impacts of proposed road construction projects, helping to compare and select alignments with the least impact to wildlife habitat, and identifying mitigation lands. It is hoped that the IWHRS 2009 will be utilized the same as the original, 2007, 2008 versions of the IWHRS and supply users with current data on wildlife needs in Florida.

The FWC is using the IWHRS 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 negative impacts of land development projects. The IWHRS assists with reviews of development projects including new highway construction or expansions and dredge and fill associated with bridge construction. The FWC uses the IWHRS to evaluate and compare multiple alignments, and assess direct, secondary, and cumulative impacts to important habitat systems and wildlife resources. The IWHRS 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 (PD&E) phase such as impacts to listed species, public lands, and habitat connectivity. The natural resource information forms the basis for a FWC letter to regulatory agencies on recommendations on ways to avoid, minimize, or mitigate impacts.

The IWHRS is being used as one of the guiding data layers for selecting and mapping spatially explicit conservation lands for the myregion.org program. Myregion.org is a regional growth management visioning program consisting of citizens and leaders from public, private, and institutional sectors to prepare the Central Florida Region to compete more effectively in the 21st century while enhancing the quality of life of its citizenry (myregion.org 2007). The conservation plan for myregion.org is being used as the environmental infrastructure that will guide growth modeling for placement of growth centers, transportation corridors, and local land use planning.

The Orlando Orange County Expressway Authority's Environmental Advisory Committee is using the IWHRS as one of the major environmental data layers and as a primary biodiversity data layer used in feasibility studies.

The IWHRS has been used by the St. John's River Water Management District and FDOT to identify habitat areas for the public acquisition of $8.17 million of mitigation lands as part of the of the I-4 expansion project in Volusia county. The lands purchased enlarge the public land habitat system in the area of Tiger Bay State Forest in Volusia County, and enhance the connection of the Tiger Bay State Forest with the Ocala National Forest.

The IWHRS is one of the FWC datasets incorporated into the FDOT Environmental Screening Tool used to analyze impacts of all FDOT proposed road projects reviewed by various private, state, and federal agencies for all 7 FDOT districts and the Turnpike Enterprise. In 2006 the IWHRS was used in approximately 130 project reviews and for 2007 will total about 140 project reviews. The IWHRS will also be used by the FDOT for an upcoming pilot project to assess the indirect and cumulative impacts that highway projects have on wildlife and biodiversity. The IWHRS is especially suited for this application since the evaluation parameters are diverse and wide-reaching. The IWHRS provides a convenient and consistent way to measure habitat quality at the various scales and provides a means to assess the indirect and cumulative impacts (often occurring far from the actual project area) that a road development project can facilitate in the surrounding area. The IWHRS is discussed as part of a Case Study in the 2009 report "New Approaches to Ecological Surveys" (NCHRP 2009).

Data Distribution

We provide the results of the IWHRS, the data layers that contributed to the IWHRS, and an ArcGIS (ESRI, Redlands, CA) project on digital media. By providing the data in this format, users have the full capabilities of GIS to perform further analysis or inquiries with the IWHRS data. Using the identify tool in ArcGIS, users can identify individual pixel values of the IWHRS results, and any data layer used to calculate the IWHRS at specific locations or regions in Florida. This allows users to get a clear understanding of the importance of each data layer at specific locations. Users can also use their own data or the additional data included on the digital media in conjunction with the IWHRS.

Users can customize and recalculate the IWHRS by adding or removing data layers to better fit the task at hand. 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 becomes available, users can replace old data layers and update the IWHRS. This will keep the IWHRS as current and accurate as the data available.

Limitations

A GIS model is only as accurate as the data it contains. The information provided on the IWHRS CD 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.

Five of the data layers (spatial heterogeneity, roadless habitat patch size, SHCA, listed species, and species richness) use the FWC 2003 land cover image as the base map to represent the habitat classes and wildlife habitat that exist statewide. Misclassifications in the FWC 2003 landcover image are possible because the landcover image was not assessed for accuracy. During map construction the map was visually inspected and reviewed by local managers, and cursory site inspections of many areas was conducted by the map creators, but the accuracy of the landcover image statewide was not formally assessed. Thus, the effects of misclassification errors on species habitat delineations are unknown. Also, the FWC land cover image was created from 2003 Landsat Thematic Mapper imagery. The Florida landscape is rapidly changing and any changes since 2003 are not reflected in the data layers constructed from the land cover imagery.

The remaining data layers were constructed using datasets not created by the FWC. The errors associated with these datasets can be referenced by reviewing the documentation and metadata associated with each specific dataset.

The IWHRS is intended to be used as a guide. Land development and ownership in Florida is ever-changing and priority areas identified in the IWHRS might already have been significantly altered due to development or acquired into public ownership. 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. Be sure to check the status of all lands prior to making any decisions based upon the information contained in the IWHRS.

REFERENCES CITED

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., H. Schreier, W. A. Thompson, 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.

Dempster, J. P., and E. Pollard. 1986. Spatial Heterogeneity, Stochasticity and the Detection of Density Dependence in Animal Populations. Oikos 46: 413-416.

Dunning, J. B., B. J. Danielson, and H. R. Pulliam. 1992. Ecological processes that affect populations in complex landscapes. Oikos 65: 169-175.

Endries, M. J., B. E. Stys, R. J. Kawula, G. M. Mohr, G. Kratimenos, S. Langley, K. V. Root, and R. S. Kautz. In Preparation. Wildlife Habitat Conservation Needs in Florida: Updated Recommendations for Strategic Habitat Conservation Areas. Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

ESRI. 2003. ArcGIS, version 9.2. ESRI, Redlands, California, USA.

Florida Department of Transportation. 2007. Roads Characteristics Inventory Dataset. http://www.dot.state.fl.us/planning/statistics/gis/default.htm#roads. Accessed 10 Janurary 2007.

Florida Fish and Wildlife Conservation Commission. 2005. Florida's Wildlife Legacy Initiative. Florida's Comprehensive Wildlife Conservation Strategy. Tallahassee, Florida, USA.

Florida Geographic Data Library. 2007. Florida Ecological Greenways Network Critical Linkages and Priorities Results. http://www.fgdl.org/metadata/fgdc_html/gweco_prio_2005.fgdc.htm. Accessed 1 February 2007.

Florida Natural Areas Inventory. 2007*a*. Florida Forever / Board of Trustees Environmental Land Acquisition Projects. http://www.fnai.org/gisdata.cfm. Accessed 8 February 2007.

Florida Natural Areas Inventory. 2007*b*. Florida Forever Conservation Needs Assessment Habitat Conservation Priorities. http://www.fnai.org/gisdata.cfm. Accessed 8 February 2007.

Florida Natural Areas Inventory. 2007*c*. Florida Managed Areas (FLMA). http://www.fnai.org/gisdata.cfm. Accessed 8 February 2007.

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

Gilbert, T., R. Kautz, T. Eason, R. Kawula, and C. Morea. 2001. Prioritization of Statewide Black Bear Roadkill Problem Areas in Florida. Pp. 574-579 *in* 2001 Proceedings of the International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, North Carolina, USA.

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

Henein, K., J. Wegner, and G. Merriam. 1998. Population Effects of Landscape Model Manipulation on Two Behaviourally Different Woodland Small Mammals. Oikos 81: 168-186.

Hilty, J. A., W. Z. Lidicker Jr., and A. M. Merenlender. 2006. Corridor Ecology: The Science and Practice of Linking Landscapes for Biodiversity Conservation. Island Press, Washington DC, USA.

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.

Holt, R. D. 1984. Spatial Heterogeneity, Indierect Interactions, and the Coexistence of Prey Species. American Naturalist 124: 377-406.

Holt, R. D. 1997. From Metapopulation Dynamics to Community Structure: Some Consequences of Spatial Heterogeneity. Pages 149-164 *in* I. Hanski and M. E. Gilpin, editors. Metapopulation Biology: Ecology, Genetics , and Evolution. Academic Press, San Diego, California, USA.

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, New York, USA.

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

Kautz, R., B. Stys, R. Kawula. 2007. Florida Vegetation 2003 and Land Use Change Between 1985-89 and 2003. Florida Scientist 1: 12-23.

Kie, J. G., R. T., Bowyer, M. C. Nicholson, B. B. Boroski, and E. R. Loft. 2002. Landscape Heterogeneity at Differing Scales: Effects on Spatial Distribution of Mule Deer. Ecology 83: 530-544.

Lambeck, R. J. 1997. Focal species: a multi-species umbrella for nature conservation. Conservation Biology 11: 849-856.

MacArthur, R. H., and E. O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, New Jersey, USA.

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

McGarigal, K. S. A., S. A. Cushman, M. C. Neel, and E. Ene. 2002. FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. www.umass.edu/landeco/research/fragstats/fragstats.html Accessed 14 May 2008

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.

Myregion.org. 2007. About myregion.org. http://www.myregion.org Accessed 17 March 2007.

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

NCHRP (National Cooperative Highway Research Program). 2009. New Approaches to Ecological Surveys: A synthesis of highway practice. Transportation Research Board of the National Academies. Washington DC. 73 pp.

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

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

Pianka, E. 1992. Fire Ecology. Disturbance, Spatial Heterogeneity, and Biotic Diversity: Fire Succession in Arid Australia. National Geographic Research and Exploration 8: 352-371.

Pierce, B. M., V. C. Bleich, and R. T. Boyer. 2000. Social Organization of Mountain Lions: Does a Land-tenure System Regulate Population Size? Ecology 81: 1533-1543.

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

Reynolds, J. E. 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, USA.

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

Stys, B, R. Kautz, D. Reed, M. Kertis, R. Kawula, C. Keller, and A. Davis. 2004. Florida vegetation and land cover data derived from 2003 Landsat ETM+ imagery. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

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 Bureau. 2010. Population Finder, Florida. http://www.census.gov. Accessed 20 March 2009.

VISIT FLORIDA Research. 2010. Visit Florida's Online Portal to Florida Tourism Information and Resources. http://www.visitflorida.org. Accessed 20 March 2010.

Wilsey, B. J., and C. Potvin. 2000. Bodiversity and Ecosystem Functioning: Importance of Species Evenness in an Old Field. Ecology 81: 887-892.

With, K. A. 1997. The Application of Neutral Landscape Models in Conservation Biology. Conservation Biology 11: 1069-1080.

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 41:438-44.