Updating the Florida Ecological Greenways Network

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ABSTRACT

The Florida Ecological Greenways Network (FEGN) identifies opportunities to protect large, intact landscapes important for conserving Florida's biodiversity and ecosystem services, and serves as one of the conservation priority foundations for biodiversity and ecosystem protection efforts in Florida. Since the original FEGN boundary was delineated in 1997, many new GIS data layers identifying areas of conservation significance have been developed and land use has continued to change. This project provided the opportunity to complete a comprehensive update of the FEGN using the best available and current data to ensure that the priorities and boundaries remain up to date.

With the help of a Technical Advisory Group (TAG), we identified various relevant state and regional GIS data layers including data from the Florida Natural Areas Inventory's (FNAI) Florida Forever Conservation Needs Assessment, the Florida Fish and Wildlife Conservation Commission's (FWC) Wildlife Habitat Conservation Needs in Florida project, the Critical Lands and Waters Identification Project (CLIP), the Florida Geographic Data Library, the Florida Department of Environmental Protection (FDEP), and Florida panther (*Puma concolor coryi*) and Florida black bear (*Ursus americanus floridanus*) data from the FWC, U.S. Fish and Wildlife Service (USFWS), and the University of Kentucky (UK).

These data were reviewed and discussed with the TAG as potential criteria for identifying Priority Ecological Areas (PEAs), which serve as the conservation priority "building blocks" of the FEGN. We also discussed methods for identifying Hubs based on PEA criteria. Hubs are the larger areas of ecological significance that serve as the sources and destinations in the connectivity analyses used to complete the FEGN.

Connectivity/corridor analyses included assessments for the Florida panther, Florida black bear, riverine corridors, coastal to inland connectivity, xeric habitat connectivity, and general landscape connectivity based on discussions with our TAG. Various tools were employed, but major methods included Maxent habitat modeling, cost distance, and least cost path functions in ESRI's ArcGIS 9.3.1.

The new FEGN is slightly smaller than the previous version; major differences include additional area added in southwest and south-central Florida and less area included in north Florida compared to the previous FEGN. However, the primary areas of ecological connectivity are shared by both the new and previous FEGNs.

The last step in the FEGN update was to assign and update priorities. To start, the current eight priority levels were assigned to the new FEGN boundary. Based on discussions with the TAG, only two revisions to the FEGN priorities were accepted at this point: 1) Consolidation of the former eight priority levels into six by combining Critical Linkages 1 and Critical Linkages 2 into one top priority level, and combining the former Priority 1 and Priority 2 classes into the second highest priority class; 2) Elevating the Wakulla River Priority 3 corridor to a Critical Linkage to address potential sea level rise impacts in the St. Marks National Wildlife Refuge area. We will continue to assess additional changes to the new FEGN priorities as part of current updates to the CLIP database through mid 2014.

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INTRODUCTION

The Florida Ecological Greenways Network (FEGN) is part of the legislatively adopted Florida Greenways Plan administered by the Office of Greenways and Trails (OGT) in the Florida Department of Environmental Protection (Florida Statutes, Chapter 260). The Florida Ecological Greenways Network (FEGN) identifies the opportunities to protect large, intact landscapes important for conserving Florida's biodiversity and ecosystem services, and serves as a backbone for biodiversity and ecosystem protection efforts in Florida. An important goal of the FEGN is to protect a functionally connected network of public and private conservation lands from the tip of south Florida to the tip of the Florida panhandle while also potentially providing functional connectivity to conservation lands in Georgia and Alabama. The original boundaries of the FEGN were delineated in 1997 after two years of work with a large Technical Advisory Group. Since then, the FEGN has been prioritized, had a basic boundary update, and was then re-prioritized. Since the original FEGN boundary delineation, many new GIS data layers identifying areas of conservation significance have been developed. The Florida Comprehensive Wildlife Conservation Strategy places emphasis on priority natural communities and species of greatest conservation need. For many natural communities and species emphasized in the strategy, there are new or enhanced relevant GIS data available. A comprehensive update of the FEGN ensures that Florida's biodiversity conservation and ecosystem service priorities are effectively addressed when identifying the large, intact, and functionally connected landscapes across Florida. Climate change impacts, specifically sea-level rise (SLR), are also an important consideration when identifying and protecting a functionally connected network of public and private conservation lands across the state. Therefore, this update of the FEGN includes analysis and identification of conservation priorities to make certain that critical south-north and coastal habitat gradients are included and linkage priorities are selected that will not be compromised by SLR.

Finally, it is important to note that the FEGN and all of its component data layers are intended for planning purposes only. This issue is covered both within the relevant state greenways program legislation (Florida Statutes, Chapter 260) and in the caveats attached to CLIP data (see the Critical Lands and Waters 2.0 Technical Report).

METHODS

Summary

We compiled all relevant data sets, and work with the Technical Advisory Group (TAG) to update the criteria and methods for identifying Priority Ecological Areas, Hubs, and corridors. Once the new FEGN is compiled, we prioritized the new FEGN based on the original priorities and additional considerations including sea level rise (SLR) and development projections. Specific steps included: 1) compiling all relevant data sets including land use, land cover, species habitat conservation priorities, surface water protection priorities, and any additional data identified by the TAG; 2) identifying Priority Ecological Areas and Hubs, which are areas of state-level ecological significance and serve as the sources and destinations for connectivity modeling; 3) conducting connectivity analysis including a combination of least cost path/cost distance corridor modeling and species-specific connectivity priorities identified with help from relevant experts; 4) identifying areas of intact coastal to inland gradients that provide the best opportunities for functional responses of species and community gradients to sea level rise; and 5) prioritizing the new FEGN using the original FEGN priorities as a starting point, and then determining updated priorities based on both potential conflict with sea level rise, a new development projection model (an update to the Florida 2060 growth projection factoring in projected sea level rise), and the consensus expert opinion of the TAG.

Technical Advisory Group

The TAG is an essential part of the FEGN Update process providing review and an opportunity to develop expert consensus for selecting, prioritizing, and integrating the best available GIS data. TAG members have relevant scientific or technical expertise in regional conservation assessment, natural resources and ecosystems, relevant natural resource priorities or plans, and Geographic Information Systems (GIS). The Florida Ecological Greenways Update project TAG members were:

Jon Oetting	FNAI
Amy Knight	FNAI
Beth Stys	FWC
Bob Kawula	FWC
Richard Hilsenbeck	TNC
Walt McCown	FWC
Brian Scheick	FWC
John Cox	University of Kentucky
Darrell Land	FWC
Dave Shindle	Conservancy of Southwest Florida
Paul Lang	USFWS
Dennis Hardin	FFS
Dan Smith	UCF
Joe Prenger	FWC
Bonita Gorham	FWC
Joe Guthrie	University of Kentucky/NWR Association
Julie Morris	Wildlands Conservation
Jim Wood	FDEP Office of Greenways and Trails (OGT)
Samantha Brown	FDEP OGT
Robin Birdsong	FDEP OGT
Dean Rogers	FDEP OGT
Doug Alderson	FDEP OGT

We held five TAG meetings to review available data, develop the Priority Ecological Area (PEA) and Hub Criteria, assess and refine the Connectivity Analyses, approve the new FEGN base boundary, and develop and approve the new FEGN prioritization. These meetings were held on April 2011, January 2012, October 2012, April 2013, and June 2013. In addition, we held other meetings and discussions with FNAI (Jon Oetting and Amy Knight) and FWC (Bob Kawula and Beth Stys) TAG members who are most familiar with relevant natural community, species, and other natural resources priority GIS data to further discuss options and refine modeling criteria. Finally, we also had additional consultations with our panther (Darrell Land, Dave Shindle, John Cox, Dan Smith) and bear (Walt McCown, Brian Scheick, John Cox, and Joe Guthrie) TAG members to develop and refine the Florida panther and Florida black bear habitat and connectivity analyses.

One key element of the TAG recommended changes in the FEGN identification process is a less discrete process for identification of PEAs, Hubs, and corridors. For example, Florida panther and Florida black bear criteria have been included in the PEA and Hub identification but also the connectivity analysis for each of these species may result in some combination of the identification of priority habitat cores (or Hubs) and connectivity analyses, at least for these species. In addition, the coastal to inland, major river, and xeric connectivity analyses will also likely result in some merging of PEA, Hub, and connectivity methods.

In addition, the TAG was interested in considering the development of various data products similar to the Critical Lands and Waters Identification Project, which would include the new aggregated FEGN, but could also include specific landscape data or models including landscape integrity, landscape intactness, roadless areas, “landscape” species habitat, riparian ecological networks, coastal connectivity and/or networks, and corridors or connectivity identified for specific reasons. For example, in an FEGN database the PEA criteria could be separated into Species, Natural Community, and Landscape criteria both for user database flexibility and utility purposes but also to potentially require combinations of PEA categories for identifying Hubs. These recommended modeling process changes and products would expand the scope of the FEGN Update project but are a logical extension of the FEGN into a database with multiple layers and benefits, and these additional data layers will likely greatly expand the utility of the FEGN.

Priority Ecological Area (PEA) Criteria

PEAs are areas of statewide ecological significance that are based on established GIS data for identifying areas important for conserving biodiversity and ecosystem services. PEAs are the base building block of the FEGN that are used to help identify large, intact, and potentially functionally connected natural and semi-natural landscapes with higher ecological significance across the state. We used the criteria from the original Florida Ecological Greenways Network delineation (Hoctor et al. 2000) and the Florida Ecological Greenways Network boundary update (Hoctor 2004) as the basis for creating a draft delineation of Priority Ecological Areas (PEAs) and Hubs using a combination of updated and new GIS data layers. Some of the original data are out-of-date and are not expected to be useful for delineating the new FEGN (Hoctor et al. 2000). Other data have been updated since the original FEGN delineation so that they are still suitable, or likely suitable, for use in the FEGN Update. For example, Florida Fish and Wildlife Conservation Commission Strategic Habitat Conservation Areas recently went through an extensive update and modification. Other GIS layers that were not available for the original FEGN delineation were incorporated in the 2004 base boundary update (Hoctor 2004). Such data layers include some of the data from the Florida Natural Areas Inventory Florida Forever Conservation Needs Assessment (Florida Natural Areas Inventory 2011). These data layers are updated approximately annually and therefore are good candidates for continued inclusion as PEA criteria. Table 1 outlines the original draft PEA criteria for the FEGN Update that are based on the original FEGN delineation and the 2004 boundary revision with relevant updates.

Table 1 also shows the original draft "exclusion" rules used with each PEA input data layer, which are criteria to delete areas from inclusion in the PEA model based on overlap with more intensive land uses (using the new FNAI and FWC Cooperative Land Cover data) that are not compatible with the various PEA input layers. In this draft process, PEA criteria are separated into two sets of exclusion rules as shown in Table 1. The "Remove only developed lands" rule, which involves only excluded intensive development such including residential, commercial, or industrial land uses, is used for those PEA criteria where either 1) the original selection process for the PEA criterion removes areas that are not compatible with the type of resource being identified or 2) the PEA criterion could include agricultural or other less intensively developed lands that are compatible with the resource being identified. The "Do not include any intensive agriculture or developed lands" rule is used for PEA criteria where intensive development or more intensive agriculture (such as cropland, citrus, and nurseries) is incompatible with the identified resource.

Over the first two years of the FEGN Update project, we had three meetings of the Technical Advisory Group (TAG) as well as additional meetings with TAG members from Florida

Natural Areas Inventory (FNAI) staff, Florida Fish and Wildlife Conservation Commission, Florida black bear experts, and Florida panther experts to review and develop the new PEA criteria. The starting point of this process was the criteria and draft PEA results based on the data and criteria thresholds included in Table 1. The discussion about the original proposed criteria included several considerations:

1) Larger areas included based on the proposed PEA criteria than in all of the current Florida Ecological Greenways Network (FEGN).
2) More focus on landscape-dependent or wide-ranging species, landscape or matrix natural communities, and areas with high landscape integrity or landscape context.
3) Including updated and new criteria representing the most important areas for conserving species and natural communities within intact, functionally connected landscape across the state.
4) More focus on terrestrial ecosystems versus aquatic ecosystems.

These considerations resulted in a process of exploration and refinement of PEA criteria over several drafts. These additional drafts and the detailed revisions that drove the revision process are included in Appendix A. The final draft criteria were reviewed and accepted by the TAG on April 12, 2013, and these final PEA criteria are included in Table 2.

Through the review process, the TAG members agreed with the overall goals of the FEGN and the importance of updating the FEGN to incorporate new and updated data layers and more explicit consideration of climate change impacts. The most important recommendation from the TAG involved recasting PEA criteria to emphasize or only use PEA criteria that are specifically or generally related to large landscape and ecological connectivity conservation. This included the potential identification of large, intact landscapes that address criteria such as:

- large natural and semi-natural landscapes that are least impacted by human activity
- habitat for species that require large, intact areas to support viable populations, are area-sensitive, or fragmentation-sensitive
- identification of appropriate types of ecological connectivity or corridors including riparian networks (including in watersheds important for rare fish species) and coastal systems connectivity

Including conservation priorities more focused on landscape-dependent species and landscape-scale or matrix natural communities in the PEA criteria was one of the important elements of the FEGN Update. After much discussion over the TAG meetings, the following species and natural communities were selected as either landscape-dependent or matrix:

1) Landscape-dependent species:

Crested caracara (*Caracara cheriway*)
Florida sandhill crane (*Grus canadensis pratensis*)
Short-tailed hawk (*Buteo brachyurus*)
Swallow-tailed kite (*Elanoides forficatus*)
Sherman's fox squirrel (*Sciurus niger shermani*)
Big Cypress fox squirrel (*Sciurus niger avicinnia)*
Florida panther (*Puma concolor coryi)*
Florida black bear (*Ursus americanus floridanus)*

2) Landscape/matrix natural communities:

Sandhill
Flatwoods
Upland pine forest
Upland hardwood
Dry prairie

In addition, based on recommendations from FWC's Walt McCown and Brian Scheick and the new Florida Black Bear Statewide Management Plan, we decided to use the Florida black bear population Population Priority Conservation Areas (PPCA) iteration developed by Tom Hoctor that came closest to matching the following habitat conservation goals for each of Florida's bear subpopulations in the Florida Black Bear Statewide Management Plan:

a. West Panhandle	1,198,461 acres (479,384 hectares)
b. East Panhandle	2,359,856 acres (943,946 hectares)
c. Big Bend	549,809 acres (219,923 hectares)
d. North	457,145 acres (182,858 hectares)
e. Central	1,062,553 acres (425,021 hectares)
f. South Central	580,698 acres (232,279 hectares)
g. South	1,322,014 acres (191,753 hectares)

Finally, another attempt to focus on areas of higher landscape significance or integrity included using the CLIP 2.0 Landscape Integrity and Landscape Context data layers as filters for all "non-landscape" PEA criteria as well as a filter for some of the landscape-based criteria. Depending on the PEA data layers, selected priority thresholds had to also be in areas that had a Landscape Integrity and Landscape Context index value of 7 or higher (for non-landscape criteria) or a Landscape Integrity and Landscape Context index value of 5 or higher (for certain landscape-based criteria). Again, the final PEA criteria are included in Table 2.

Table 1. Original Draft Updated Criteria for selecting Priority Ecological Areas

Data layer	Priority area criterion	Exclusion criteria
Existing public and private conservation lands	All such lands	Remove only developed lands
FWC Strategic Habitat Conservation Areas (SHCA)	All SHCAs P1-P3	Remove only developed lands
FWC Species Richness	Areas containing potential habitat for 7 or more focal species	Remove only developed lands
FNAI Rare Species Habitat	Priority 1 and 2	Remove only developed lands
FNAI Rare Natural Communities	All identified communities	Remove only developed lands
FNAI Natural Floodplains	All natural riparian floodplains	Remove only developed lands
FNAI Functional Wetlands	Priority 1 and 2	Remove only developed lands
Proposed conservation lands	All such lands	Remove only developed lands
USFWS Florida panther conservation zones	All areas except intensive development within the Primary and Dispersal Zones for the Florida panther. Areas identified as panther habitat within the Secondary Zone.	Remove only developed lands
Florida black bear habitat model	All areas having a habitat quality index of 6 or higher	Remove only developed lands
FNAI Potential Natural Areas (PNAs)	All PNAs except those receiving the lowest rank	Do not include any intensive agriculture or developed lands
Roadless areas (all roads)	Areas 5,000 acres (2,000 hectares) or larger containing no roads of any kind	Do not include any intensive agriculture or developed lands
Roadless areas without major Roads (FDOT maintained roads)	Areas 100,000 acres (40,000 hectares) or larger containing no major roadways such as interstate, federal, or state highways, and large capacity county roads	Do not include any intensive agriculture or developed lands
FNAI surface water priorities model	Priority 1 and 2	Do not include any intensive agriculture or developed lands
Lands identified as part of the Coast Barrier Resources Act	All such lands	Do not include any intensive agriculture or developed lands
State Aquatic Preserves, National Estuarine Research Reserves, Outstanding Florida Waters, Shellfish Harvesting Waters, Wild and Scenic Rivers (and 1000 foot buffer)	All such designated aquatic ecosystems	Do not include any intensive agriculture or developed lands
Bumpup criteria	All areas within 100 year floodplains, high velocity zones, or high aquifer recharge (priorities 1-3) that also contain lowest ranked FNAI PNAs, smaller roadless areas (2500 acres or greater and 50,000 acres or greater respectively), SHCA P3-P5, FWC species richness (5-6 species), or FNAI moderate species habitat priorities (priority level 3-4), Panther Secondary Zone, Value 5 in the Florida black bear habitat model, Priority 3 of the FNAI surface water priorities, or Priority 3 or 4 FNAI functional wetlands	Do not include any intensive agriculture or developed lands

Table 2. Final Criteria for selecting Priority Ecological Areas for the Florida Ecological Greenways Network Update.

Data layer	Priority area criterion	Exclusion criteria
Landscape Species	All high priority FNAI habitat or SHCAs or FWC potential habitat (for Sherman's fox squirrel only) with Landscape Integrity and Landscape Context index values of 5 or higher.	Remove only developed lands
FNAI Rare Matrix-Landscape Natural Communities	Patches of matrix communities 500 acres (200 hectares) or larger (sandhill, flatwoods, dry prairie, upland hardwood forest, upland pine)	Remove only developed lands
USFWS Florida panther conservation zones	All areas within the Primary or Dispersal Zones for the Florida panther. All areas within the Secondary Zone or North Focal Area with Landscape Integrity and Landscape Context index values of 5 or higher.	Remove only developed lands
University of Tennessee USFWS panther habitat	All areas identified as potential habitat in areas with moderate to high habitat potential.	Remove only developed lands
Florida black bear habitat quality model (Hoctor)	All areas having a habitat quality index of 7 or higher also with Landscape Integrity and Landscape Context index values of 5 or higher and within 30 km of bear range.	Remove only developed lands
Florida black bear Population Priority Conservation Areas (PPCA)	All such areas needed to address population habitat requirements for each Florida black bear subpopulation	Remove only developed lands
Integrated Habitat Network	All areas within the network	Remove only developed lands other than current mining
Existing conservation lands	All such lands with high LI-LC scores (7 or above)	Remove only developed lands
FWC Strategic Habitat Conservation Areas (SHCA)	SHCAs P1-P3 with high LI-LC scores	Remove only developed lands
FNAI Rare Species Habitat	Priority 1-3 with high LI-LC scores	Remove only developed lands
FNAI Rare Natural Communities	All areas with high LI-LC scores	Remove only developed lands
FNAI Functional Wetlands	Priority 1-2 with high LI-LC scores	Remove only developed lands
FNAI Potential Natural Areas (PNAs)	All PNAs 1-4 and 100s with high LI-LC scores	Do not include any intensive agriculture or developed lands
Lands identified as part of the Coastal Barrier Resources Act	All such lands with high LI-LC scores	Do not include any intensive agriculture or developed lands

Hubs

Identification of Hubs is the next step of the FEGN delineation process. Hubs are connected areas of PEAs that are 5,000 acres (2,000 hectares) or larger. This size criterion was developed after much discussion during the work of the original FEGN TAG (Hoctor 2000). Hubs also are spatially assessed to ensure inclusion of suitably wide internal connections (when delineating areas that meet the 5,000 acre or larger threshold) and spatially optimized by closing internal gaps containing natural or semi-natural land uses and potentially smoothing/buffering external edges where suitable land uses also occur. In the final version of Hub delineation, we removed less consolidated, narrowly connected, or other potential spatially peripheral areas that do not represent the more intact, large landscapes. This was accomplished by using a sequence of Shrink and Expand functions in ArcGIS to first remove all narrow connections 120 meters or less wide (based on having to work with a 30 meter cell size) and then closing small gaps 60 meters or narrower surrounded by PEAs.

Connectivity Analysis Methods

The connectivity modeling was discussed at each of the TAG meetings, though we did not begin the connectivity analyses until the second half of the project. However, during the earlier TAG meetings there was agreement that the following options should be explored as part of the FEGN update:

1) Riverine/riparian corridor buffers and connectivity analysis

2) Coastal to Inland connectivity analysis

3) Xeric natural community connectivity within large-scale inland ridge systems

4) Florida black bear habitat and connectivity analysis

5) Florida Panther habitat and connectivity analysis

6) General landscape connectivity analysis (similar to the cross Hub-to-Hub connectivity analysis done in the original FEGN delineation)

7) Analysis of potential sea level rise impacts on south-north connectivity

We discussed with the TAG and explored several ArcGIS or other modeling tools that could be relevant to the Florida black bear and Florida panther habitat and connectivity models including:

- Maxent and/or other habitat modeling tools (http://www.cs.princeton.edu/~schapire/maxent/)
- CorridorDesigner (http://corridordesign.org/)
- Connectivity Analysis Toolkit (http://corridordesign.org/blog/post/connectivity_analysis_toolkit_now_available/)
- Circuitscape (http://www.circuitscape.org/)

Maxent is a stand alone and now commonly used habitat modeling algorithm that can be applied to bear and panther to at least inform the development of cost surfaces for bear and panther connectivity analysis. CorridorDesigner is an ArcGIS application that builds on Cost Distance and Least Cost Path functions to facilitate connectivity and corridor analyses for species or potentially other resources. The Connectivity Analysis Toolkit is a stand alone modeling tool that works outside ArcGIS but has additional tools including Current Flow and Shortest Path modeling. Circuitscape is another connectivity modeling toolkit based on electronic circuit theory to predict potential animal movement and gene flow at landscape and regional landscape scales. Application of these tools were evaluated regarding ease and feasibility of use in the context of the budget and time constraints of this project. Ultimately, working with our bear and panther TAG members, we decided to use Maxent to develop multi-criteria statewide habitat suitability models for both bear and panther and then used these habitat models as the base for a cost surface for connectivity models; applied standard ArcGIS Least Cost Path (LCP) modeling since it provided the most explicit methods for identifying corridors between selected bear and panther habitat cores; also applied Circuitscape to develop an "areas of connectivity priority" assessment for both bear and panther that could be used both in the FEGN prioritization process or as a supplemental data in the new FEGN database. These habitat and connectivity tools are discussed in more detail in the bear and panther habitat connectivity modeling subsections below and in Appendix B and Appendix C.

1) Riverine/Riparian Corridor Buffers and Connectivity Analysis.--The riverine/riparian connectivity analysis focuses on Florida's 50 major rivers as identified by FREAC (1990) and used in the riverine corridor modeling in the original delineation of the FEGN in 1997. The goal is to identify both potentially functional buffers around these river systems both for protection of water resources and provision of habitat and to serve as corridors for focal species where possible. This includes provision of various south to north corridors that may be critical for facilitating adaptation to climate change both in the Florida peninsula and Florida panhandle including: St. Johns River, Peace River, Kissimmee River, Withlacoochee River, Suwannee River, Steinhatchee River, Aucilla River, St. Marks River, Ochlocknee River, Apalachicola River, Chipola River, Econfina Creek, Choctawhatchee River, Yellow River, Escambia River, and the Perdido River.

In the first draft, the Major Rivers line shape file from the Florida Geographic Data Library was used as the starting point. Only areas within the shape file identified as rivers or creeks were retained. The Cooperative Land Cover Data from FNAI was used to identify natural and semi-natural land use including all natural communities, forest plantations, and unimproved pastures/rangelands. Then, all areas of natural and semi-natural land adjacent to and connected to these rivers were identified within 800 meters (approximately ½ mile). With these methods the identified corridor around a major river could be up to approximately one mile (1600 meters) in width if there is a broad enough swath of connected natural and semi-natural land.

In the final draft, three revisions were made to the analysis:

- Added all Outstanding Florida Waters connected to Major Rivers before conducting the buffer model
- Added all paddling trails that are on river, creeks, and streams and buffered them using the same methods as for Major Rivers.
- Deleted any narrow corridors and peripheral areas included in the buffering process by identifying and deleting all narrow areas less than 120 meters wide.

2) ***Sea Level Rise Coastal Gradient Connectivity Analysis.--***The sea level rise coastal gradient connectivity analysis is a general assessment of the broader areas of higher landscape integrity that are potentially available to allow retreat/migration of native species from current coastlines to areas beyond a 3 meter sea level rise projection. The steps in the process included:

- Identifying all areas in Florida within 5 kilometers of a 3 meter sea level rise projection using the FWC DEM as the base elevation model.
- Identifying current coastline as a combination of all marine/estuarine waters and all marine/estuarine wetlands.
- Using the Cooperative Land Cover Data from FNAI to identify all natural and semi-natural land use including all natural communities, forest plantations, unimproved pastures/rangelands, and improved pastures.
- Identifying all areas of natural and semi-natural land connected to the identified coastline and up to five kilometers beyond the 3 meter sea level rise projection.
- Limiting the identified areas to those with CLIP Landscape Integrity values of 6 or higher to avoid landscapes significantly degraded by current urban or intensive agricultural uses.
- Ensuring that such areas of higher Landscape Integrity were still connected to the current coastline by natural or semi-natural lands.

Based on discussion with the TAG, the final draft was created with this revised process:

- Identified estuarine wetlands and coastal natural communities using new CLC v2.3 landcover/land use data.
- Identified all areas of well connected natural and semi-natural land (and improved pasture) functionally that also had Landuse Intensity (Landuse Intensity is one of the two landscape indices used to create the CLIP Landscape Integrity) values of 5 or higher.

- Identified all areas of suitable land for connectivity connected to current coastal natural communities and to the landward edge of the 3 meter sea level rise projection using the new statewide Lidar composite (resampled to a 30 meter cell size to match the cell size used in this project). This composite Lidar dataset is based on a collaborative effort between the University of Florida GeoPlan Center, University of Florida Center for Landscape Conservation Planning, Florida Natural Areas Inventory, and the Florida Fish and Wildlife Conservation Commission.

3) Xeric Natural Community Connectivity.--The xeric connectivity analysis is intended to identify functionally connected patches of primary xeric natural community through surrounding compatible landcover and land use classes on xeric soils. The methods were:

- Only included sandhill, scrub, and scrubby flatwoods in patches 100 acres (40 hectares) or larger as source xeric natural communities. This was based on detailed discussion with the TAG about defining xeric natural communities and it was determined that this analysis should include only the communities that are most specifically xeric.
- Suitable matrix defined as any of the three natural communities included in the step above or any other natural or semi-natural vegetation on xeric soils (defined as anything that is moderately well-drained or drier).
- Deleted any narrow connections less than 200 meters wide from the suitable matrix.
- Identified all well connected areas of xeric habitat within 1.5 miles (2400 meters) of xeric natural communities.

- Retained only xeric landscapes with two or more xeric habitat patches, which means that retained xeric natural communities have to be well connected by a suitable xeric matrix and within 3 miles (4800 meters) of each other.
- Separated these patches into two size classes: 1,000 acres to 4,999 acres (400-1999 hectares); 5,000 acres (2,000 hectares) or larger

4) Florida Black Bear Habitat and Connectivity Analysis

Habitat Suitability Model.--To predict the extent of a species' distribution, the Maximum Entropy Model (Maxent) was applied. Maxent predicts the probability of a species' occurrence across a landscape based on presence only point data in conjunction with multiple environmental variable layers.

Presence data was taken from either GPS or radio telemetry of tagged individuals obtained through Florida Fish and Wildlife Commission and the University of Kentucky's Department of Forestry South-Central Florida Black Bear Project. Supplied data spans from 1983 – 2010. At a minimum, each record provided indicates species, latitude, longitude, date, time and sex.

Maxent uses a percentage of input data to test model performance while the remaining data is used as training data to determine model parameters. Different percentage values were tested, but the general consensus in the machine learning community recommends using approximately 30% of the data for testing purposes (Witten et al. 2011). This is what was eventually decided upon. The performance of different combinations of variables was evaluated to achieve the best results for successive connectivity analyses.

Multiple model scenarios were tested, and the most recent ten years of data was found to be of the highest statistical significance. To ensure uniformity and discourage bias, Black Bear presence locations were filtered using the following criteria: the most recent 10-year period (2000 – 2010), both male and female bears, a random subset of 50 records was selected per individual and individuals with less than 50 records were removed.

Independent variables used for Maxent modeling fall into two groups, the first of which consisted of Landscape Context layers from CLIP 2.0 (Oetting et al. 2012). This group contains: landscape integrity, intactness/fragmentation, distance from intensive land uses, and roads context. In addition several bear specific layers were compiled, these include: primary and secondary bear habitat, block size primary and secondary habitat, major roadless patches, forest density, land use intensity and bear habitat density.

In addition, separate scenarios were modeled using only the Highlands/Glades population to address subpopulation-specific needs. This model was trained using Highlands/Glades data only. Model runs using the individual subpopulations as test data, and the whole population as training data, also indicate poor model performance using the Highlands/Glades subpopulation as a test example. Results were then integrated with the statewide habitat suitability model by using the Highlands/Glades subpopulation home range.

Five different independent variable scenarios were modeled for each of two different point datasets (Statewide and Highlands/Glades), indicating ten scenarios overall: Landscape Context, Bear Specific Variables, Bear Specific Variables minus Bear Habitat Block Size, Bear Specific Variables + Landscape Context and Bear Specific Variables + Landscape Context minus Bear Habitat Block Size. The resulting models were evaluated for model performance metrics and visual consensus among wildlife experts. Based upon these considerations, the “Bear Specific Variables + Landscape Context minus Bear Habitat Block Size” model was chosen to be used as a basis for future connectivity analyses. Maxent model output used in connectivity analyses includes an additional noData filter for developed lands. Doing this excludes such areas from subsequent connectivity analyses.

Habitat Patch Creation.-- Core areas of habitat were created using a combination of the selected Maxent output and existing Bear home ranges. Maxent results were filtered by probability of presence and patch size. A minimum 50% probability or presence threshold with 2,000-acre (800 hectare) minimum patch size was used to identify core areas. Final Hubs (the sources and destinations for the bear connectivity analysis) for bears were based on these core areas and the input of our bear expert TAG members (Walt McCown, Brian Scheick, Joe Guthrie, and John Cox).

Connectivity Analysis.--Connectivity was assessed in three different ways: least cost path, shortest path and current flow methods. Least cost paths were modeled between specified hubs using the cost distance and least cost path tools in ArcGIS. This analysis identifies a single path between the selected hubs using an inverse of the Maxent habitat model as a cost surface.

The shortest path analysis was performed using Connectivity Analysis Toolkit. This methodology identifies a minimum network of linkages between nodes. The Connectivity Analysis Toolkit employs network theory to assess connectivity throughout the landscape.

Current flow analysis considers conductance and resistance though a diffuse landscape and produces a more distributed output. The Connectivity Analysis Toolkit also models current flow, but the model Circuitscape was ultimately chosen due to its added features and faster performance. Circuitscape analyses connectivity as if the landscape were an open circuit. Therefore, a habitat suitability model can be used to specify either conductance or resistance throughout the landscape. Each hub area is used as a current source node to assess pairwise connectivity between hubs. The model supplies a current source and results are shown as voltage flow across the landscape.

After comparing connectivity modeling results, we decided to use the ArcGIS least cost path results as the means for identifying corridors for the Florida black bear. We identified all well connected (deleting all connections less than 120 meters wide) natural, semi-natural, and agricultural land use within 1 mile (1600 meters) of each LCP, which could result in an identified corridor of up to 2 miles (3200 meters) wide.

5) Florida Panther Habitat and Connectivity Analysis

Habitat Suitability Model.--To predict the extent of a species' distribution, the Maximum Entropy Model (Maxent) was applied. Maxent predicts the probability of a species' occurrence across a landscape based on presence only point data in conjunction with environmental variable layers.

Presence data was taken from either GPS or radio telemetry of tagged individuals. Florida Fish and Wildlife Conservation Commission data spans from 1981 – 2012 and at a minimum, each record provided indicates species, latitude, longitude, date, time and sex. Maxent uses a percentage of input data to test model performance while the remaining data is used as training data to determine model parameters. Different percentage values were tested, but the general consensus in the machine learning community recommends using approximately 30% of the data for testing purposes (Witten et al. 2011). This is what was eventually decided upon. Additionally, multiple point data scenarios were tested, and the most recent ten years of data was found to be of the highest statistical significance. As a result, final presence data were filtered using the most recent 10-years of data available (2002 – 2012). Both male and female records were included, a random subset of 50 records was selected per individual were included and individuals with less than 50 records were removed.

Environmental layers used in the analysis can be divided into two groups. The first group contains components of the Landscape Context layer from CLIP 2.0 (Oetting et al. 2012) and includes: landscape integrity, intactness/fragmentation, distance form intensive land uses and the roads context layer. An additional group of layers were created based on a similar study done by USFWS (Frakes et al. 2011). This group contains: land cover, forest edge, population density and road density. Three different independent variable scenarios were modeled in conjunction with the final point dataset. The environmental layer scenarios used were: Landscape context layers, Panther specific variables and the two combined.

The resulting models were evaluated for model performance metrics and visual consensus among wildlife experts. Based upon these considerations, the “Landscape context + Panther Specific variables combined” model was chosen to be used as a basis for future connectivity analyses. Furthermore, the Maxent model output used in connectivity analyses includes an additional noData filter for developed lands. Doing this excludes such areas from subsequent connectivity analyses.

Habitat Patch Creation.--Core areas of habitat were created using a combination of the selected Maxent output and existing Panther home ranges and suitable core habitat areas. Maxent results were filtered by probability of presence and patch size. A minimum 50% probability or presence threshold with 5,000-acre (2,000 hectare) minimum patch size was used to identify core areas. Final Hubs (the sources and destinations for the bear connectivity analysis) for bears were based on these core areas and the input of our panther expert TAG members (Darrell Land, David Shindle, and Dan Smith).

Connectivity Analysis.--Connectivity was assessed in three different ways: least cost path, shortest path and current flow methods. Least cost paths were modeled between hubs using the cost distance and cost path tools in ArcGIS. This analysis identifies a single path between the selected hubs using an inverse of the Maxent habitat model as a cost surface.

Shortest path analysis was performed using Connectivity Analysis Toolkit. This methodology identifies a minimum network of linkages between nodes. The Connectivity Analysis Toolkit employs network theory to assess connectivity throughout the landscape.

Current flow analysis considers conductance and resistance though a diffuse landscape and produces a more distributed output than shortest path. The model Circuitscape was used to analyze connectivity as if the landscape were an open circuit. Therefore, a habitat suitability model can be used to specify either conductance or resistance throughout the landscape. Each hub area is used as a current source node to assess pairwise connectivity between hubs. The model supplies a current source and results are shown as voltage flow across the landscape.

After comparing connectivity modeling results, we decided to use the ArcGIS least cost path results as the means for identifying corridors for the Florida panther. We identified all well connected (deleting all connections less than 120 meters wide) natural, semi-natural, and agricultural land use within 1 mile (1600 meters) of each LCP, which could result in an identified corridor of up to 2 miles (3200 meters) wide. In addition, based on discussion with our panther ecology TAG members, we determined to use the panther corridor results for connections between panther hubs south of Orlando.

6) General Landscape Connectivity Analysis.--The General Landscape Connectivity Analysis was run after all other connectivity analyses were completed and combined with the Hubs. The goal of this analysis was determine whether there a are any additional gaps between Hubs not addressed by the other connectivity analyses that should be assessed for corridor suitability.

We developed a general cost surface general landscape connectivity analysis based on the CLIP 2.0 Land Use Intensity layer and current land use from the Cooperative Land Cover (CLC) version 2.3 layer. The Landuse Intensity layer is ranked from 1 to 10 scale, where a value of 10 indicates the lowest land use intensity (areas dominated by natural communities); these values were reclassified to a 1 to 9 scale by combining the index scores of 9 and 10 and then inverting the values (to create a cost surface where the lowest value has the lowest cost or "impedance"). The CLC layer was reclassified into 5 classes and assigned impedance scores (the impedance scores follow the category description in parentheses): natural not including open water (1), semi-natural (2), pasture (5), other agriculture and low intensity development (7), and moderate to high intensity development (No Data). In addition, water and intense development less than 60 meters wide and surrounded by lower intensity land uses were given an impedance score of 9 but all wider or larger areas of open water and intense development were assigned No Data (which means no corridor could be identified through such areas). These two cost surfaces (CLIP Landuse Intensity and CLC 2.3 Landuse categories) were then combined by averaging the two into one cost surface with impedance values from 1 to 9.

Then based on visual inspection of remaining gaps between Hubs (as well as existing conservation lands), the cost surface, land use data, and aerial photography, pairs of Hubs were selected for running least cost path (LCP) models. For all accepted LCP results, we identified all well connected (deleting all connections less than 120 meters wide) natural, semi-natural, and agricultural land use within 800 meters of each LCP, which could result in an identified corridor of up to 1 mile (1600 meters) wide.

Combination of Hubs and Connectivity Analyses to Create New FEGN Base Boundary

After all of the connectivity analyses are completed, the Hubs and Connectivity results (Corridors) were combined. This preliminary ecological network was then subjected to a spatial optimization process to fill in both narrow external gaps and smaller internal gaps containing suitable land cover/land use or additional conservation priorities to create the new FEGN base boundary. The process for this last spatial optimization was discussed with the TAG several times. Final spatial optimization methods included:

- Added all existing conservation lands connected to network (using FNAI managed areas as well as additional conservation land easements obtained from sources including The Nature Conservancy, Archbold Biological Station, and Collier County).
- Added all Florida Forever projects connected to network.
- Filled in holes less than 1000 acres (400 hectares) with suitable landcover/land use (natural, semi-natural, and improved pasture).
- Filled external gaps with natural or semi-natural land use less than 120 meters wide.
- Deleted all narrow connections, edge areas less than 120 meters wide.
- Filled in small gaps 60 meters or narrower.
- Removed all areas not connected to the rest of the FEGN.

Prioritization Process

Prioritization of the new FEGN base boundary is required to refine priority focal areas and facilitate implementation efforts by the Office of Greenways and Trails and partners and related conservation evaluation processes including the Florida Forever Conservation Needs Assessment. Based on discussions with TAG member at various meetings, we determined to keep the prioritization process relatively simple, with an adoption of same or similar priorities as the current FEGN with revisions determined through relevant, feasible analyses (such as the potential impact of sea level rise on various south-north corridors in the peninsula and east-west corridors in the panhandle and potential future development pressure) and the opinion of the TAG. Using the new FEGN base boundary, we conducted a prioritization analysis where the current FEGN priorities were assigned to the new base boundary (by using a the Cost Allocation function in ArcGIS, which assigns overlapping areas the same priorities and then determines the priority level of new areas within the new FEGN base boundary based on the closest priority level in the previous FEGN). Then, we compared these assigned priorities to:

- Comparison of the new FEGN base boundary to an update to the Florida 2060 Growth Projection (Zwick and Carr 2006). This new statewide development projection by Paul Zwick and Peggy Carr was created for an ongoing statewide Sea Level Rise Biodiversity Assessment by the University of Central Florida, Florida Natural Areas Inventory, and the University of Florida (which is another State Wildlife Grant project). This new development projection incorporates consideration of the impacts of a 1 meter sea level rise as well as changes in suitability, future development density, and allocation methods.

- Comparison of the new FEGN base boundary to the new 1-3 meter sea level rise projections using the new statewide Lidar composite (from the same statewide sea level rise impact assessment).

The comparisons to development and sea level rise projections resulted in a set of candidate areas that were presented and discussed with the TAG including:

1) Expand the St. Marks Critical Linkage to address SLR south of Tallahassee.
2) Consider Critical Linkage or at least P3 status for corridor that circles Tallahassee to the north (to serve as an alternate for St. Marks Critical Linkage).
3) Expand Coastal Big Bend Critical Linkage and consider elevating priority of inland Big Bend corridor to address SLR.
4) Consider expanding Critical Linkage around strategic areas of the St. Johns River to address potential sea level rise impacts.
5) Peace River from P3 to Critical Linkage to provide an additional option to connect south and north Florida.
6) Kissimmee to Green Swamp (Four Corners) corridor from P1 to Critical Linkage to provide an additional option to connect south and north Florida.
7) Consider assigning higher priority to south to north corridors within north Florida that connect to areas of conservation significance in Georgia and Alabama.

Finally, the discussion of prioritization options with the TAG included consideration of consolidating the previous 8 FEGN priority classes into 6 classes:

- Priority 1 (Critical Linkages): Formerly Critical Linkages 1 and 2
- Priority 2: Formerly Priority 1 and Priority 2

- Priority 3: Formerly Priority 3
- Priority 4: Formerly Priority 4
- Priority 5: Formerly Priority 5
- Priority 6: Formerly Priority 6

Results

PEAs and Hubs

Figure 4 shows the final Hubs. Together, these revisions to PEA criteria and minimum connectivity thresholds for identifying Hubs significantly reduced the acres in final Hubs compared to the last Hub draft and in comparison to the existing Florida Ecological Greenways Network. There are almost 3.5 million acres (1.4 million hectares) less within the final Hubs and the previous draft (Table 3; Figure 5), and approximately 4.3 million acres (1.72 million hectares) less than in the current Florida Ecological Greenways Network (Table 4; Figure 6). In addition, approximately half of the final Hubs are either open water (public domain) or existing conservation lands (Table 5). Figure 7 shows the overall PEA "richness", i.e., within the final Hubs how many different PEA criteria determined which areas were included; Table 6 shows the amount of acres in the various PEA richness categories; Table 7 shows the acres contribution of each PEA criterion to Hubs determined by only one criterion. There was only a small drop in acres within Hubs based on only one PEA criterion, but this is likely due to dropping the Landscape Integrity and Landscape Context criteria, which likely overlapped with the other landscape criteria and especially bear habitat, since the acres within Hubs based solely on bear habitat criteria increased in the final Hubs compared to the last draft. In addition, it is intuitive that as the number of independent PEA criteria drops, the likelihood of overlap between criteria also drops. Overall, these PEA richness criteria for the final Hubs are provided for comparison purposes with previous drafts; additional changes to PEA criteria will not be made based on these results.

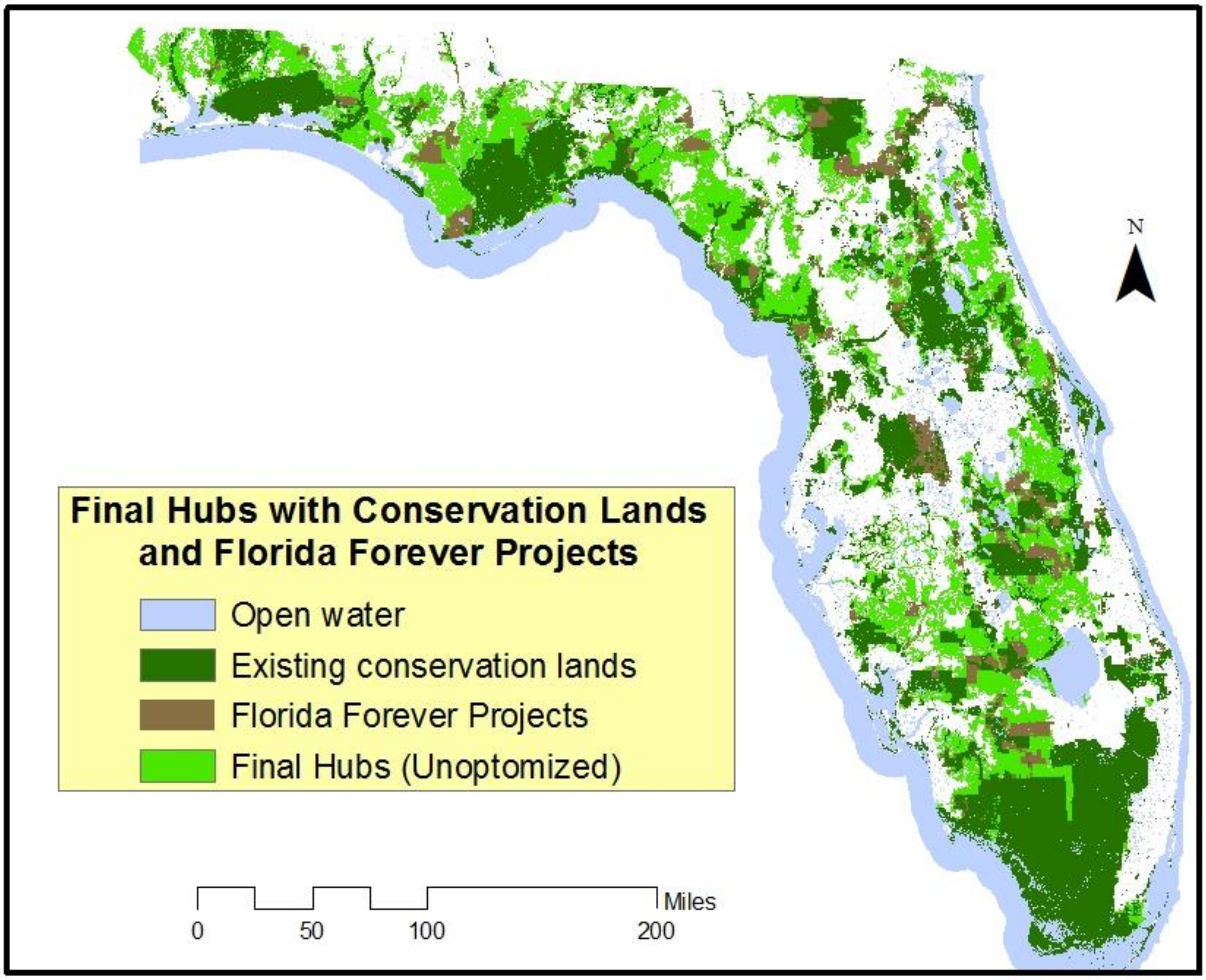

Figure 4. Final Hubs with existing conservation lands and Florida Forever Projects.

Table 3. Final Hubs compared to last draft Hubs.

Description	Acres
In both Hub Drafts	18,909,205
In Final Hubs Only	896
In Hubs Previous Draft Only	3,483,657

Table 4. Final Hubs compared to the Florida Ecological Greenways Network.

Description	Acres
In FEGN and Final Hubs	16,981,918
In Final Hubs Only	1,493,855
In FEGN Only	4,330,976

Table 5. Land Category Statistics for Final Hubs.

Land Use Category	Acres
Open Water	433,147
Existing Conservation Lands	8,962,201
Florida Forever Projects	1,480,379
Other Private Wetlands	2,651,933
Other Private Land	5,382,441
Total Acres	18,910,101

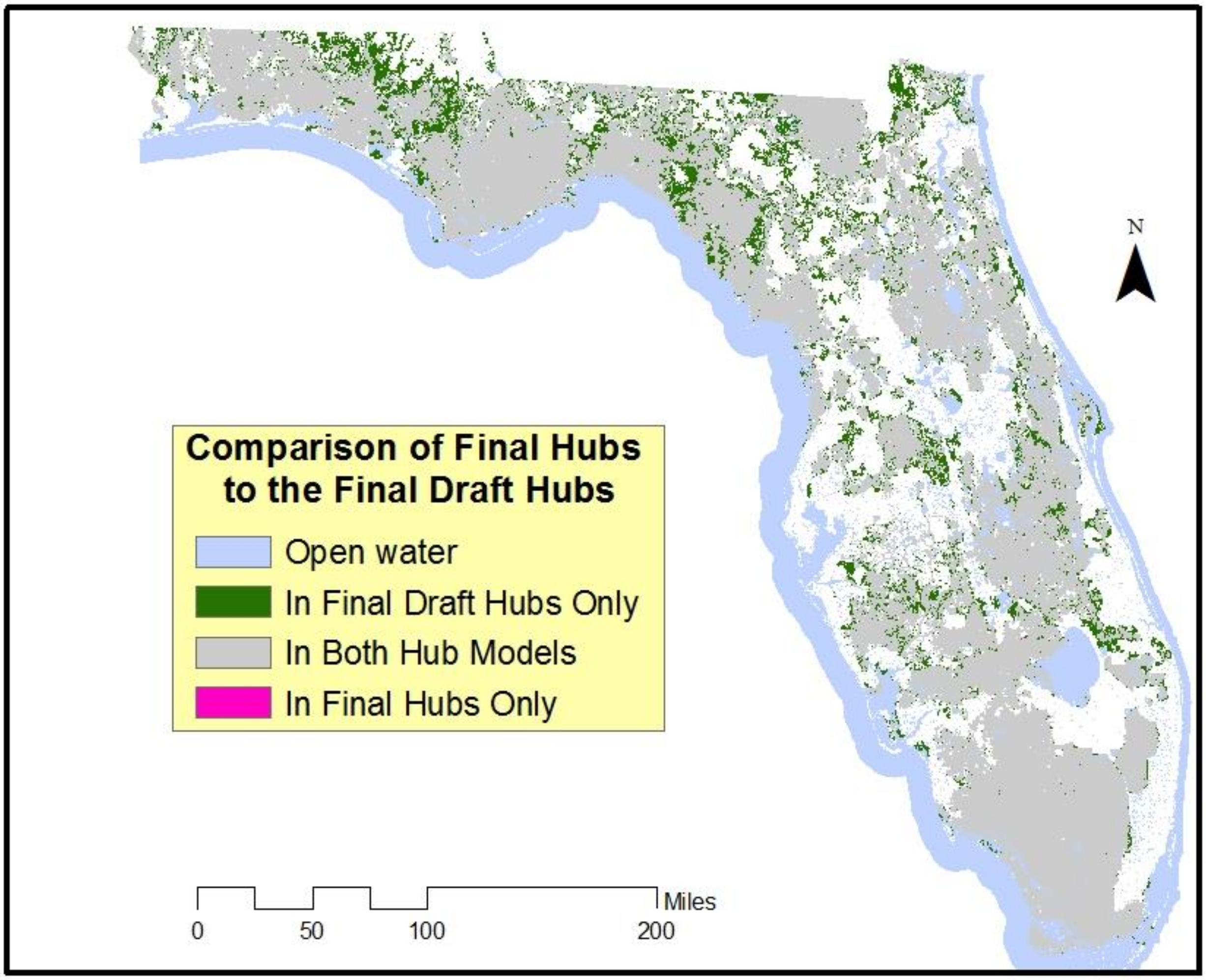

Figure 5. Final Hubs compared to previous draft Hubs.

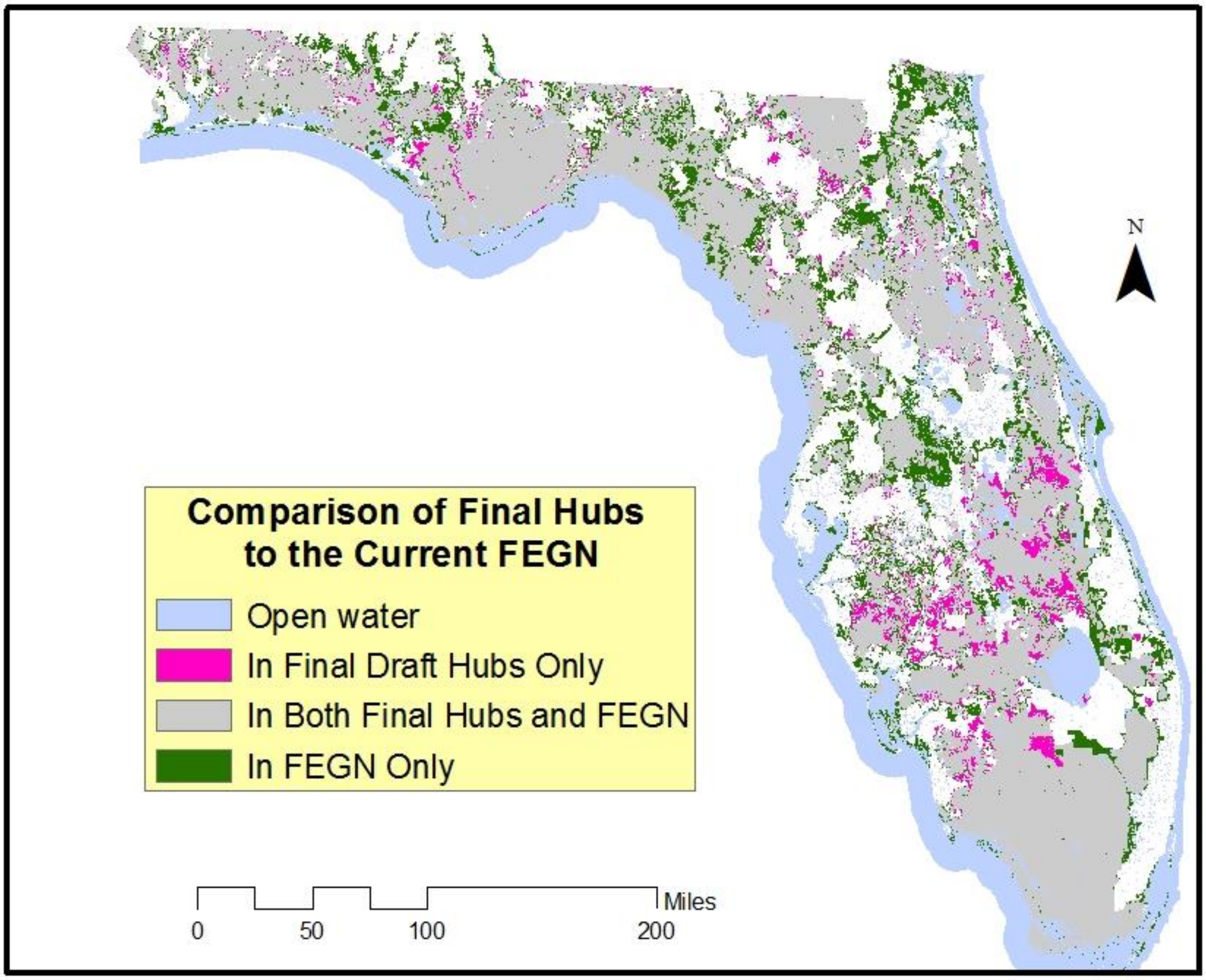

Figure 6. Final Hubs compared to the current Florida Ecological Greenways Network.

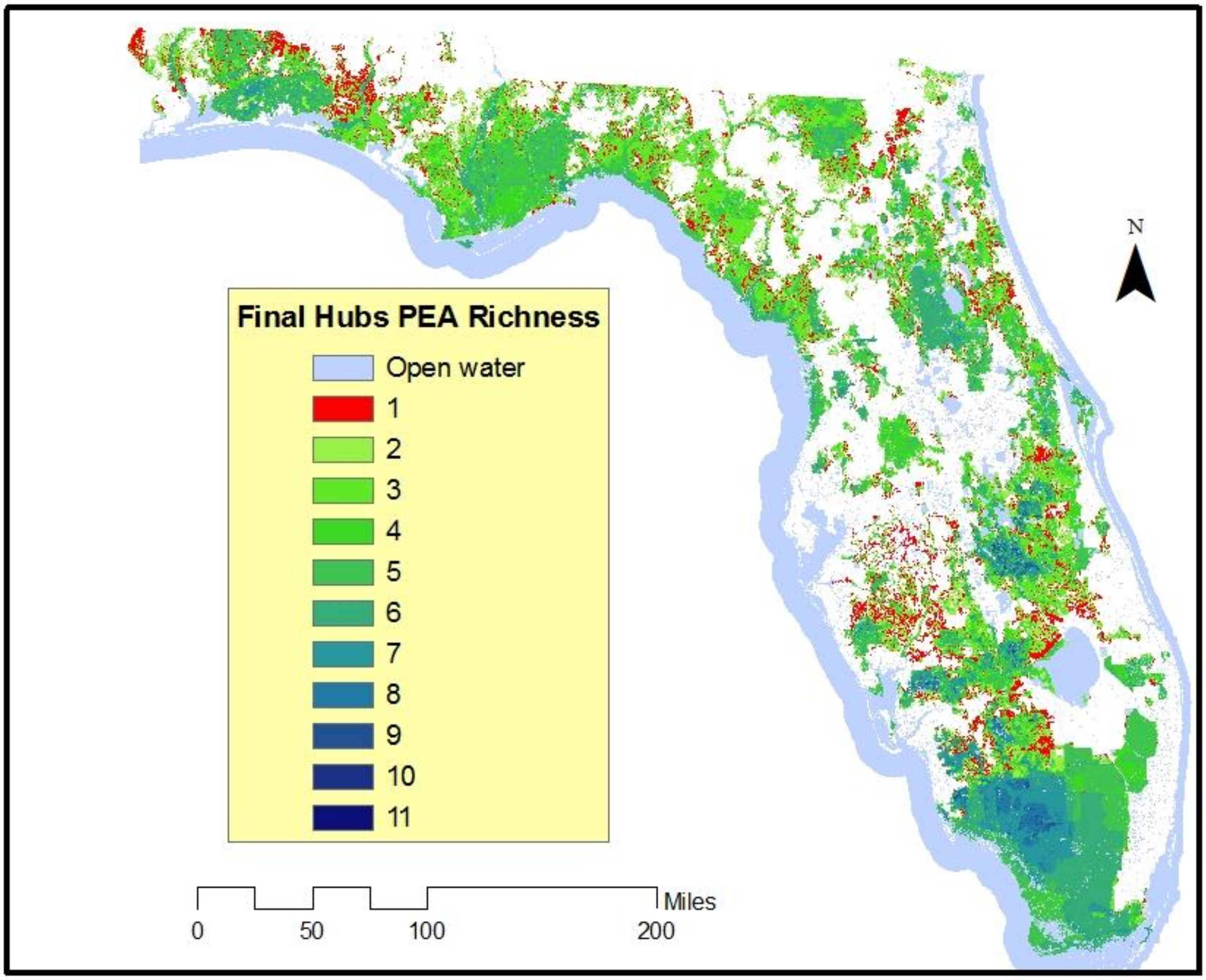

Figure 7. Final Hubs PEA Richness.

Table 6. Final Hubs PEA Richness.

PEA Criteria Overlap	Acres
0	64,093
1	2,220,839
2	2,061,131
3	3,843,238
4	2,792,112
5	3,593,586
6	2,777,424
7	1,125,746
8	361,122
9	70,548
10	262
11	0.2

Table 7. Final Hubs PEA Criteria contribution to final Hubs identified by one PEA criterion.

Pea Criterion	Acres
Bear Habitat Priorities	966,905
FNAI Landscape Species Habitat	357,739
FNAI PNAs	253,401
Panther Habitat Priorities	229,273
Integrated Habitat Network	208,482
CLIP SHCAs	61,563
Existing Conservation Lands	39,906
CLIP FNAI Species Habitat	37,334
CLIP Under-represented NCs	31,249
CLIP Wetlands	28,693
FNAI Landscape/Matrix NCs	5,251
COBRAs	616
FWC Landscape Species SHCAs/Habitat	0.4
Total Acres of Hubs based on 1 PEA Criterion	2,220,413

Connectivity Analysis

1) Riverine/Riparian Corridor Buffers and Connectivity Analysis.--Figure 8 shows the Major River and Paddling Rivers and Streams buffer/connectivity analysis results. It should be clear that the paddling rivers and stream buffers add only a few minor and more local features to the analysis. In addition, only the identified paddling stream or river buffers connected to the rest of the Hubs and other connectivity analysis results are incorporated in the new FEGN base boundary. Figure 9 shows the riverine buffer results under the Hubs, which shows that some of the major river corridors add potentially strategic connections within the ecological network including south-north linkages within Florida and into Georgia and Alabama.

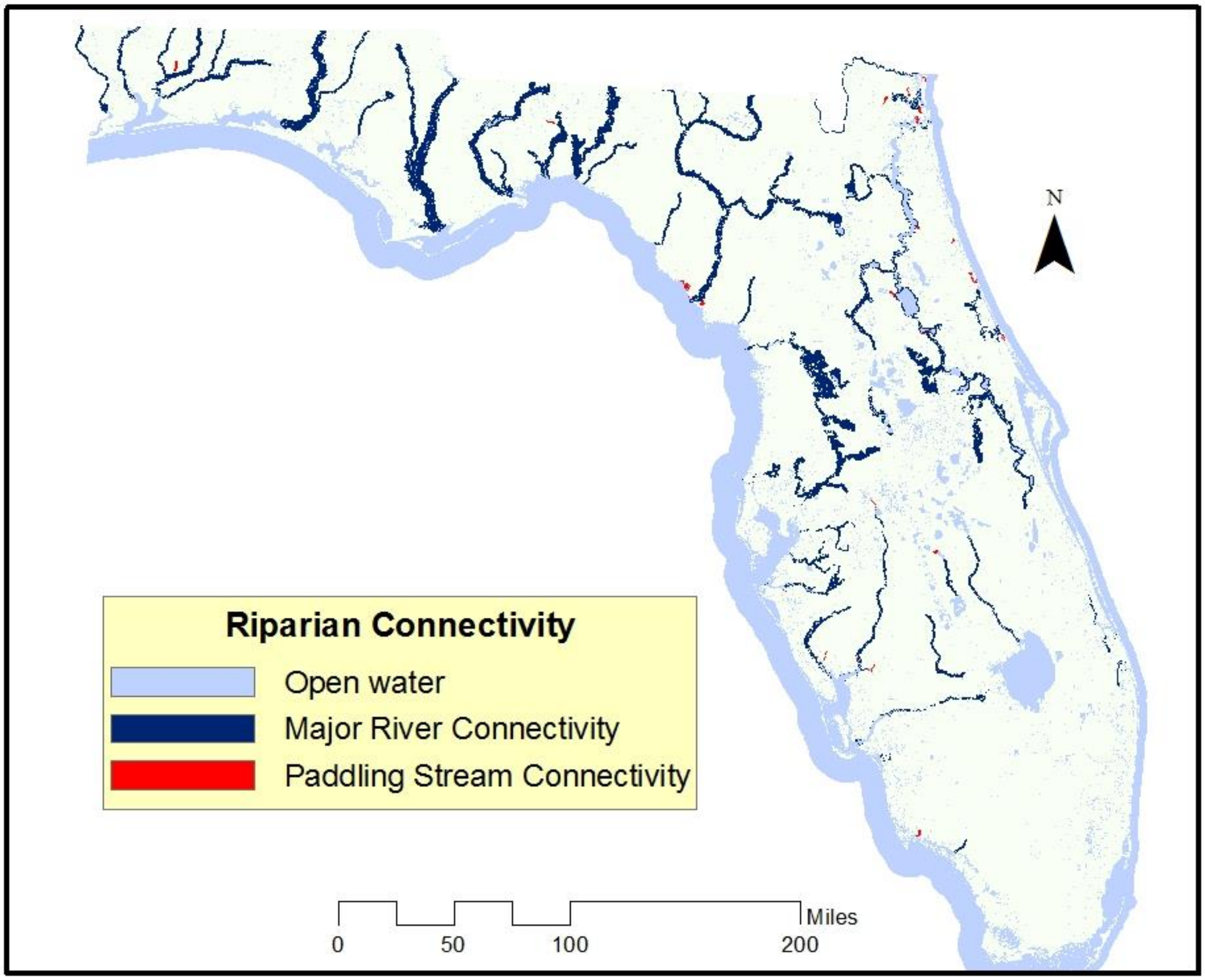

Figure 8. The map shows the riparian buffers/corridors around the fifty Florida Major Rivers included in this analysis in dark blue and the Paddling Trail based rivers and streams in red. Riparian corridors could be as wide as 1600 meters (approximately one mile wide).

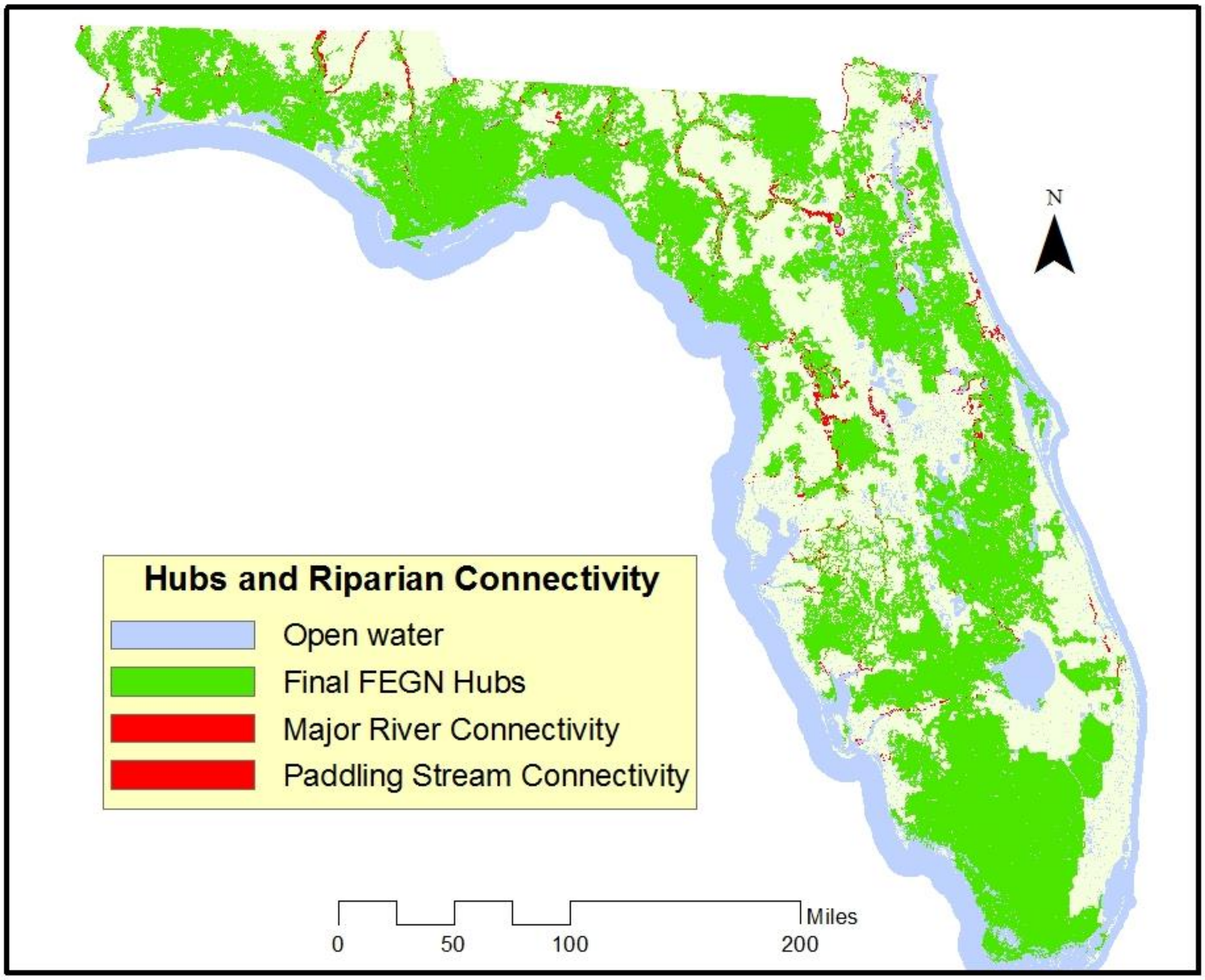

Figure 9. The map shows the riparian buffers/corridors in red with Hubs on top in bright green to show the areas that would potentially be added to the new FEGN base boundary based on riparian connectivity analysis.

2) Sea Level Rise Coastal Gradient Connectivity Analysis.--Figure 10 shows the results of the coastal to inland connectivity analysis. Figure 11 shows the results with the Hub overlaid. As with the riverine buffer/connectivity analysis, only the identified intact coast to inland gradients connected to the rest of the Hubs and other connectivity analysis results are incorporated in the new FEGN base boundary, so some of these areas isolated by urban development in some coastal areas do not get incorporated into the new FEGN. However, the coastal gradient connectivity analysis does result in significant additions to the new FEGN in areas including extreme northeast Florida, Cape Canaveral, and in parts of the Big Bend and Panhandle.

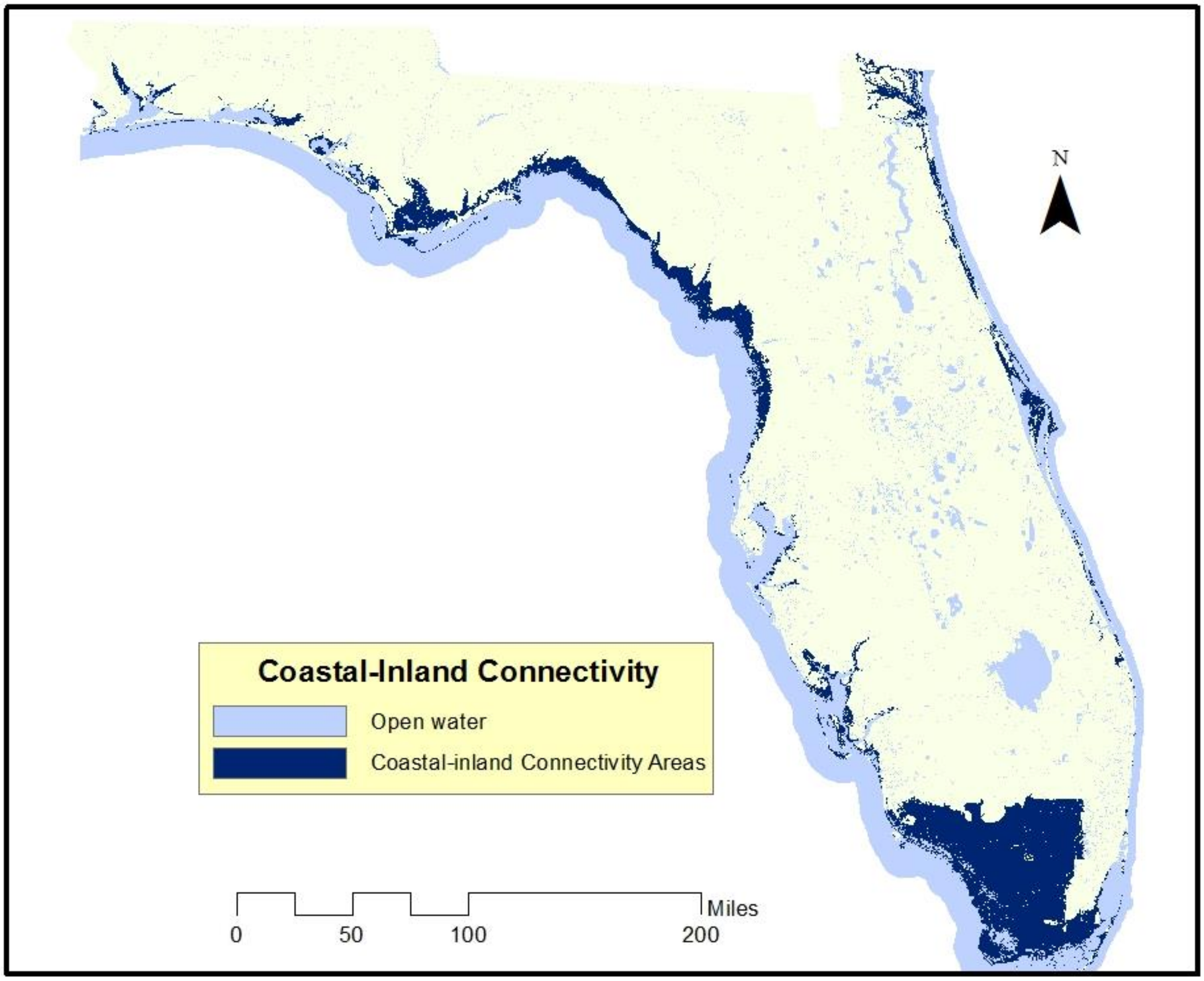

Figure 10. The map shows the areas of coastal to inland connectivity areas in dark blue. These areas incorporate larger, intact, functionally swaths of land from current coastal natural communities that are likely the most significant opportunity areas for facilitating retreat/migration for up to a 3 meter sea level rise projection.

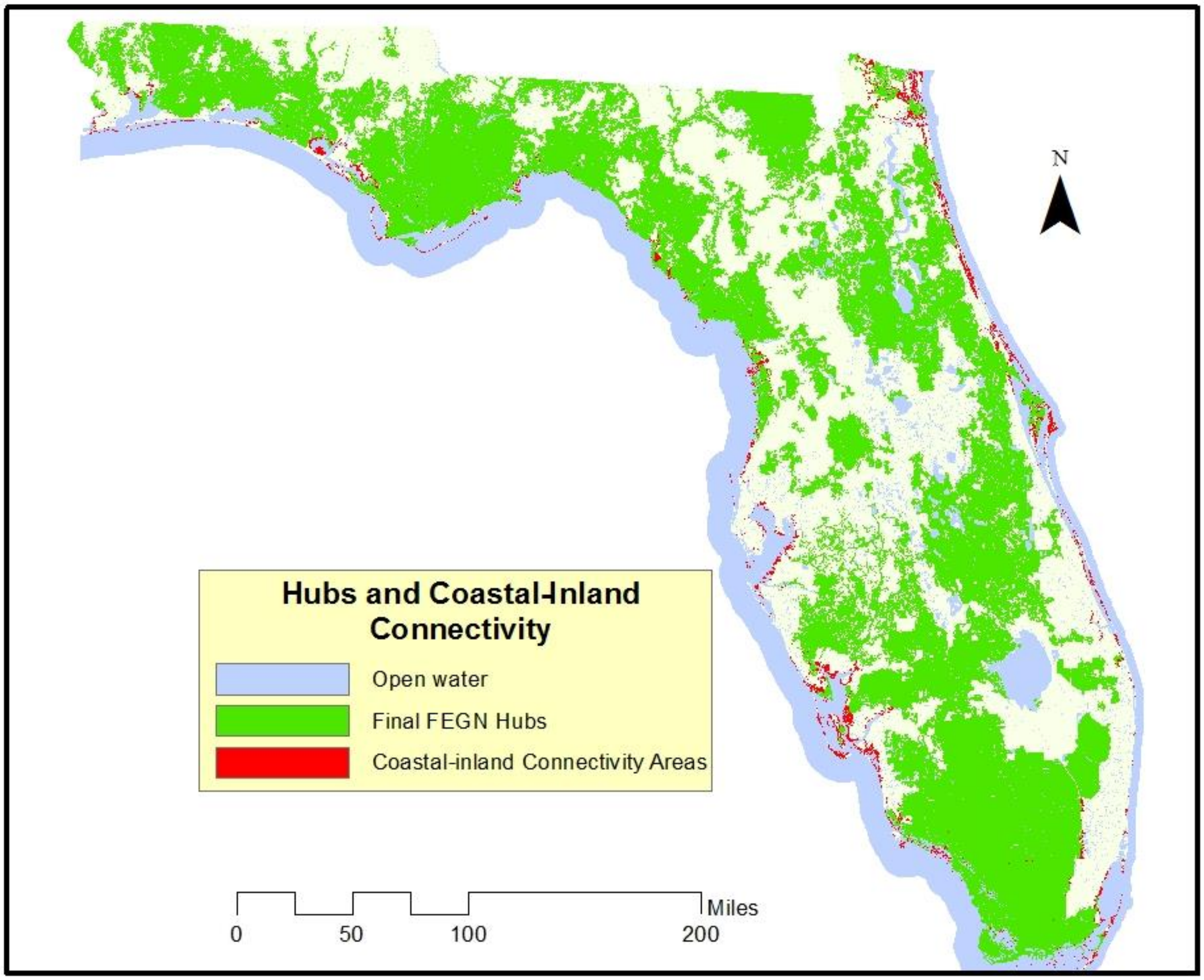

Figure 11. The map shows the areas of coastal to inland connectivity areas in dark blue with Hubs overlaid to show areas that could potentially be added to the new FEGN base boundary based on this analysis.

3) Xeric Natural Community Connectivity.--Figure 12 shows the the Xeric Natural Community Connectivity analysis. Figure 13 show the results with Hubs overlaid to help indicate what areas might be added to the new FEGN base boundary. Though these maps show two size classes of significant xeric landscapes, based on TAG input, both size classes were included when compiling the new FEGN if they are connected to Hubs and other connectivity analysis results. The xeric connectivity areas make significant contributions to the new FEGN in the central panhandle north of Panama City and the area west of Gainesville around the Waccasassa Flats and lower Sante Fe River.

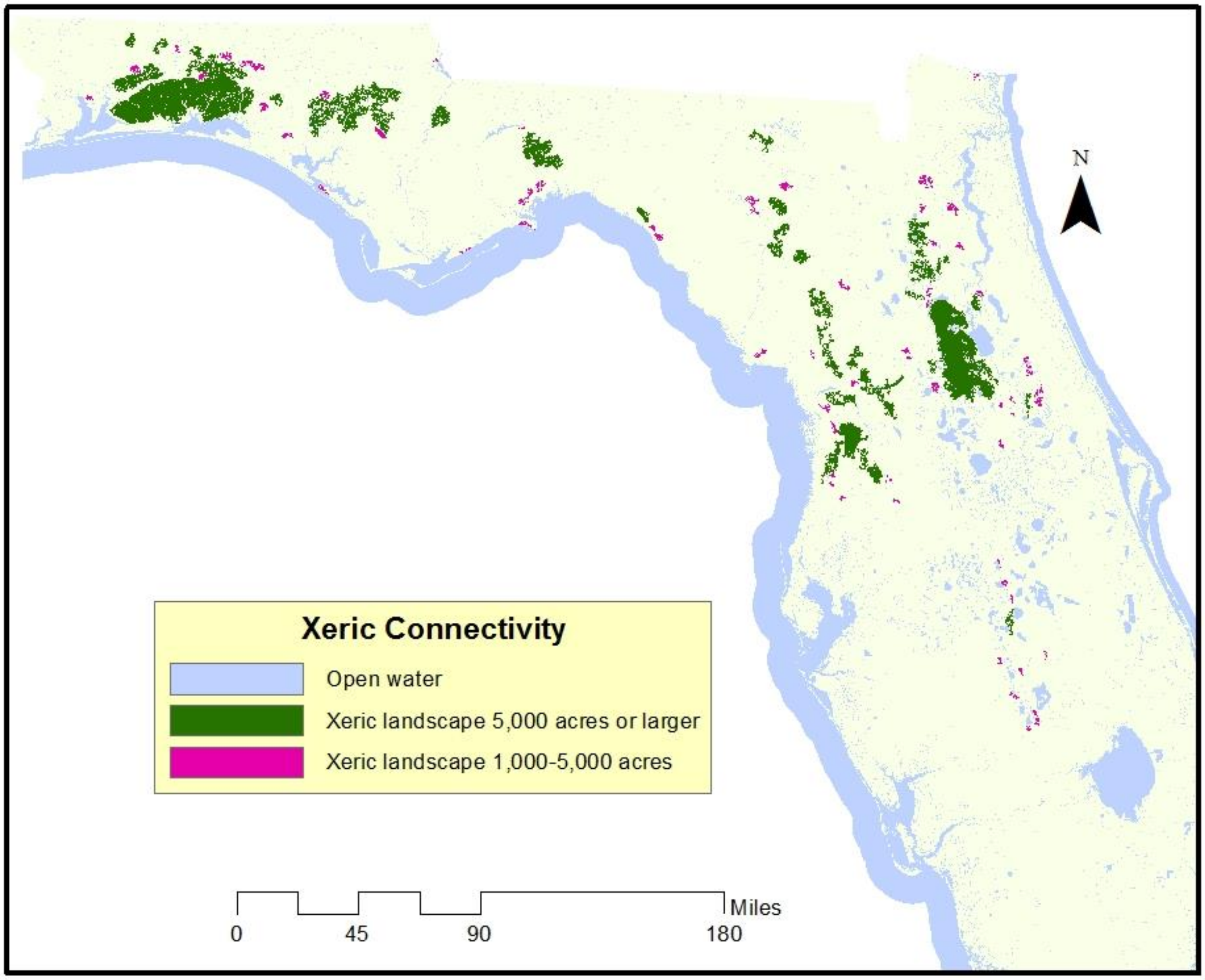

Figure 12. The map shows the xeric connectivity areas in two size classes. However, based on TAG input, both size classes will be added to the new FEGN if they are connected to Hubs or other connectivity analysis results.

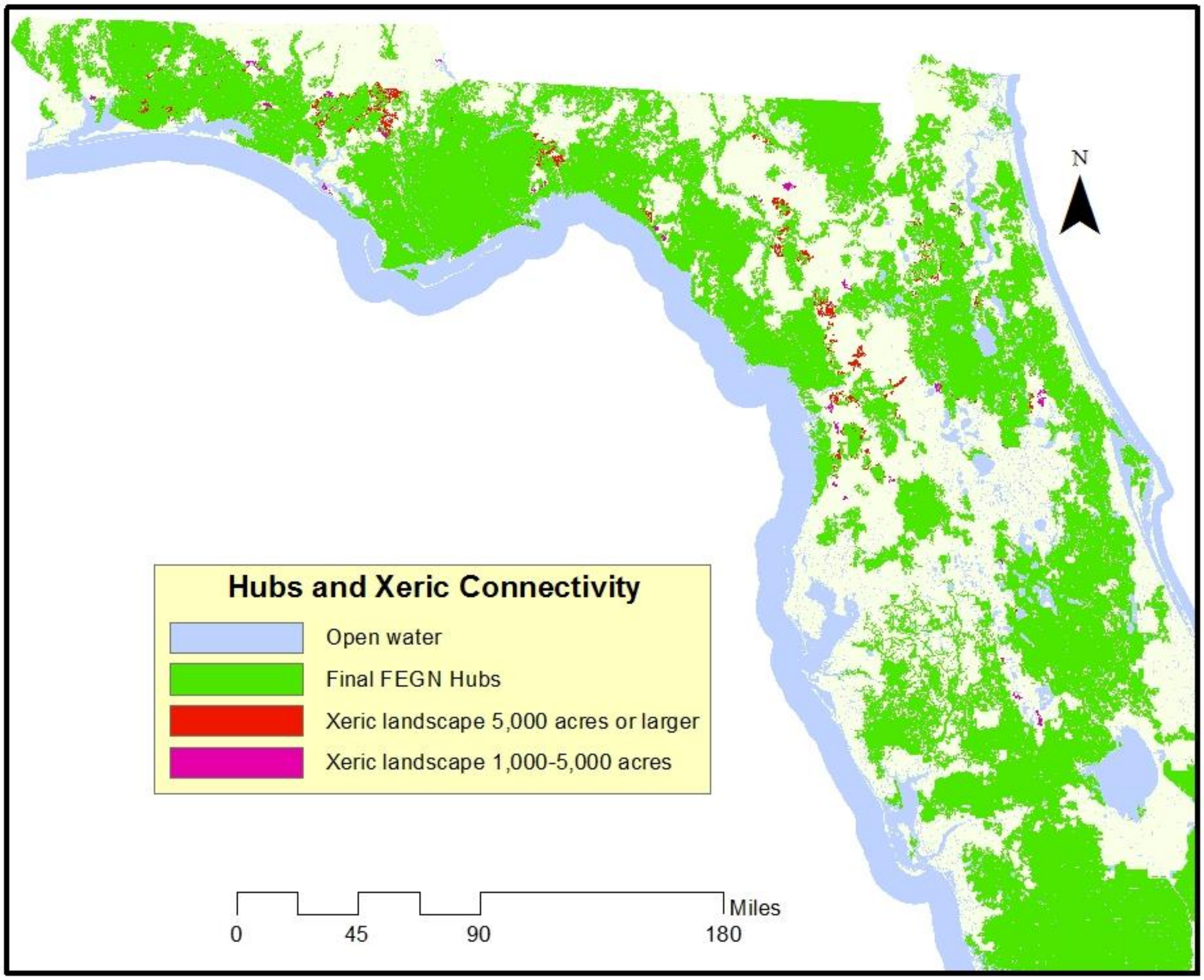

Figure 13. The map shows the xeric connectivity areas in two size classes with the Hubs overlaid.

4) Florida Black Bear Habitat and Connectivity Analysis

Maxent Output.-- Figure 14 represents the Maxent model output for the Florida Black Bear's probability of presence. Warmer colors show areas with higher probability conditions. Areas of high probability tend to occupy portions on or adjacent to existing natural/conservation areas. This helps to further validate the model. These areas include: Big Cypress, Avon Park, Kissimmee Prairie, Green Swamp, Ocala National Forest, Osceola/Okefenokee, Apalachicola and Eglin AFB.

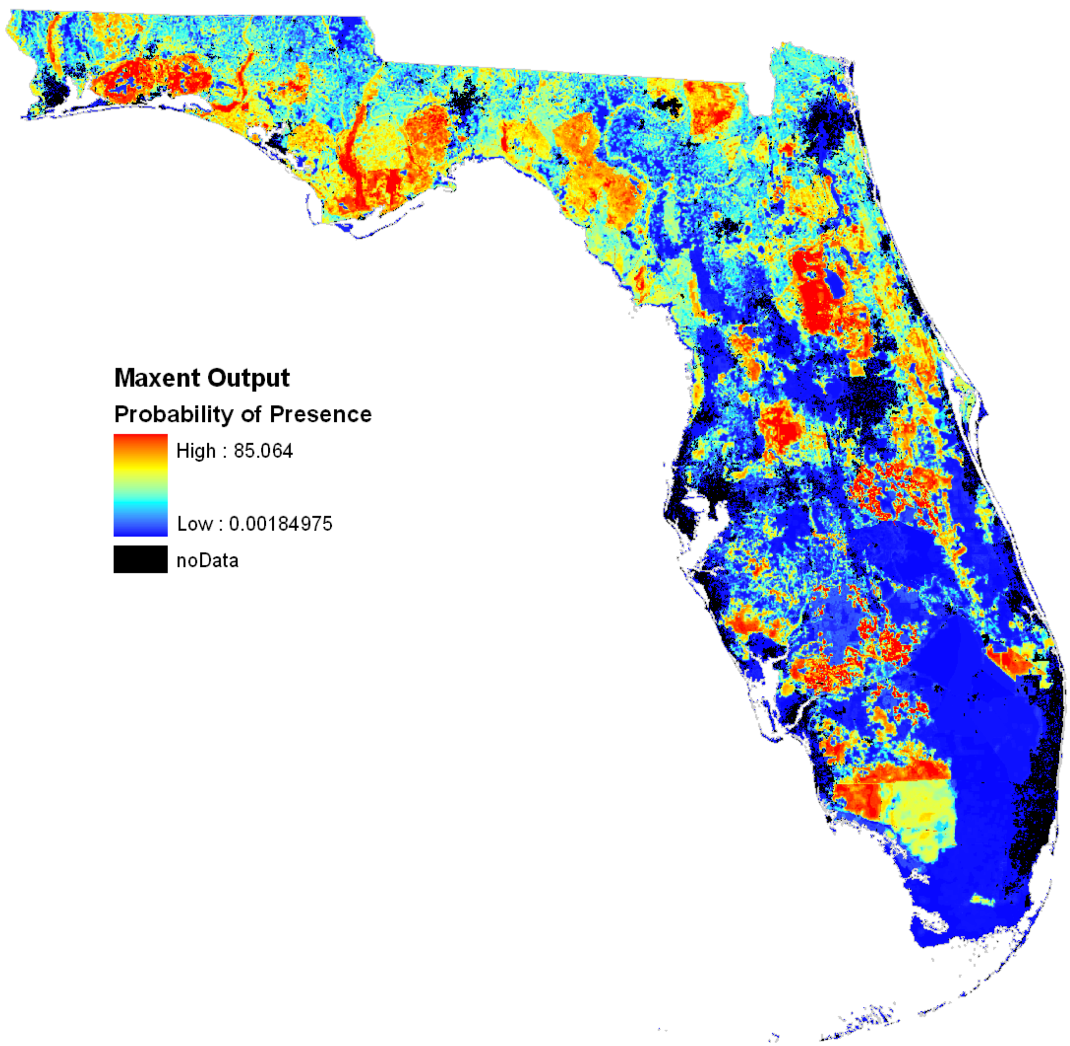

Figure 14. Florida Black Bear Maxent habitat model result

Final Hubs Delineation.--Habitat patch delineation was based upon a 50% probability threshold and a 2,000-acre (800 hectare) minimum patch size. Additional areas were added with the help of the TAG. Figure 15 shows an aggregate of the habitat patches that meet these quality and size thresholds and added areas.

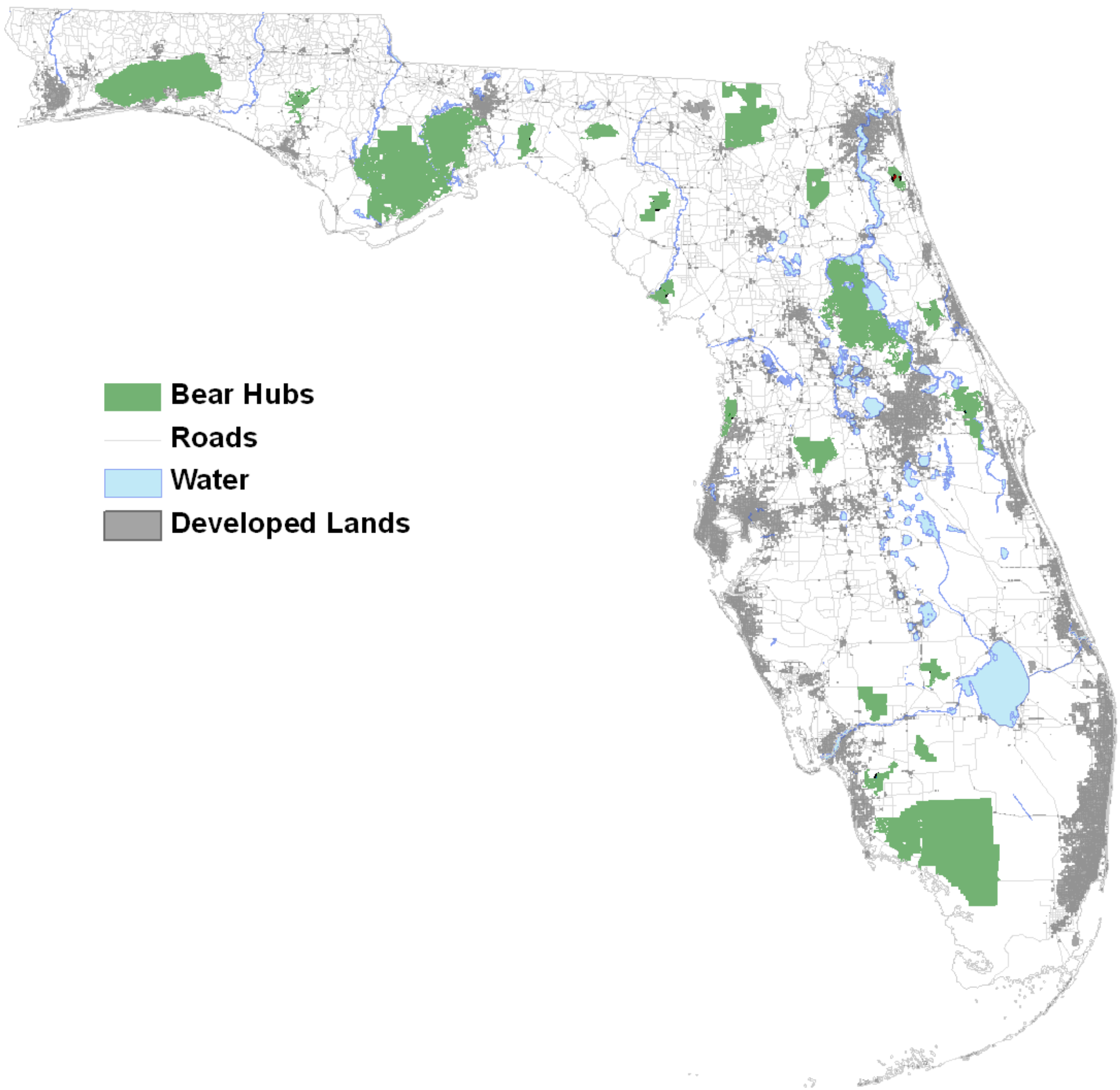

Figure 15. Bear Hubs

Connectivity Results.--Current flow, least cost path and shortest path methodologies show similar pathways and identify critical linkages that should be of high conservation priority. Least cost paths identify a single route between selected nodes while the shortest path analysis may identify alternate paths of lesser suitability. Using current flow, if a wide swath of suitable land exists for a wildlife corridor, values will be less than those of a more restricted corridor. These higher values, identifying restricted flows, can help to better identify stressed or narrow wildlife corridors. Results for current flow, least cost path and shortest path connectivity analyses are shown in Figures 16-18. After comparing connectivity modeling results, we decided to use the ArcGIS least cost path results as the means for identifying corridors for the Florida panther. We identified all well connected (deleting all connections less than 120 meters wide) natural, semi-natural, and agricultural land use within 1 mile (1600 meters) of each LCP, which could result in an identified corridor of up to 2 miles wide (3200 meters). These buffered LCPs are shown in Figure 19.

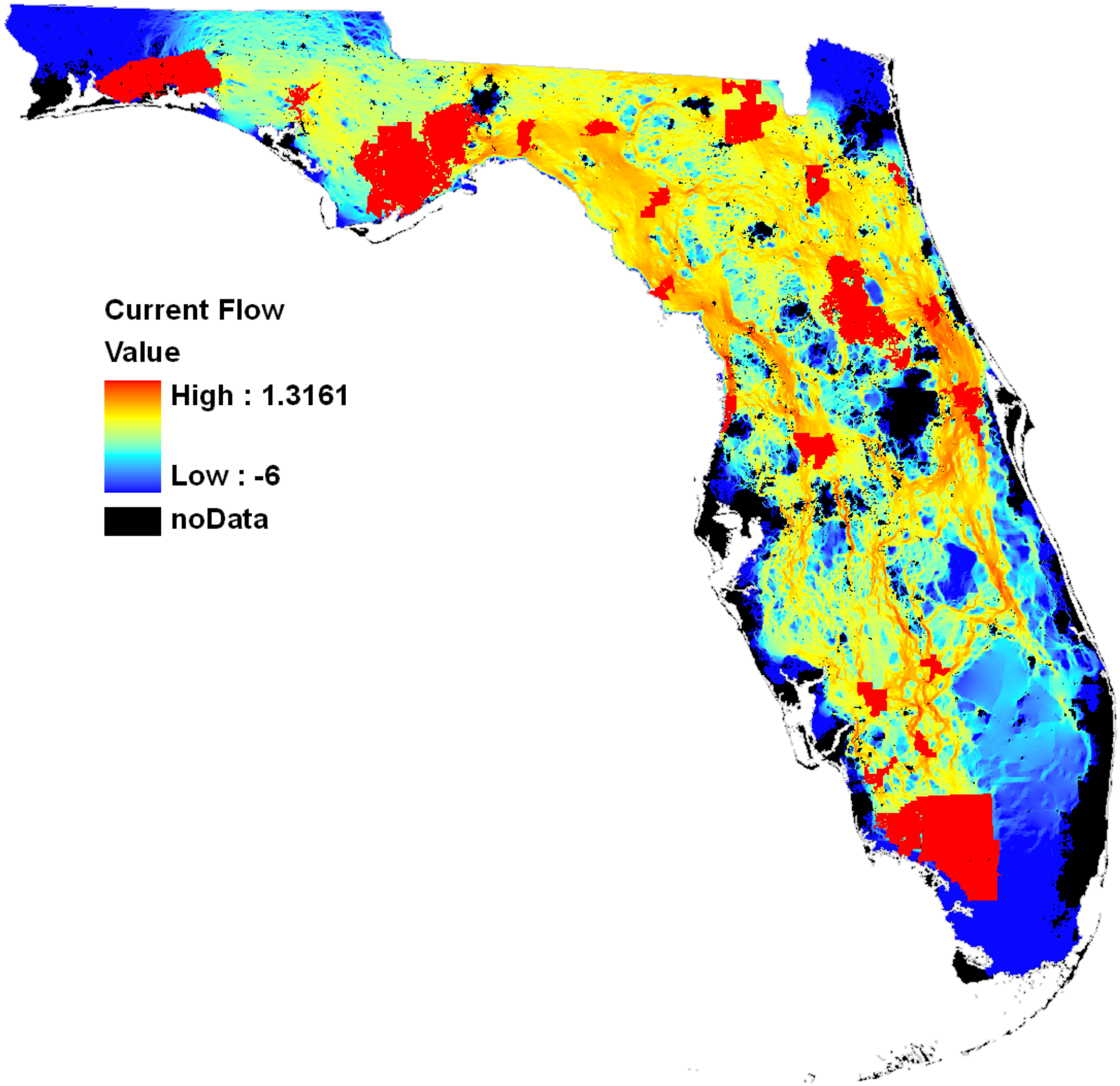

Figure 16. Florida Black Bear Current Flow Analysis Results

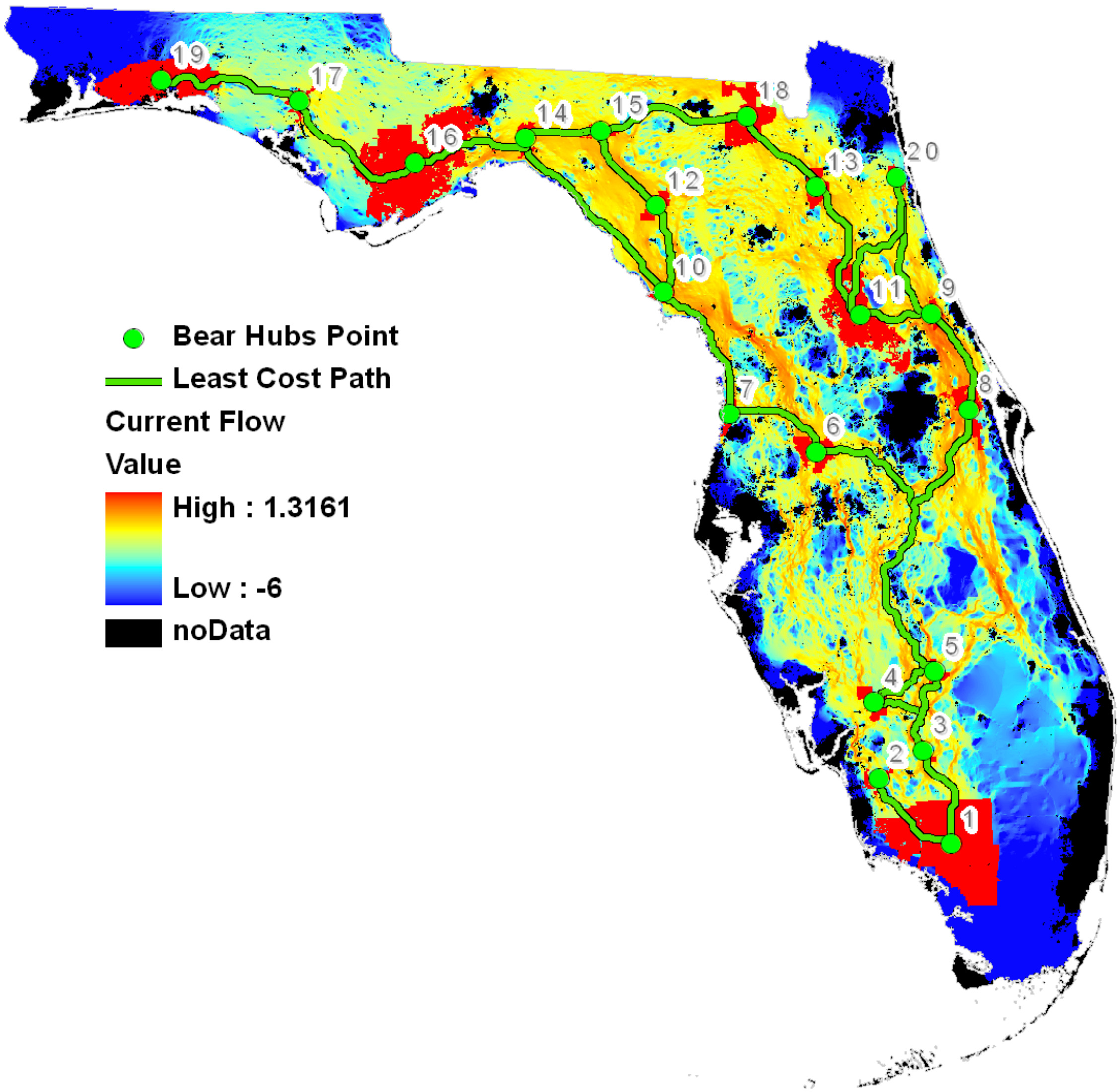

Figure 17. Florida Black Bear Least Cost Path Analysis Results

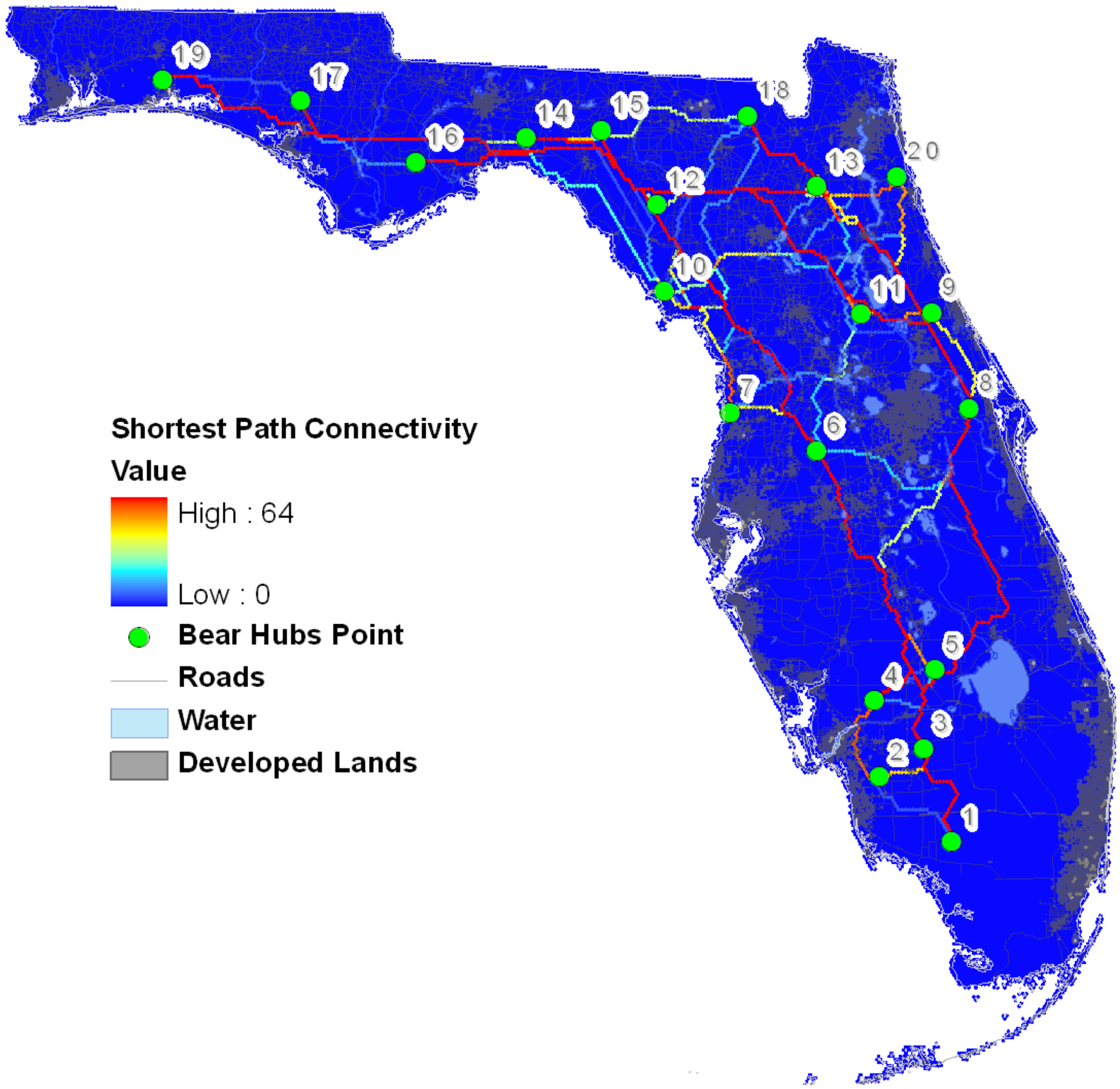

Figure 18. Florida Black Bear Shortest Path Analysis Results

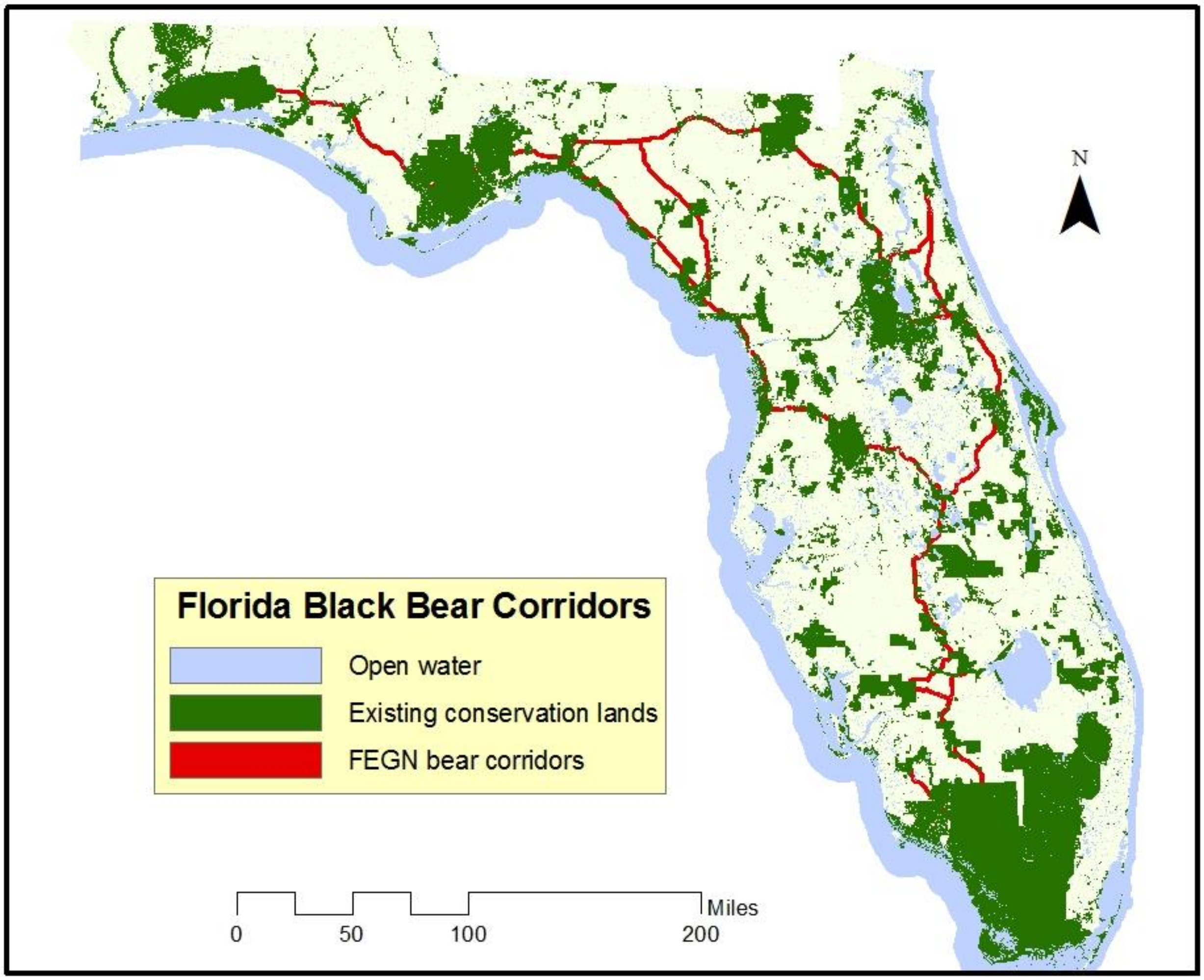

Figure 19. The final bear corridor results, which are the Least Cost Path results buffered by a mile (1600 meters) on each side to results in a potential corridor width of up to two miles (3200 meters).

5) Florida Panther Habitat and Connectivity Analysis

Maxent Output.-- Figure 20 represents the Maxent model output for the Florida Panther's probability of presence. Warmer colors show areas with higher probability conditions. Areas of high probability tend to occupy portions on or adjacent to existing natural/conservation areas. This helps to further validate the model. These areas include: Big Cypress/Everglades, Avon Park, Kissimmee Prairie, Green Swamp, Ocala National Forest, Osceola/Okefenokee, Apalachicola and Eglin AFB.

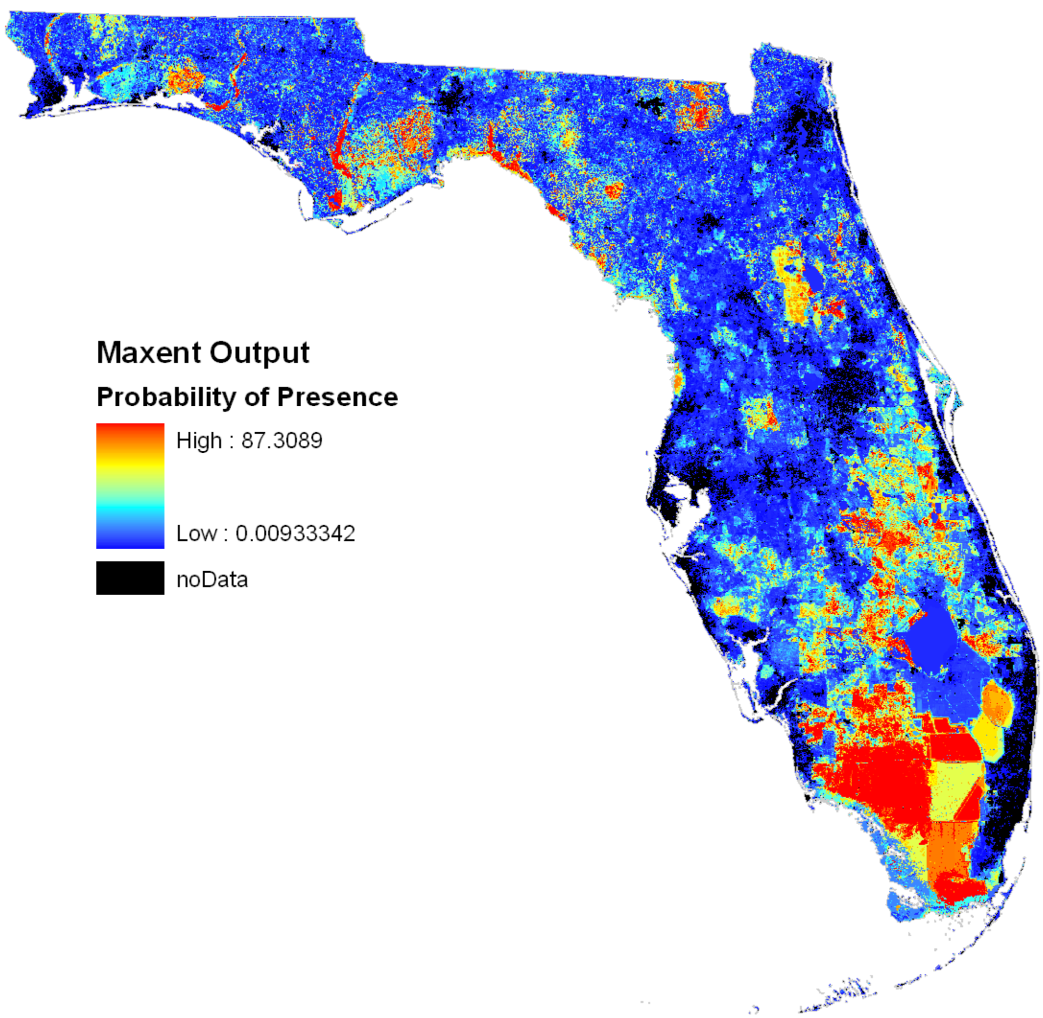

Figure 20. Florida Panther Maxent habitat model results

Core areas of habitat were created using a combination of the selected Maxent output and existing Panther home ranges and suitable core habitat areas. Maxent results were filtered by probability of presence and patch size. A minimum 50% probability or presence threshold with 5,000-acre (2,000 hectare) minimum patch size was used to create core hub areas. Figure 21 shows an aggregate of habitat patches that meet these quality and size thresholds and added areas based on TAG input.

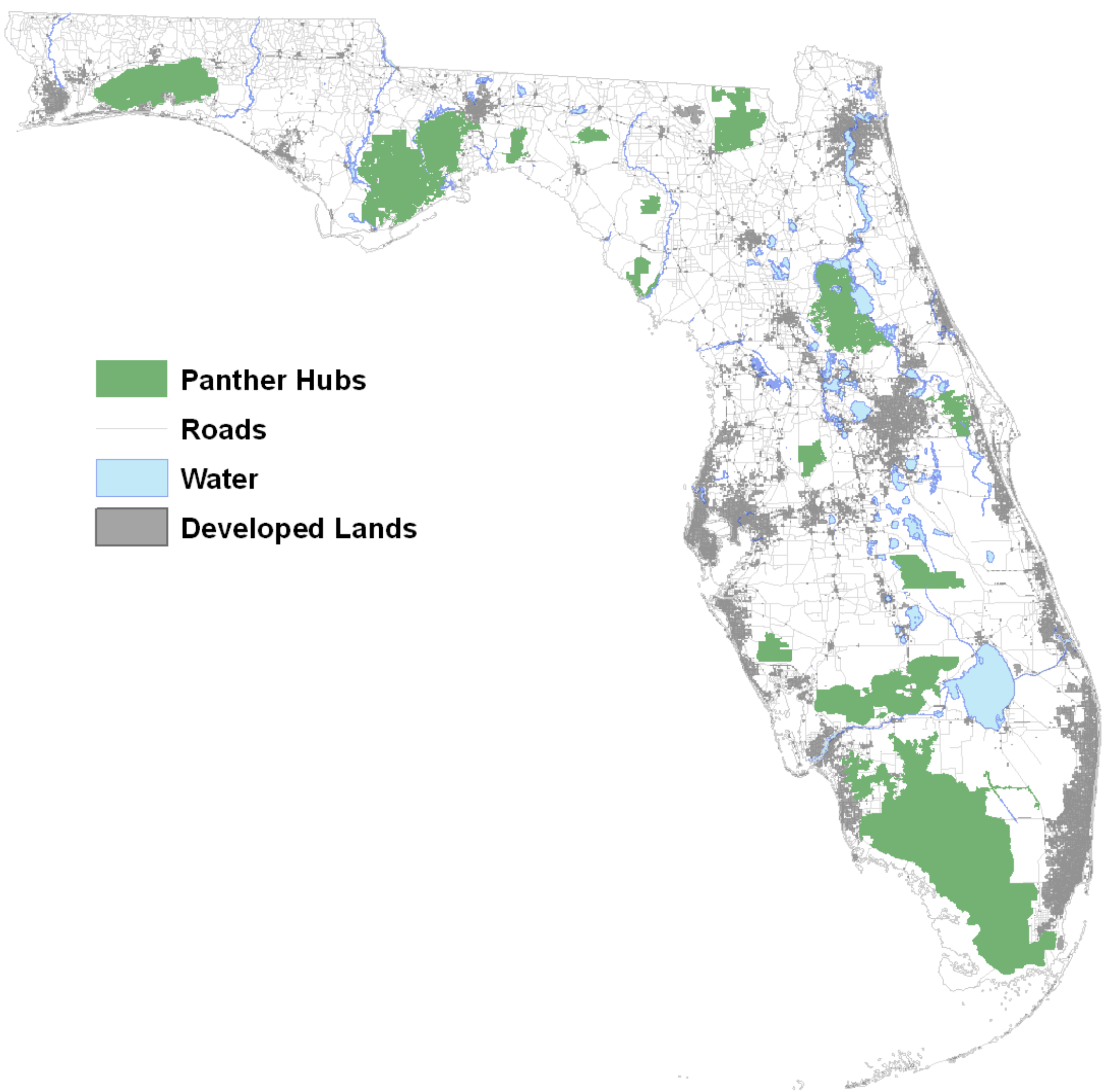

Figure 21. Florida Panther Hubs

Connectivity Analysis.--Current flow, least cost path and shortest path methodologies show similar pathways and identify critical linkages. Least cost paths identify a single route between selected nodes while the shortest path analysis may identify alternate paths of lesser suitability. Using current flow, if a wide swath of suitable land exists for a wildlife corridor, values will be less than those of a more restricted corridor. These higher values, identifying restricted flows, can help to better identify stressed or narrow wildlife corridors. Results for current flow, least cost path and shortest path connectivity analyses are shown in Figures 22-24. After comparing connectivity modeling results, we decided to use the ArcGIS least cost path results as the means for identifying corridors for the Florida panther. We identified all well connected (deleting all connections less than 120 meters wide) natural, semi-natural, and agricultural land use within 1 mile (1600 meters) of each LCP, which could result in an identified corridor of up to 2 miles (3200 meters) wide. In addition, based on discussion with our panther ecology TAG members, we determined to use the panther corridor results for connections between panther hubs south of Orlando. These buffered LCPs are shown in Figure 25.

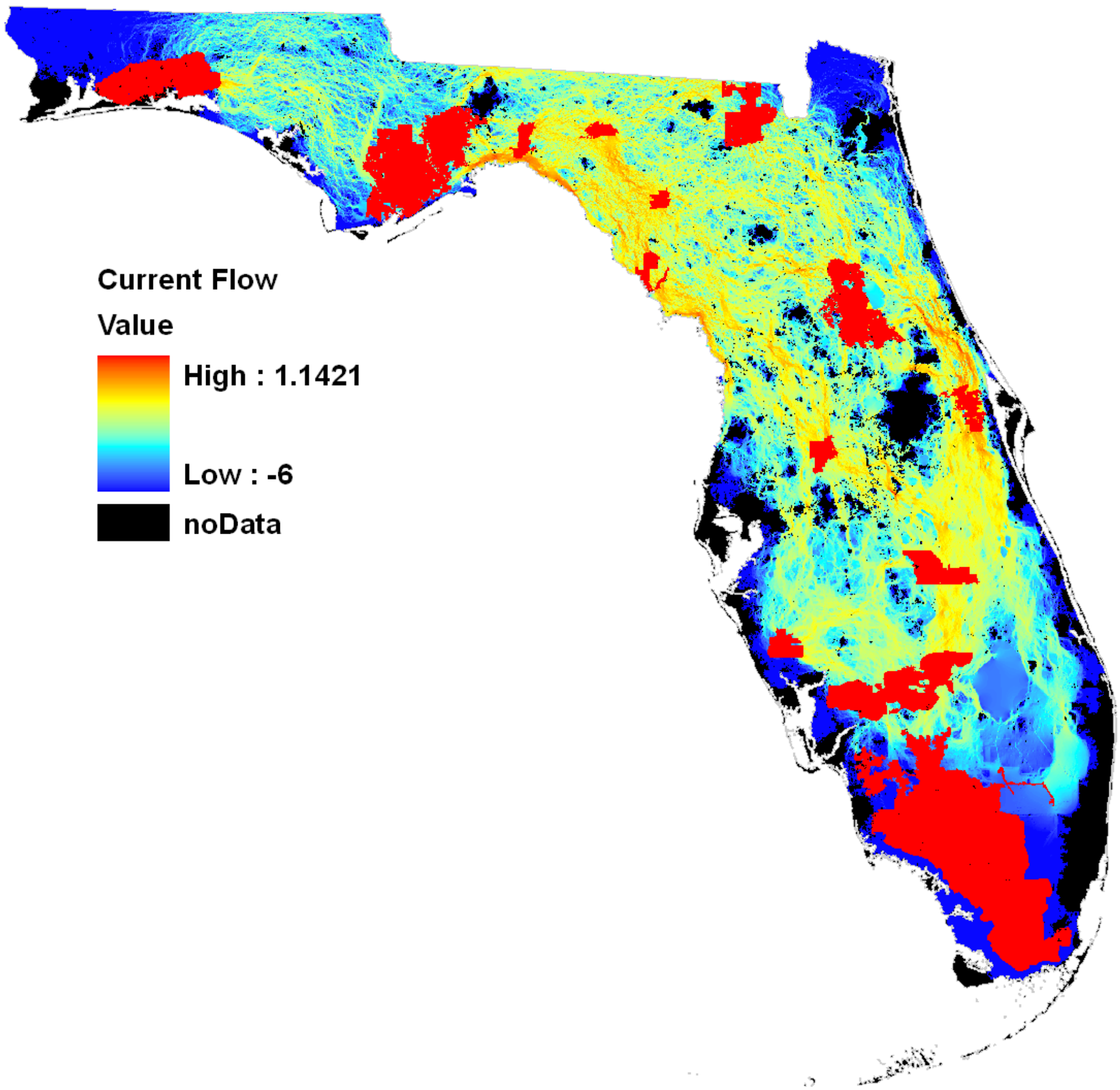

Figure 22. Florida Panther Current Flow Analysis results

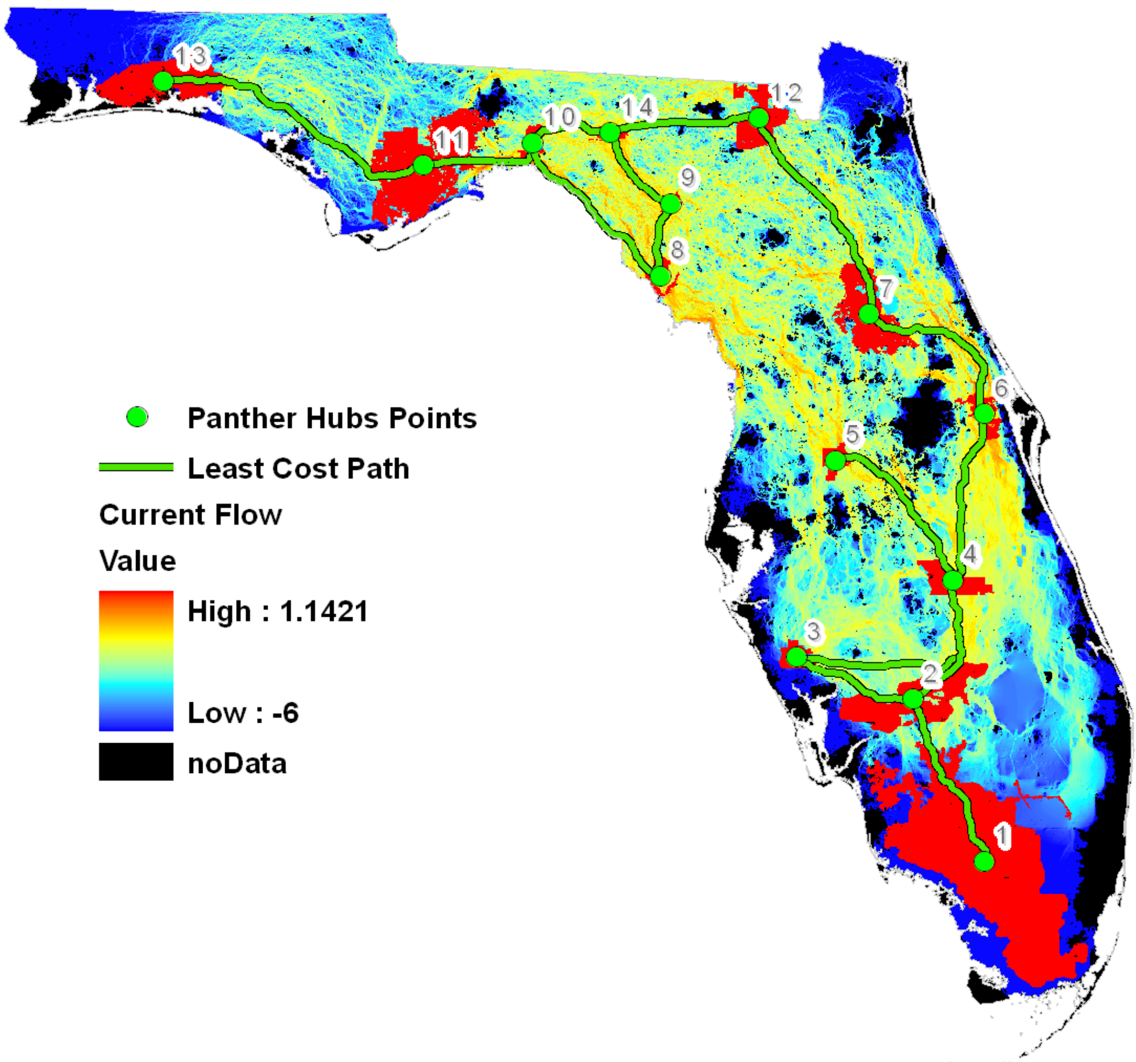

Figure 23. Florida Panther Least Cost Path Analysis results

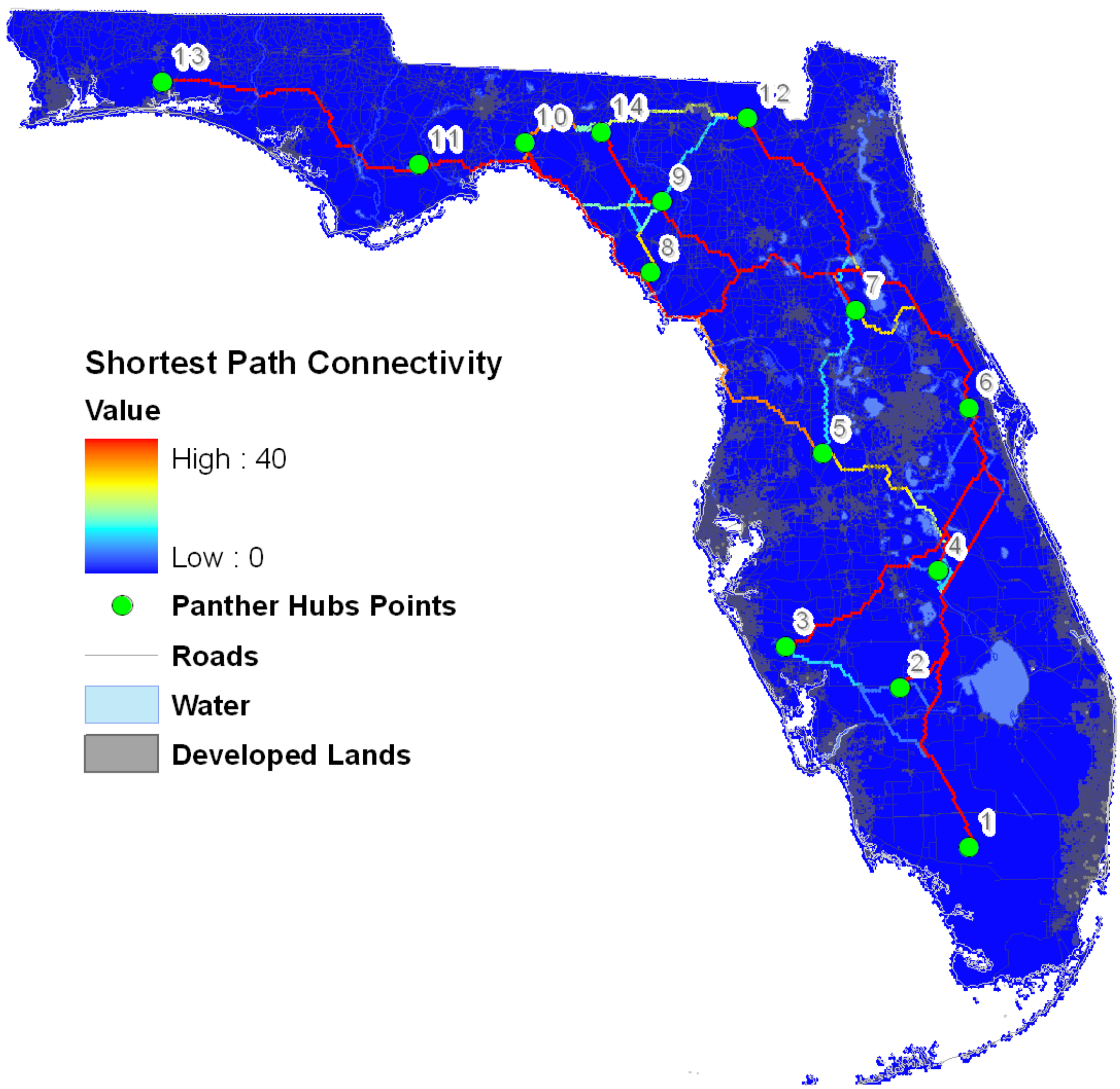

Figure 24. Florida Panther Shortest Path Analysis results

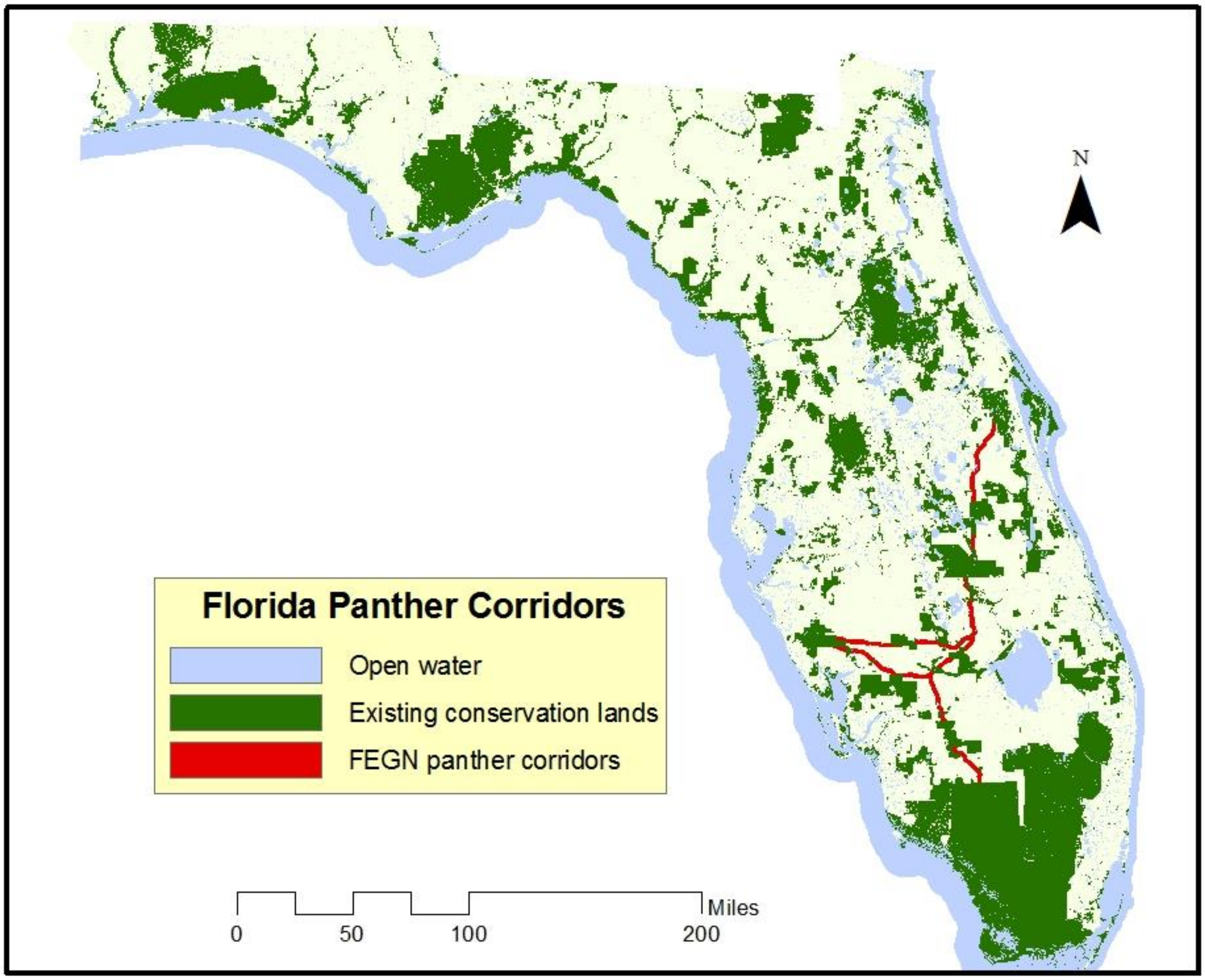

Figure 25. The final draft panther corridor results, which are the least cost path results buffered by a mile (1600 meters) on each side to results in a potential corridor width of up to two miles (3200 meters).

Florida Black Bear and Florida Panther Corridors with Hubs.-- Figure 26 shows both the final panther and bear corridors with the Hubs overlaid. Corridors for these two wide-ranging species often are within areas already identified as Hubs, but add areas to the new FEGN especially in west-central Florida around the Green Swamp, southwest Florida between Bright Hour Conservation Area and Babcock Ranch and the Myakka conservation areas, the Big Bend, and in the Panhandle north of Panama City.

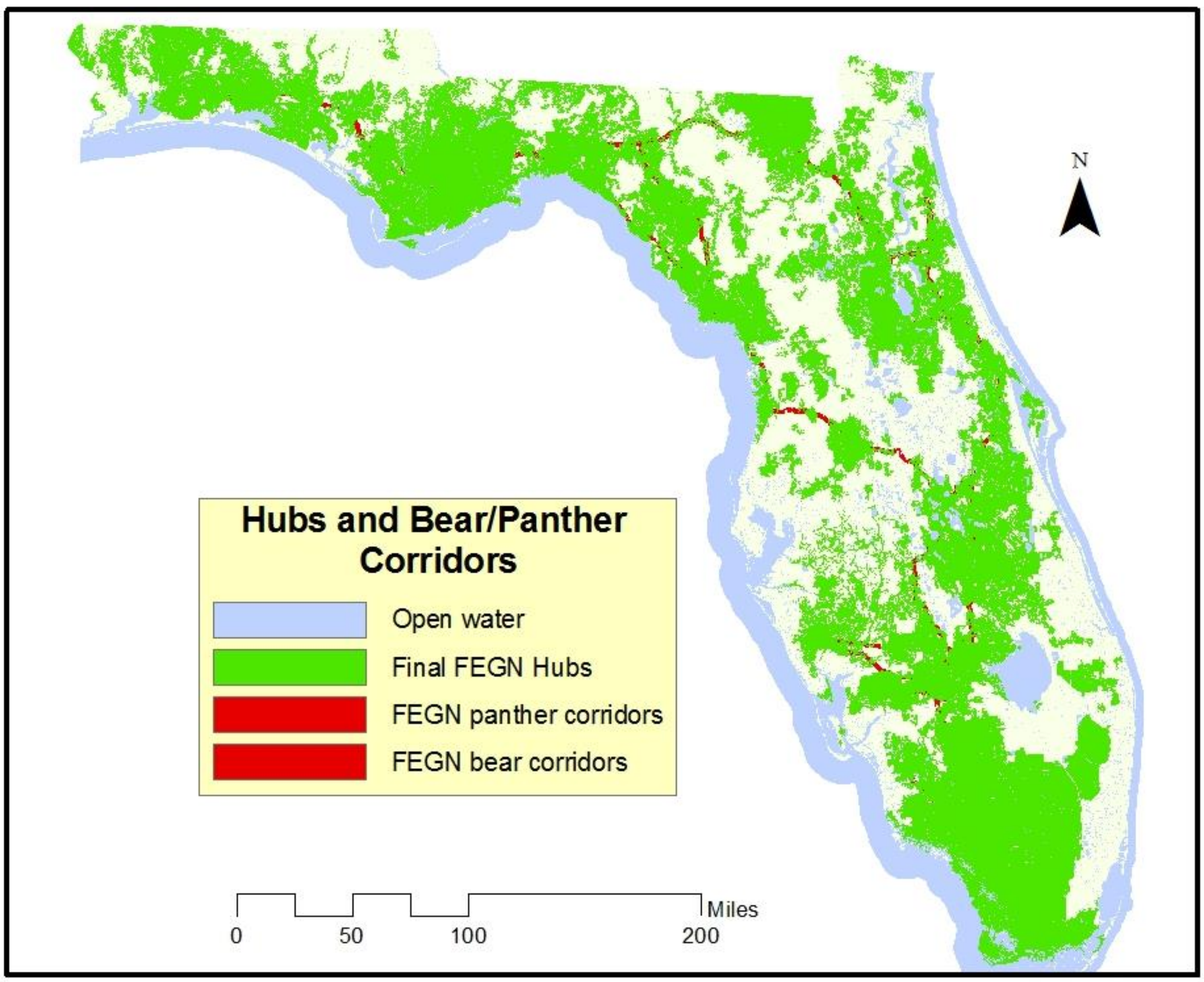

Figure 26. The panther and bear corridor results with Hub overlaid to show areas that might potentially be added to the new FEGN based on these analyses.

6) General Landscape Connectivity—The general landscape connectivity analysis was intended to close any remaining gaps in a statewide ecological network that were not addressed by the Hubs or any of the other connectivity types. After examining the Hubs combined with all of the other connectivity analysis results, existing conservation lands, land use data (CLC version 2.3), the general landscape connectivity cost surface, and aerial photography, 88 additional Least Cost Path (LCP) models were run using general landscape connectivity cost surface. These corridors either close additional gaps within the initial ecological network created by the Hubs and all of the other connectivity analyses, augment other corridors by providing additional options through otherwise marginal landscapes, or in some cases provide additional buffering for riverine and other corridors. Each of these LCPs were then run through a process where we identified all well connected (deleting all connections less than 120 meters wide) natural, semi-natural, and agricultural land use within 800 meters of each LCP, which could result in an identified corridor of up to 1 mile (1600 meters) wide. Figure 27 shows these buffered general landscape connectivity corridors underneath the Hubs.

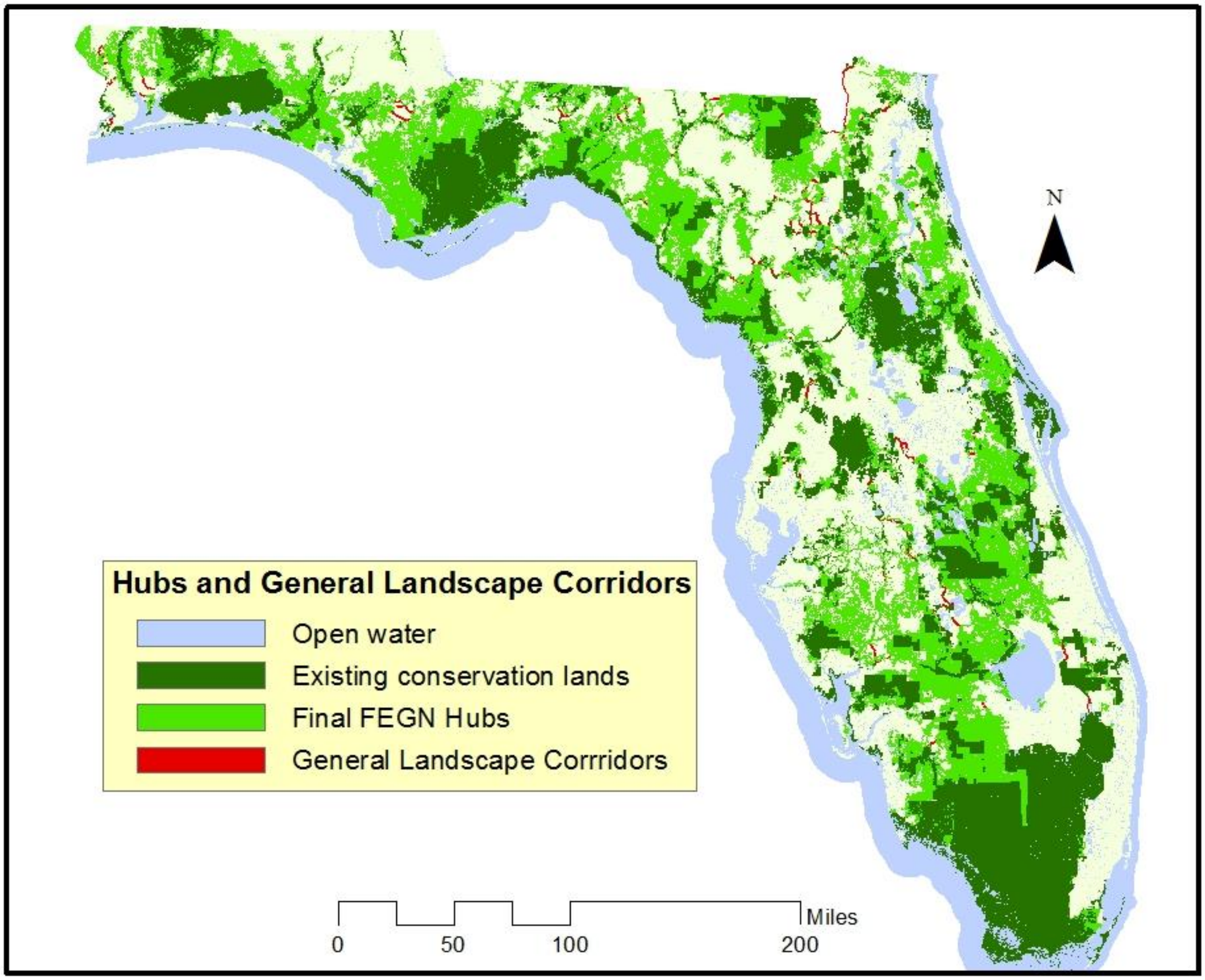

Figure 27. The General Landscape Connectivity corridors shown with Hubs overlaid.

Florida Ecological Greenways Network Base Boundary Results

Upon completion of the General Landscape Connectivity analysis, the Hubs were combined with all of the connectivity analysis results and then this interim ecological network was optimized by adding all existing conservation lands and Florida Forever projects connected to the network and then closing small gaps and deleting narrow connections. In addition, all areas of either Hubs or connectivity analysis NOT connected the rest of the statewide ecological network were dropped from being included in the new FEGN. Figure 28 shows the combination of all the completed connectivity analyses with the Hubs. Figure 29 shows changes based on the final spatial optimization process. Figure 30 shows the new FEGN with existing conservation lands and Florida Forever projects. Figure 31 shows a comparison between the new FEGN and the previous FEGN. Table 8 shows the land category statistics for the new FEGN and Table 9 shows the acreage comparison with the previous FEGN. It is important to note that the previous FEGN included a lot more coastal open water than the new FEGN, which was created with more emphasis on terrestrial landscapes and connectivity based on input from the TAG. The comparison between the previous and new FEGN in Figure 31 and Table 9 only compares terrestrial (both uplands and wetlands) acres. However, Figure 32 shows the comparison between the new and previous FEGN with open water ecosystems included.

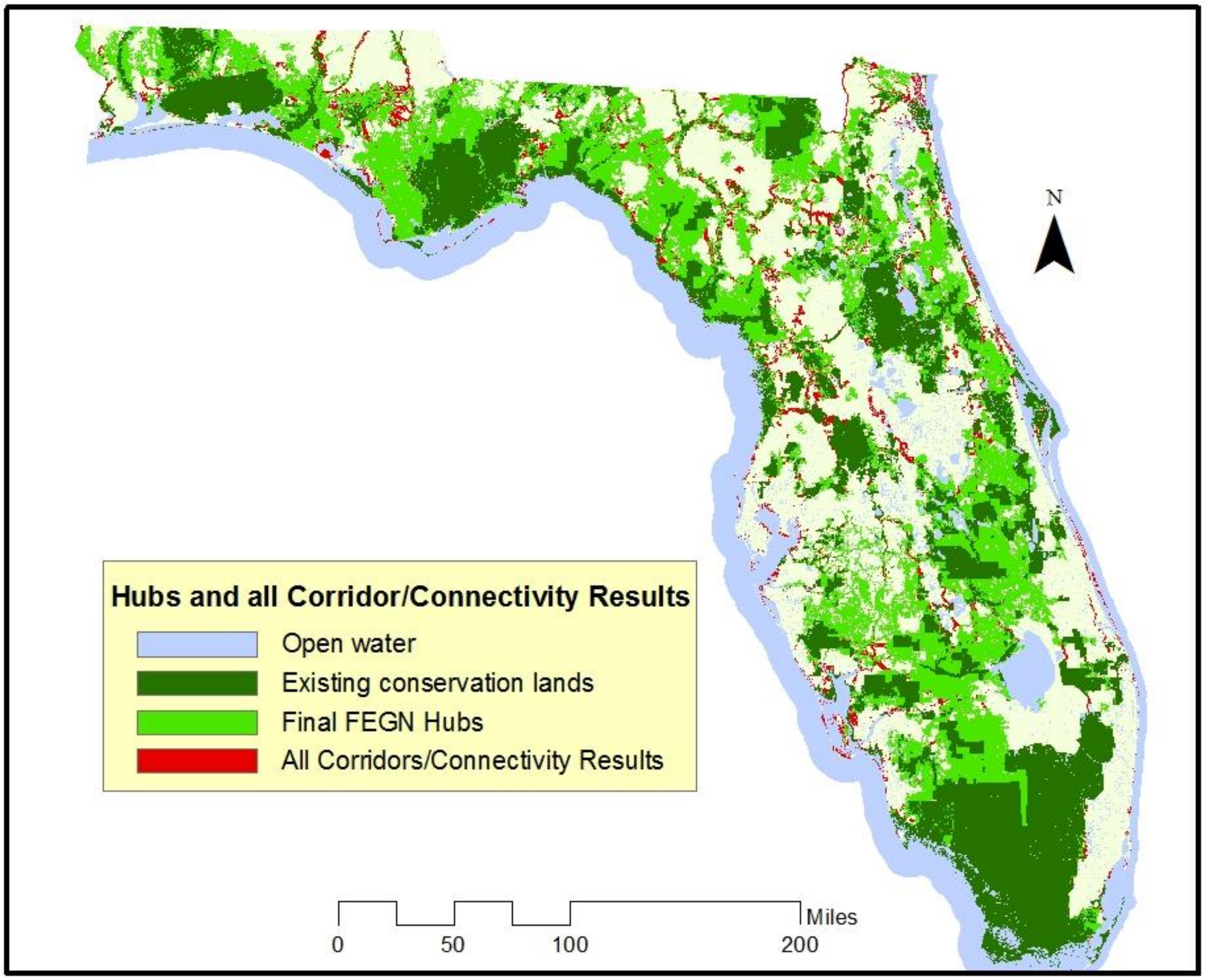

Figure 28. Hub And Connectivity Analysis results

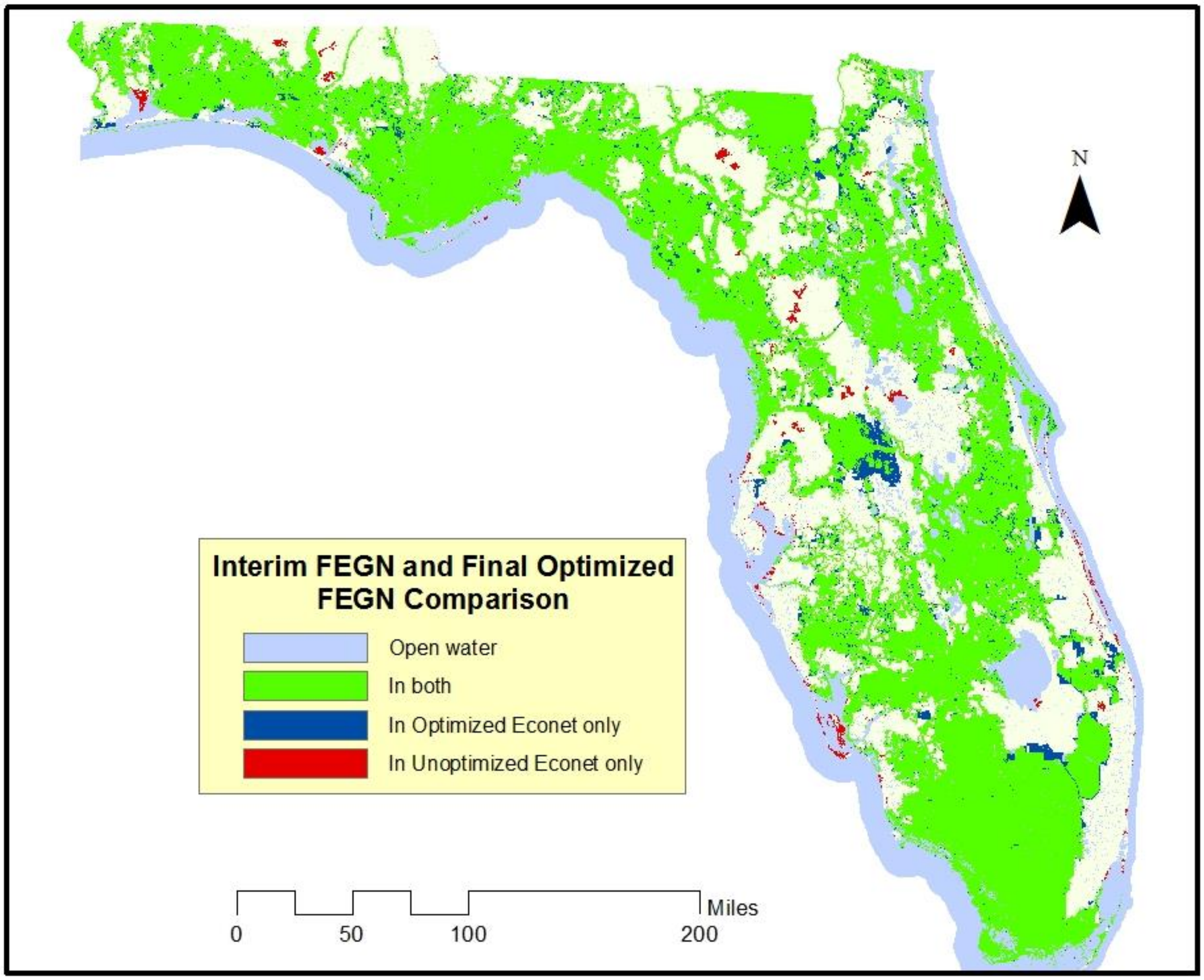

Figure 29. This figure shows the deletions and additions to the new draft FEGN based on the final spatial optimization process.

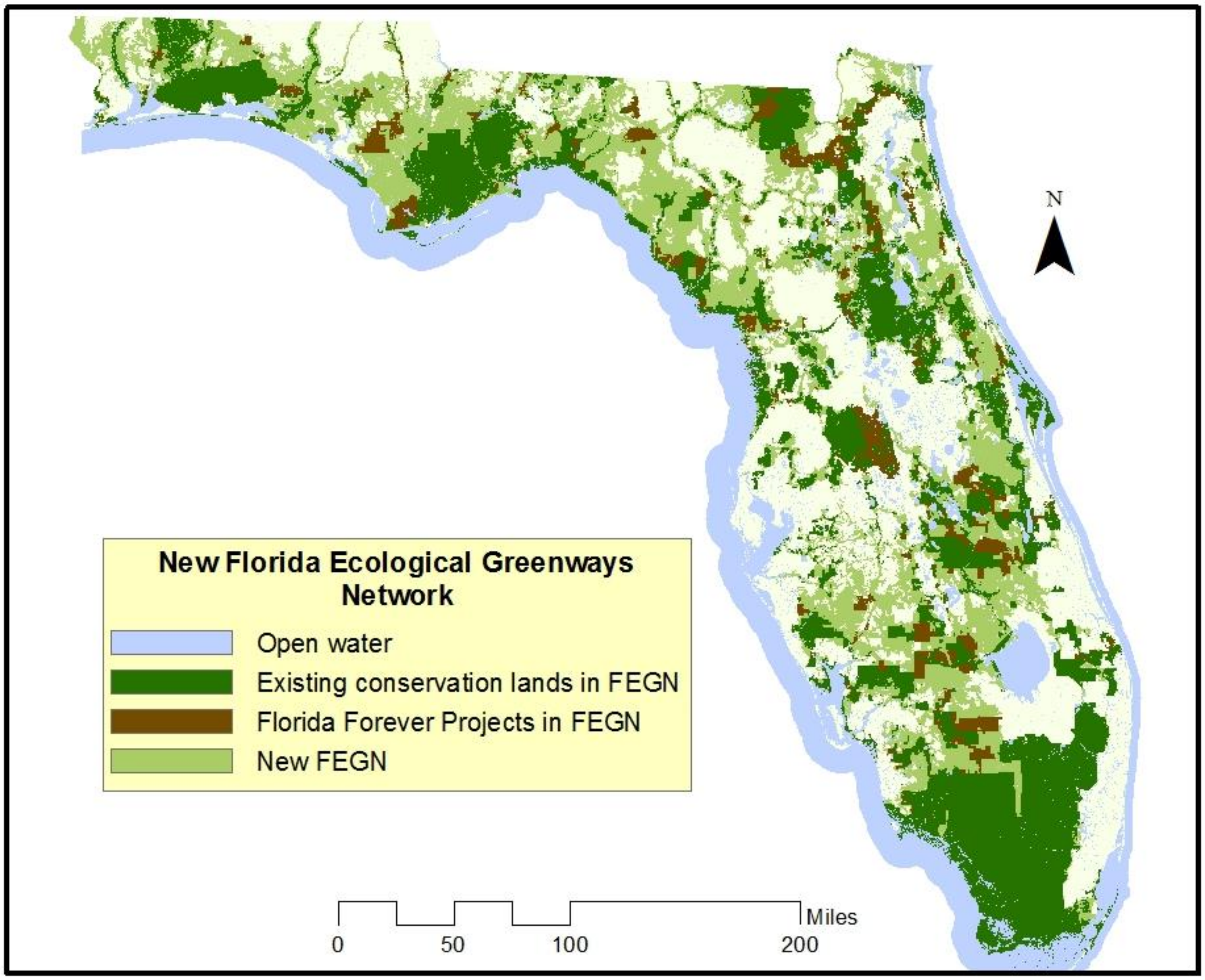

Figure 30. New Draft Florida Ecological Greenways Network with existing conservation lands and Florida Forever projects that are within the Network.

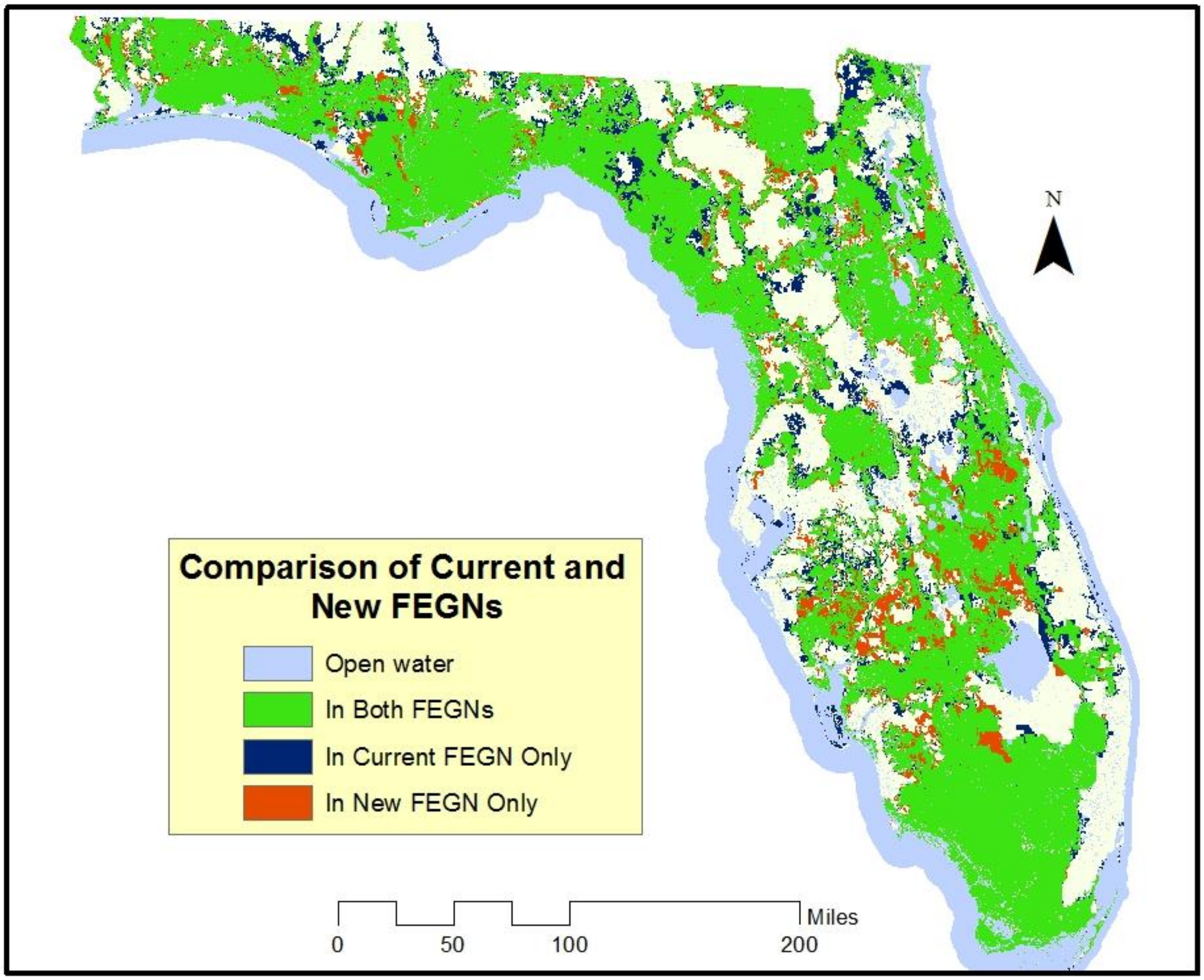

Figure 31. Comparison of the new FEGN with the previous FEGN

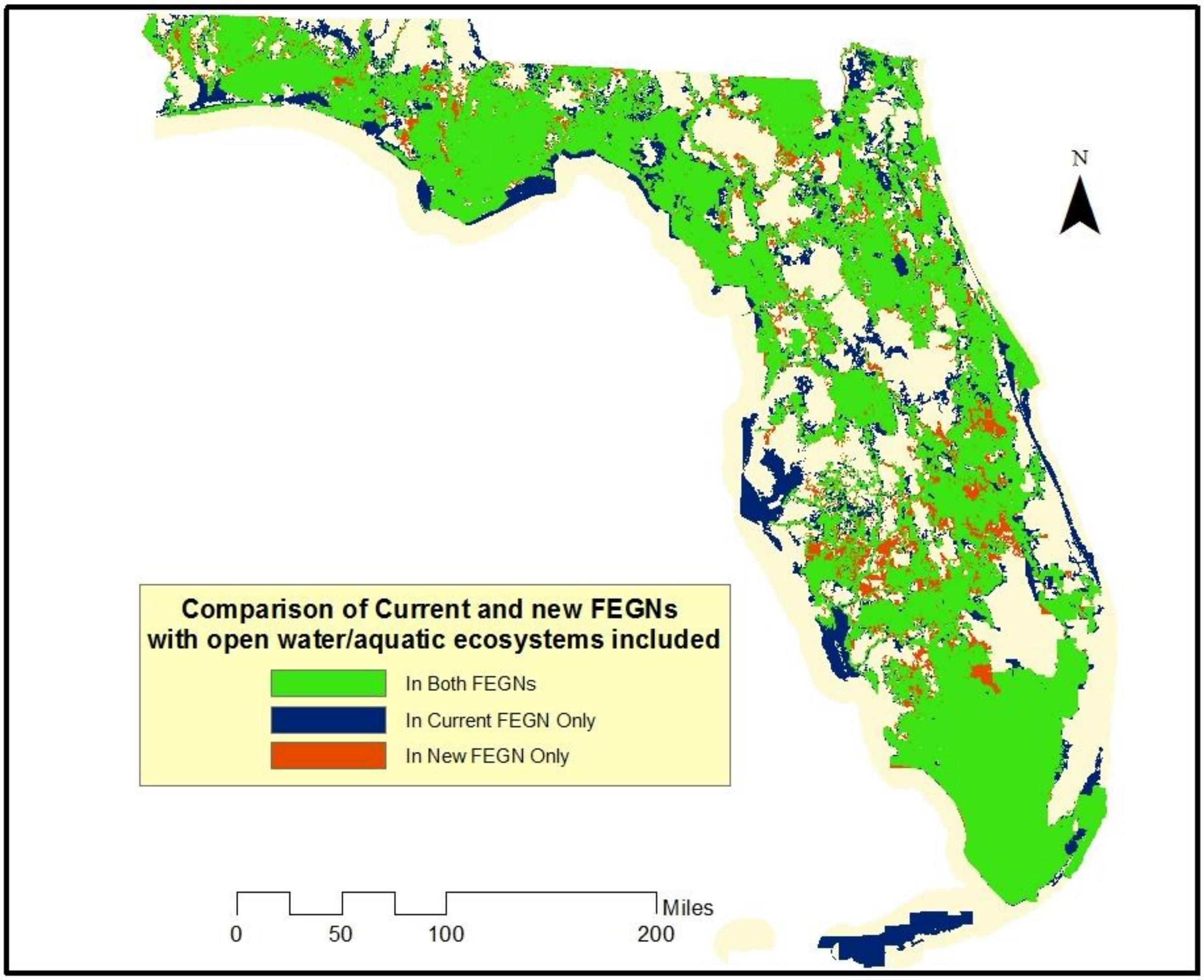

Figure 32. Comparison of the new FEGN with the previous FEGN with open water ecosystems also shown.

Table 8. Land use category statistics for the new FEGN

Land Use Category	Acres
Open Water	2,072,653
Existing Conservation Lands	9,706,439
Florida Forever Projects	1,822,274
Other Private Wetlands	2,963,792
Other Private Land	6,542,589
Total Acres	23,107,747

Table 9. Comparison of terrestrial acres included in the New and Previous FEGNs

Description	Acres
In Both	19,030,153
In New FEGN Only	2,192,800
In Previous FEGN Only	2,522,786

New FEGN Prioritization Results

Figure 33 and Figure 34 shows the new FEGN with the assigned priorities from the previous FEGN, and Table 10 shows the land use category statistics for the new FEGN assigned priority levels. Figure 35 shows the new 1 meter SLR-based 2060 development projection model by Zwick and Carr. Figure 36 shows the comparison of the new FEGN to the new 1 meter SLR-based development projection model. Figure 37 shows the comparison of the new 1 meter SLR-based development projection model to the higher priority levels in the new FEGN. Figure 38 shows the comparison of the new FEGN to the 1-3 meter sea level rise projections. Figure 39 shows the comparison of the new FEGN higher priorities to the 1-3 meter sea level rise projections. Overall, based on the results of these comparisons and discussions with the TAG, it appears that, at least from a future development perspective by 2060, that much of the new FEGN and the higher priorities in the new FEGN may be impacted by enough large-scale or scattered development that it is hard to differentiate or justify changes in priorities based on future development pressure.

However, the comparison with projected SLR indicates various areas where changes in priorities might be considered to address potential SLR impacts on terrestrial ecological connectivity, which include:

1) Expand the St. Marks Critical Linkage to address SLR south of Tallahassee.
2) Consider Critical Linkage or at least P3 status for corridor that circles Tallahassee to the north (to serve as an alternate for St. Marks Critical Linkage).
3) Expand Coastal Big Bend Critical Linkage and consider elevating priority of inland Big Bend corridor to address SLR.

4) Consider expanding Critical Linkage around strategic areas of the St. Johns River to address potential sea level rise impacts.

5) Peace River from P3 to Critical Linkage to provide an additional option to connect south and north Florida.

6) Kissimmee to Green Swamp (Four Corners) corridor from P1 to Critical Linkage to provide an additional option to connect south and north Florida.

7) Consider assigning higher priority to south to north corridors within north Florida that connect to areas of conservation significance in Georgia and Alabama.

Figures 40-46 show these various candidate areas for considering changes to the new FEGN priorities based on potential SLR impacts.

Based on discussion with the TAG and recommendations from TAG members, we determined to only adopt one of these candidates for changing the new FEGN priorities: elevating the Wakulla Priority 3 corridor to a Critical Linkage. In addition, based on TAG input including staff from the Florida Department of Environmental Protection's Office of Greenways and Trails, we decided to also consolidate the original 8 FEGN priority levels into 6 new priority levels where:

- Priority 1 (Critical Linkages): Formerly Critical Linkages 1 and 2
- Priority 2: Formerly Priority 1 and Priority 2
- Priority 3: Formerly Priority 3
- Priority 4: Formerly Priority 4
- Priority 5: Formerly Priority 5
- Priority 6: Formerly Priority 6

Figure 47 shows the Wakulla Priority 3 corridor that was changed to a Priority 1 Critical Linkage. Figure 48 shows the new final FEGN prioritization based on the change to the Wakulla corridor and the consolidation to 6 priority levels. Finally, Table 11 shows the land use category statistics for the new final FEGN priority levels.

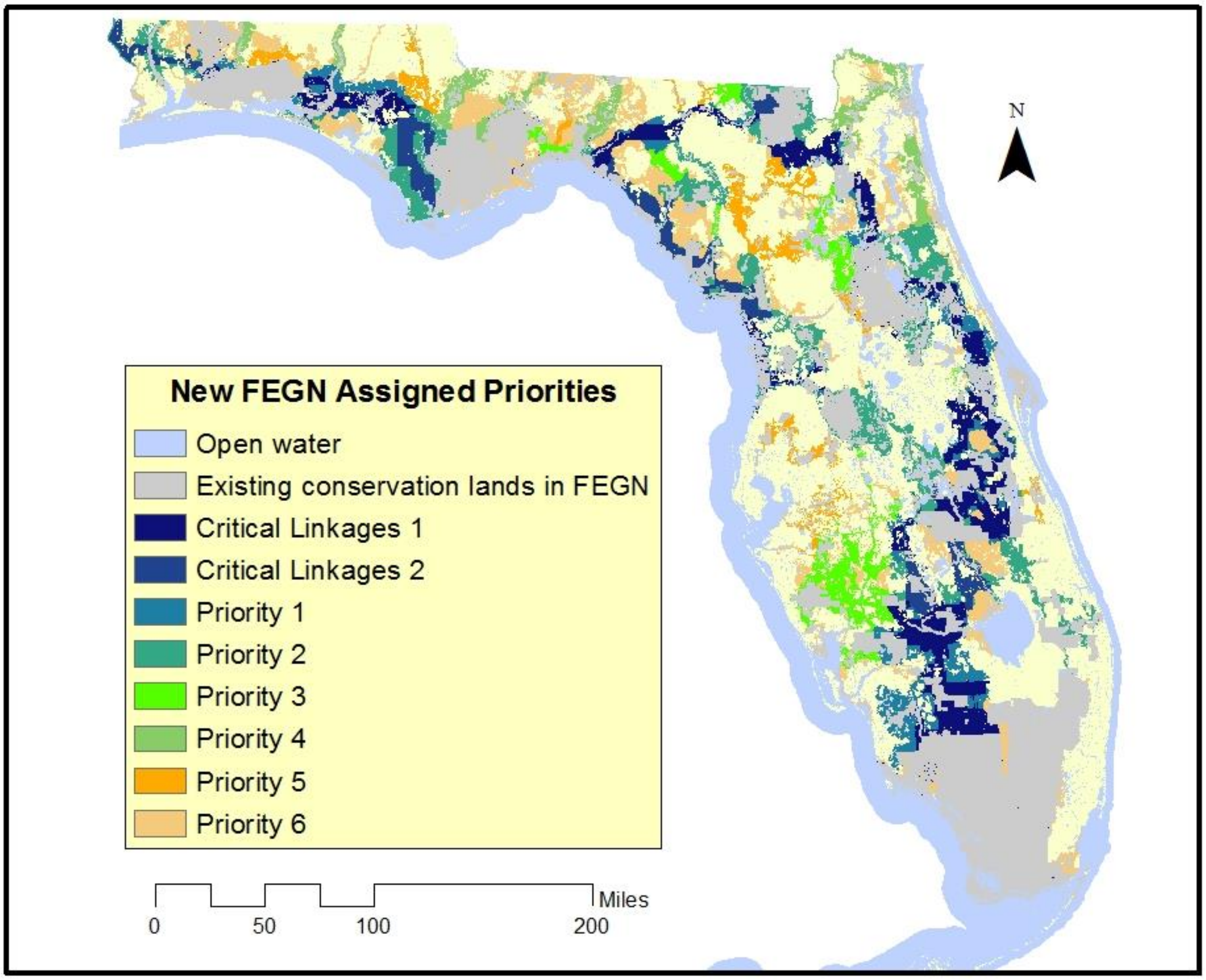

Figure 33. The new FEGN assigned with the current FEGN priorities.

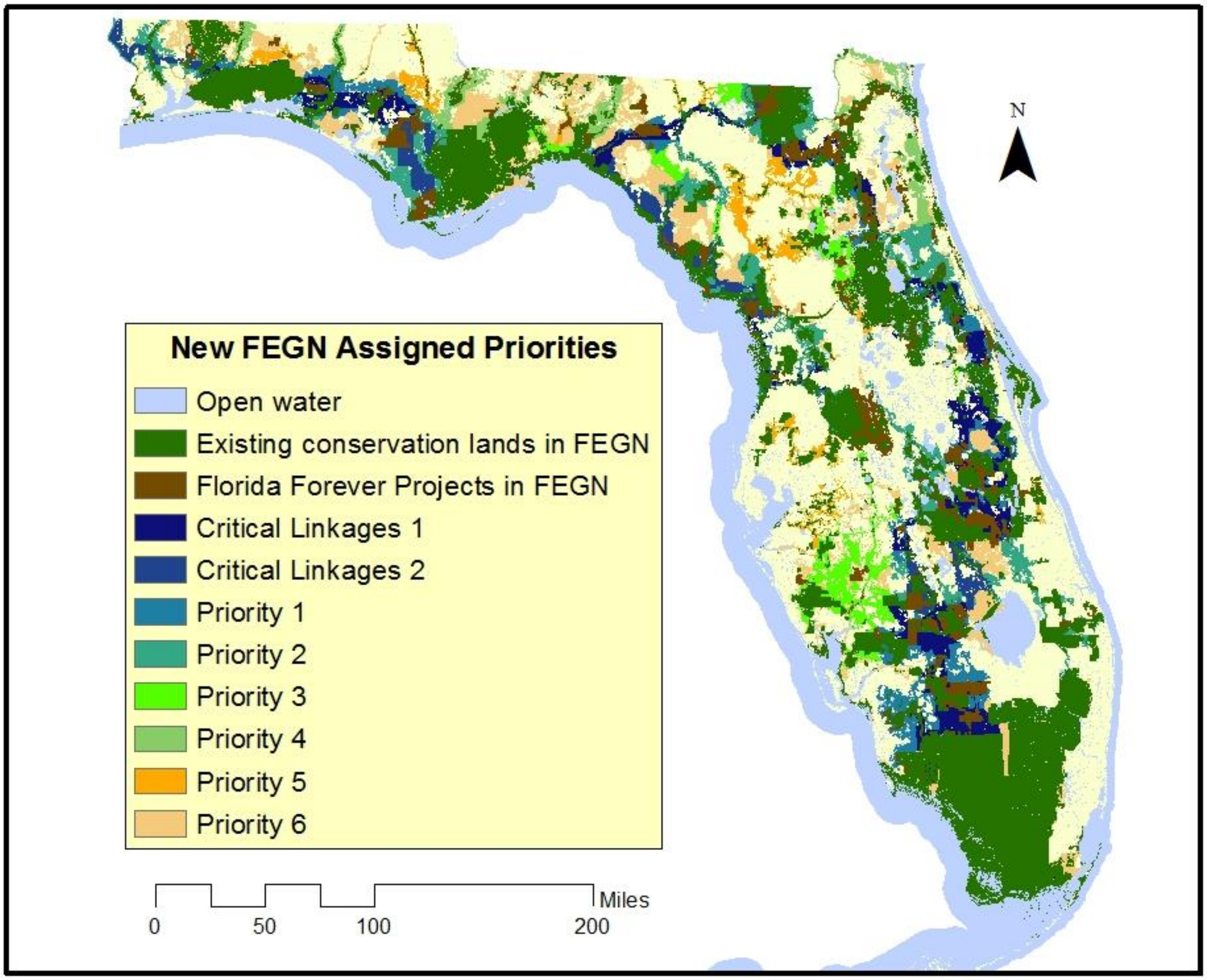

Figure 34. The new FEGN assigned with the current FEGN priorities with both existing conservation lands and Florida Forever project overlaid.

Table 10. The land use category statistics for the new FEGN assigned priority levels.

Land Use Category	FEGN Priority Level	Acres	Percent
Open Water	Critical Linkage 1	919,492	4.0%
Existing Conservation Lands	Critical Linkage 1	5,938,557	25.9%
Florida Forever Projects	Critical Linkage 1	719,942	3.1%
Other Private Wetlands	Critical Linkage 1	399,095	1.7%
Other Private Land	Critical Linkage 1	918,049	4.0%
Open Water	Critical Linkage 2	157,908	0.7%
Existing Conservation Lands	Critical Linkage 2	1,318,711	5.7%
Florida Forever Projects	Critical Linkage 2	213,358	0.9%
Other Private Wetlands	Critical Linkage 2	259,452	1.1%
Other Private Land	Critical Linkage 2	516,207	2.2%
Open Water	Priority 1	129,626	0.6%
Existing Conservation Lands	Priority 1	424,097	1.8%
Florida Forever Projects	Priority 1	101,129	0.4%
Other Private Wetlands	Priority 1	287,835	1.3%
Other Private Land	Priority 1	772,753	3.4%
Open Water	Priority 2	137,280	0.6%
Existing Conservation Lands	Priority 2	678,008	3.0%
Florida Forever Projects	Priority 2	349,298	1.5%
Other Private Wetlands	Priority 2	481,332	2.1%
Other Private Land	Priority 2	1,026,499	4.5%
Open Water	Priority 3	42,675	0.2%
Existing Conservation Lands	Priority 3	312,451	1.4%
Florida Forever Projects	Priority 3	80,773	0.4%
Other Private Wetlands	Priority 3	261,916	1.1%
Other Private Land	Priority 3	589,523	2.6%
Open Water	Priority 4	83,472	0.4%
Existing Conservation Lands	Priority 4	229,606	1.0%
Florida Forever Projects	Priority 4	89,456	0.4%
Other Private Wetlands	Priority 4	259,395	1.1%
Other Private Land	Priority 4	385,829	1.7%
Open Water	Priority 5	22,657	0.1%
Existing Conservation Lands	Priority 5	260,732	1.1%
Florida Forever Projects	Priority 5	57,593	0.3%
Other Private Wetlands	Priority 5	177,378	0.8%
Other Private Land	Priority 5	565,365	2.5%

Table 10 continued. The land use category statistics for the new FEGN assigned priority levels.

Land Use Category	FEGN Priority Level	Acres	Percent
Open Water	Priority 6	574,878	2.5%
Existing Conservation Lands	Priority 6	544,584	2.4%
Florida Forever Projects	Priority 6	196,422	0.9%
Other Private Wetlands	Priority 6	825,921	3.6%
Other Private Land	Priority 6	1,653,250	7.2%

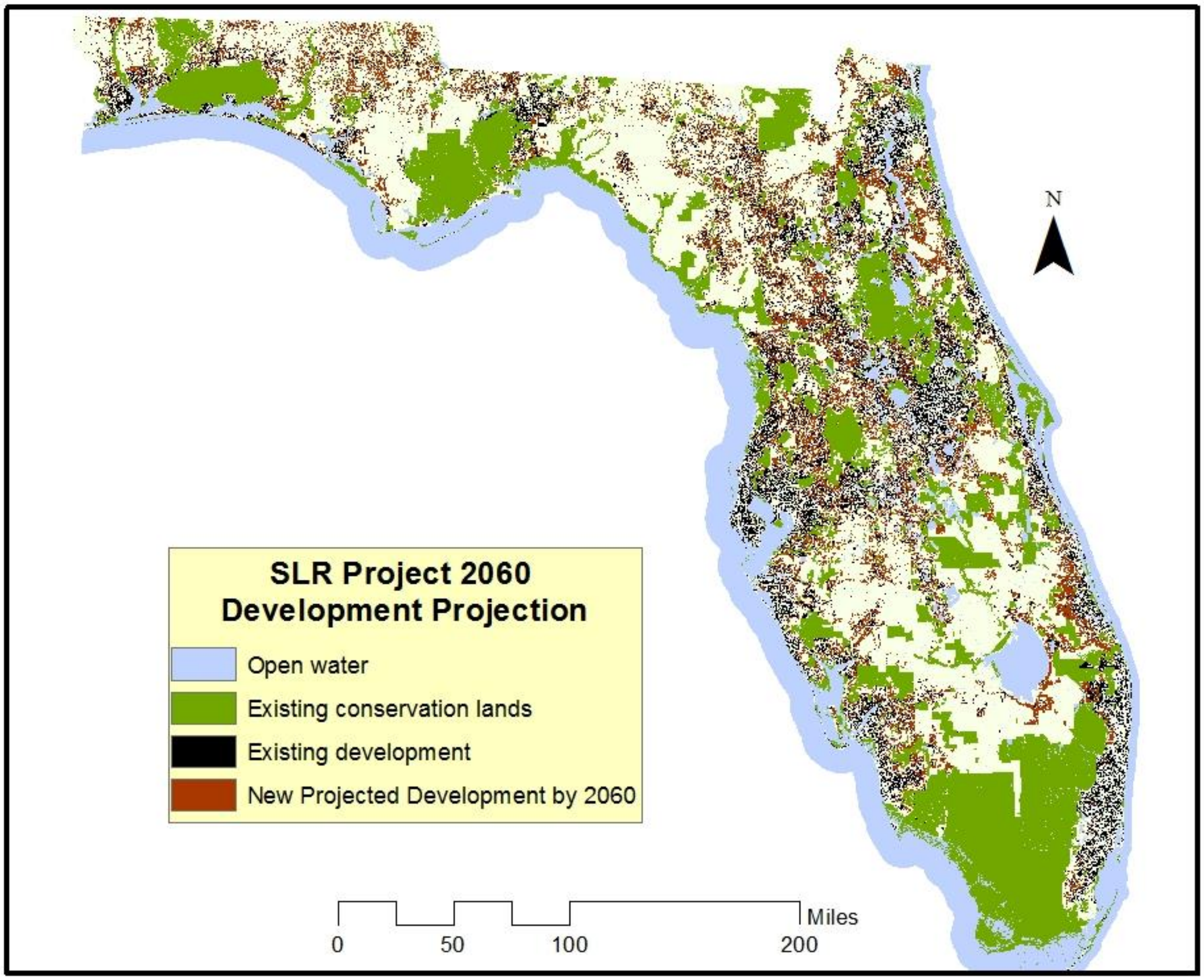

Figure 35. New 1 meter SLR-based 2060 development projection model by Zwick and Carr

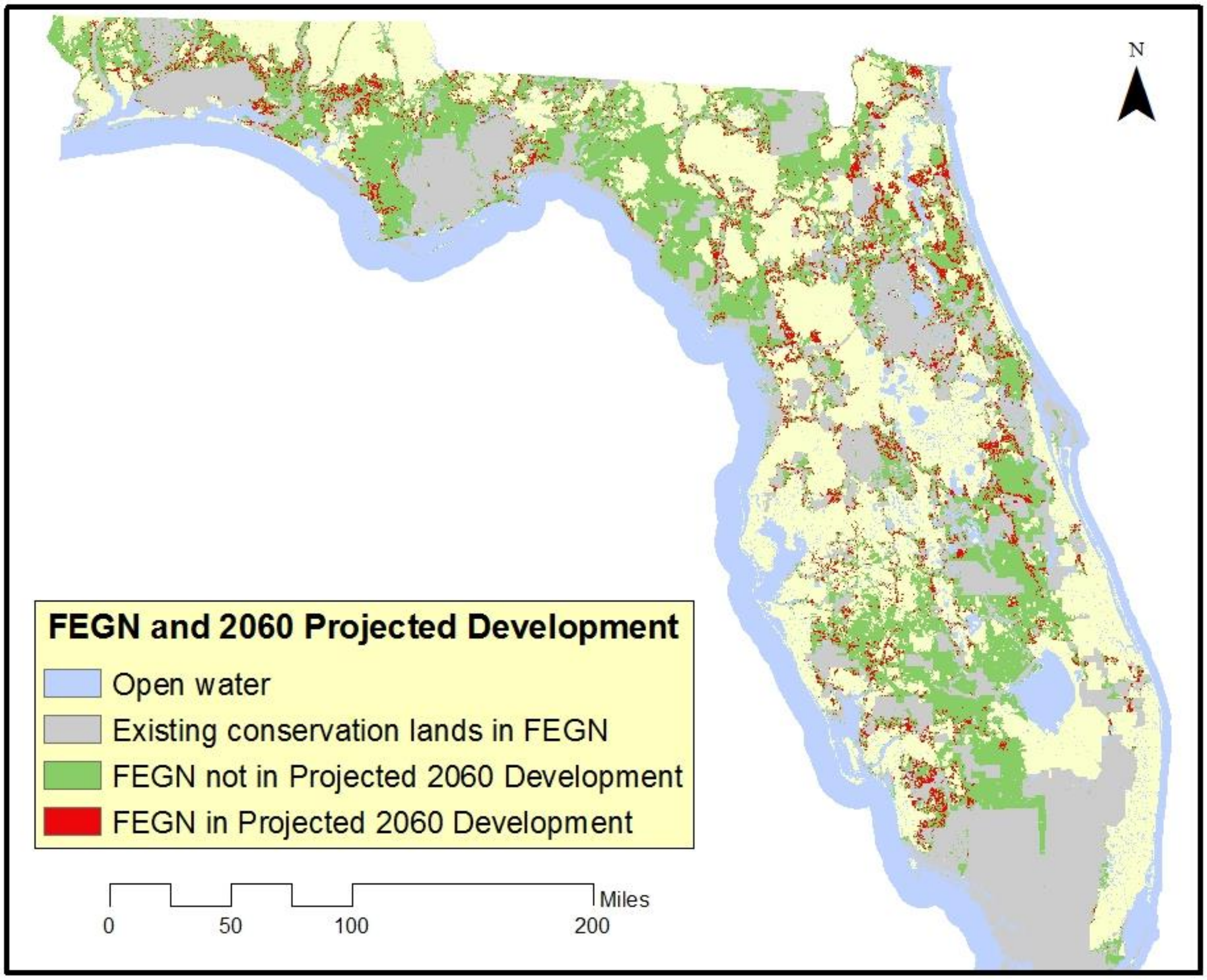

Figure 36. The new FEGN compared with the new 2060 development projection model.

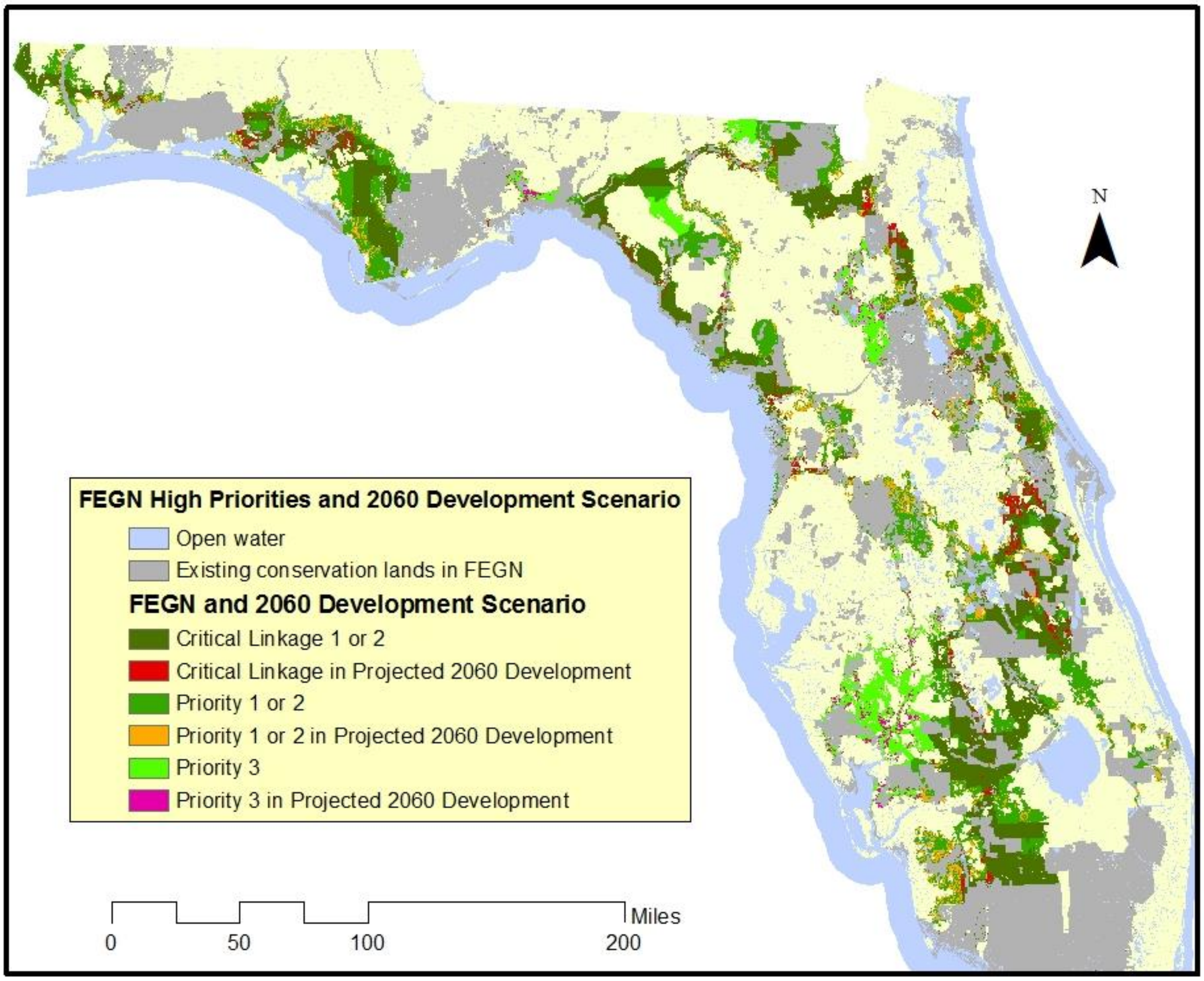

Figure 37. The new FEGN higher priorities compared with the new 2060 development projection model.

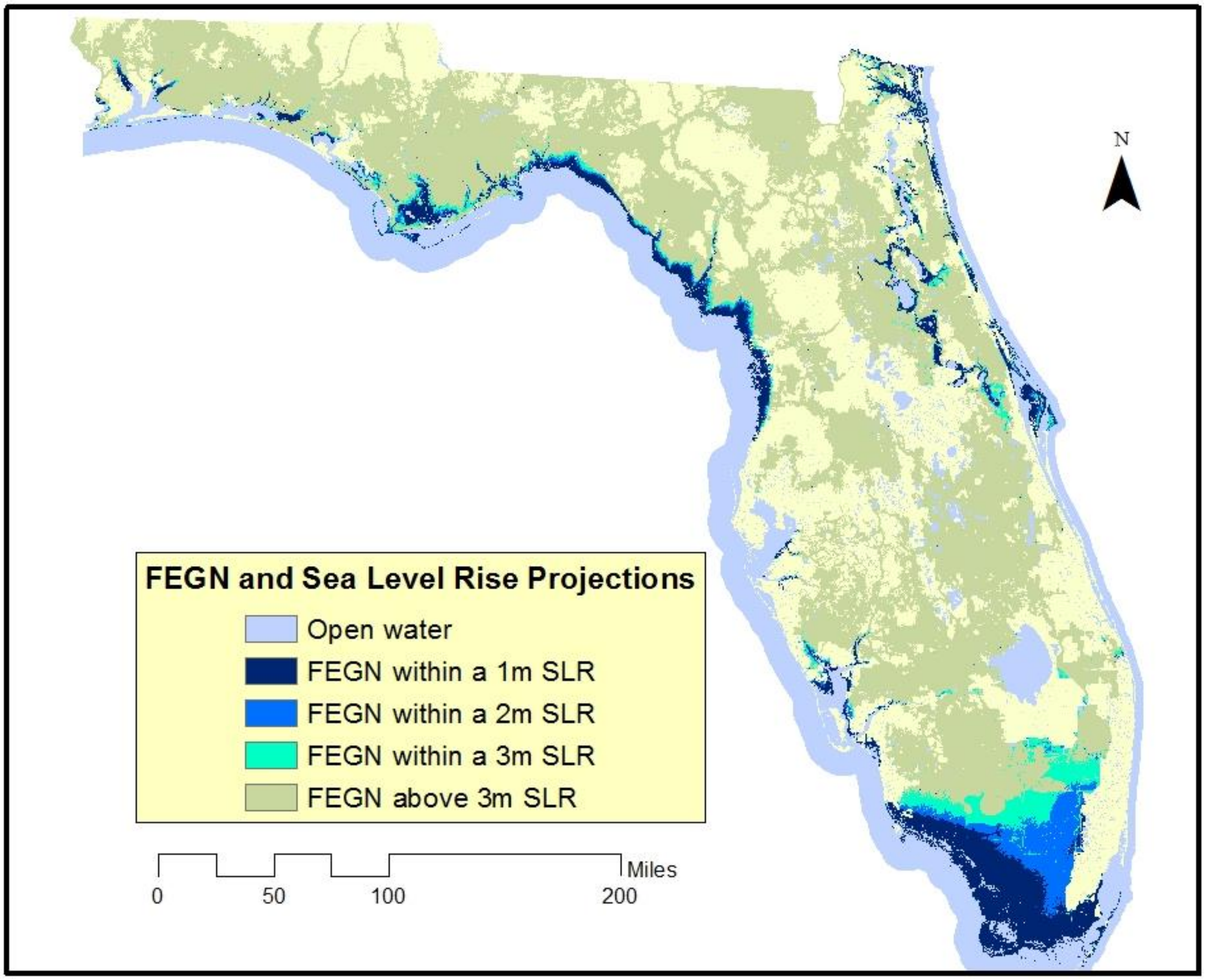

Figure 38. The new FEGN compared with the 1-3 meter sea level rise projections.

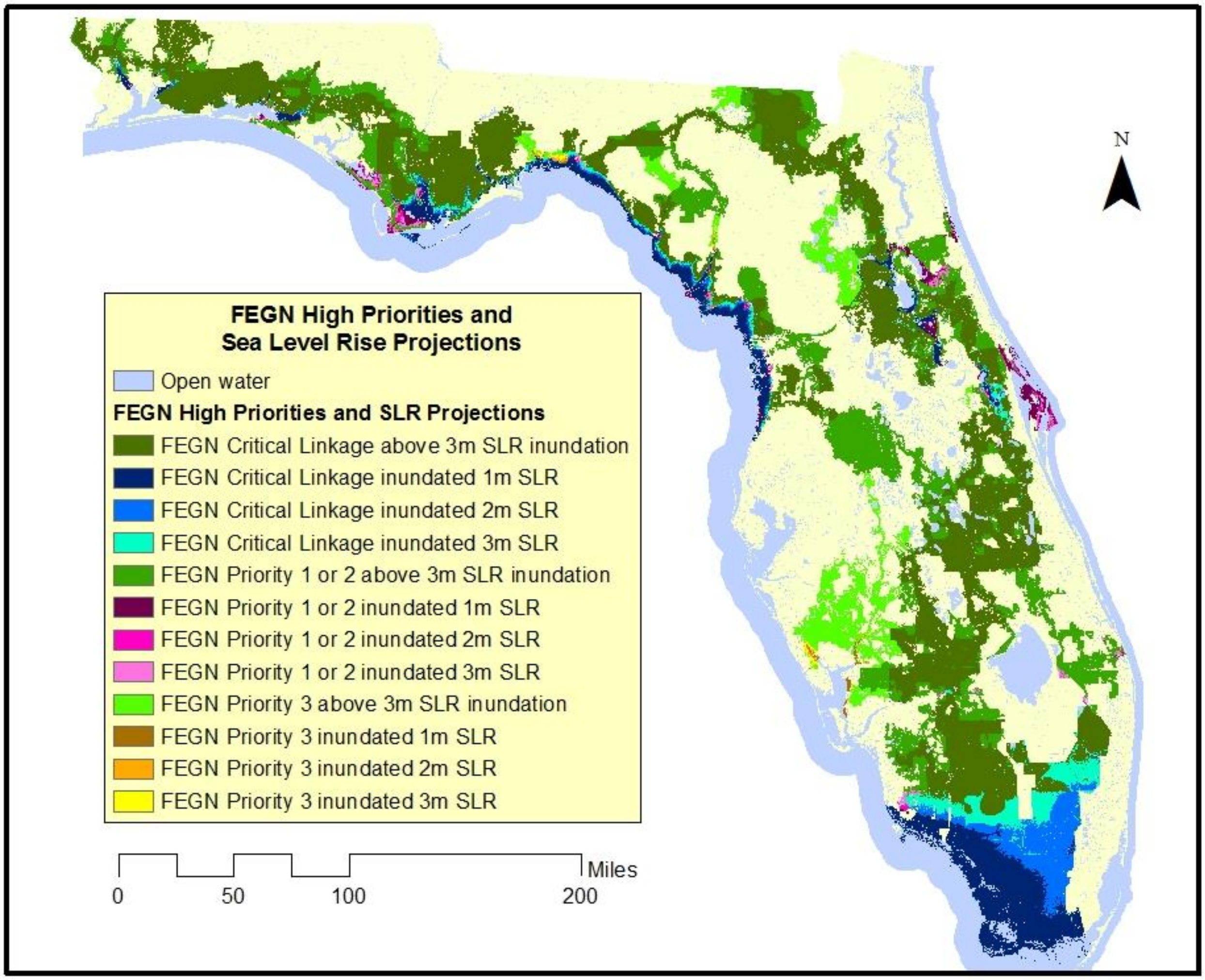

Figure 39. The new FEGN higher priorities compared with the 1-3 meter sea level rise projections.

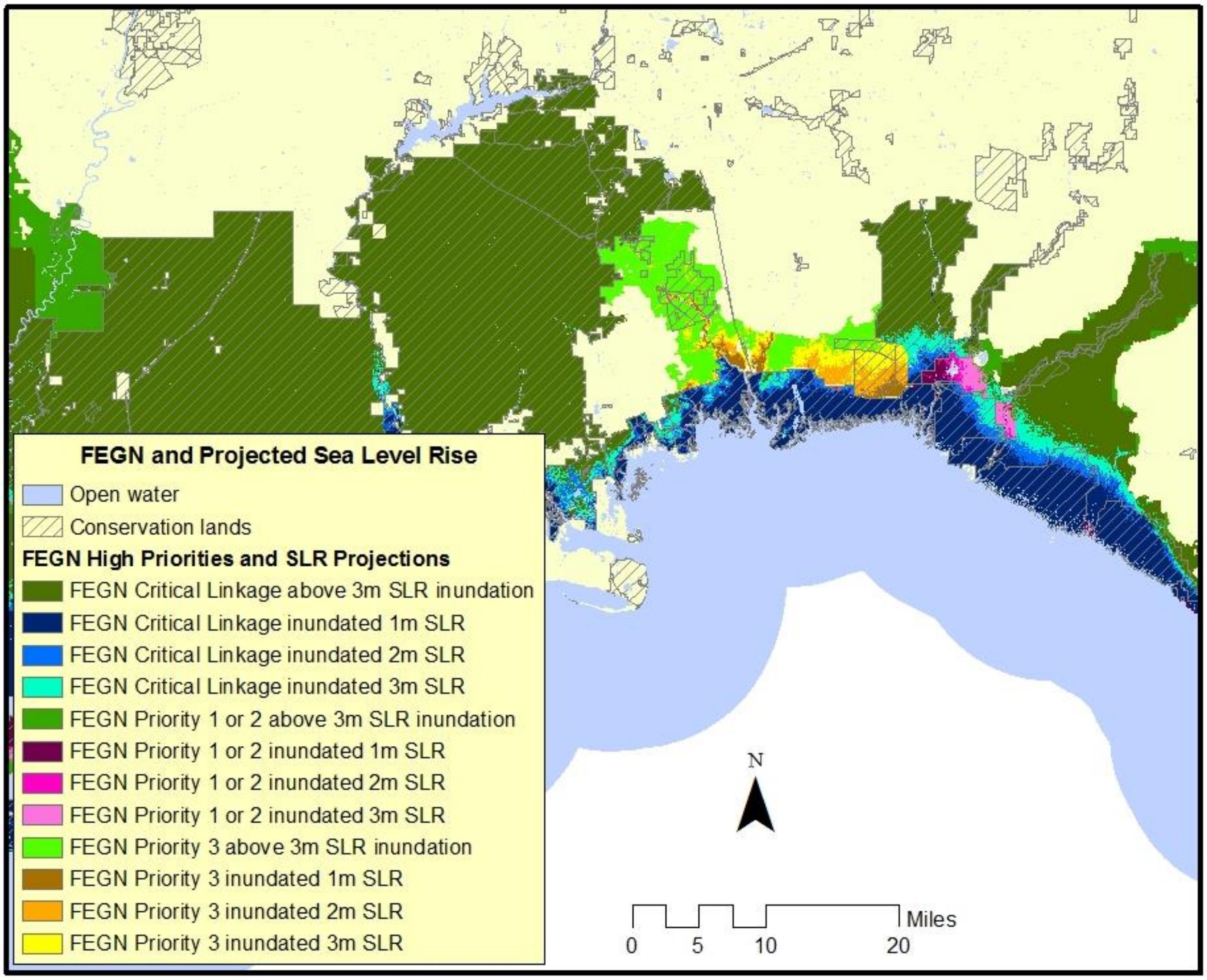

Figure 40. Candidate Area 1: Expand the St. Marks Critical Linkage to address sea level rise (SLR) south of Tallahassee. The St. Marks Critical Linkage between the Aucilla conservation areas and the Apalachicola National Forest (ANF) is all very close to the coast and within areas projected to be inundated 1-2 meter SLR. At least the first step to address this would be to add the current Priority 3 corridor following the Wakulla River northwest to the ANF to the Critical Linkage. The next step would include considering adding some of the adjacent lower priority areas to the Critical Linkage as well to provide additional buffering and connectivity sufficiently far from the coast.

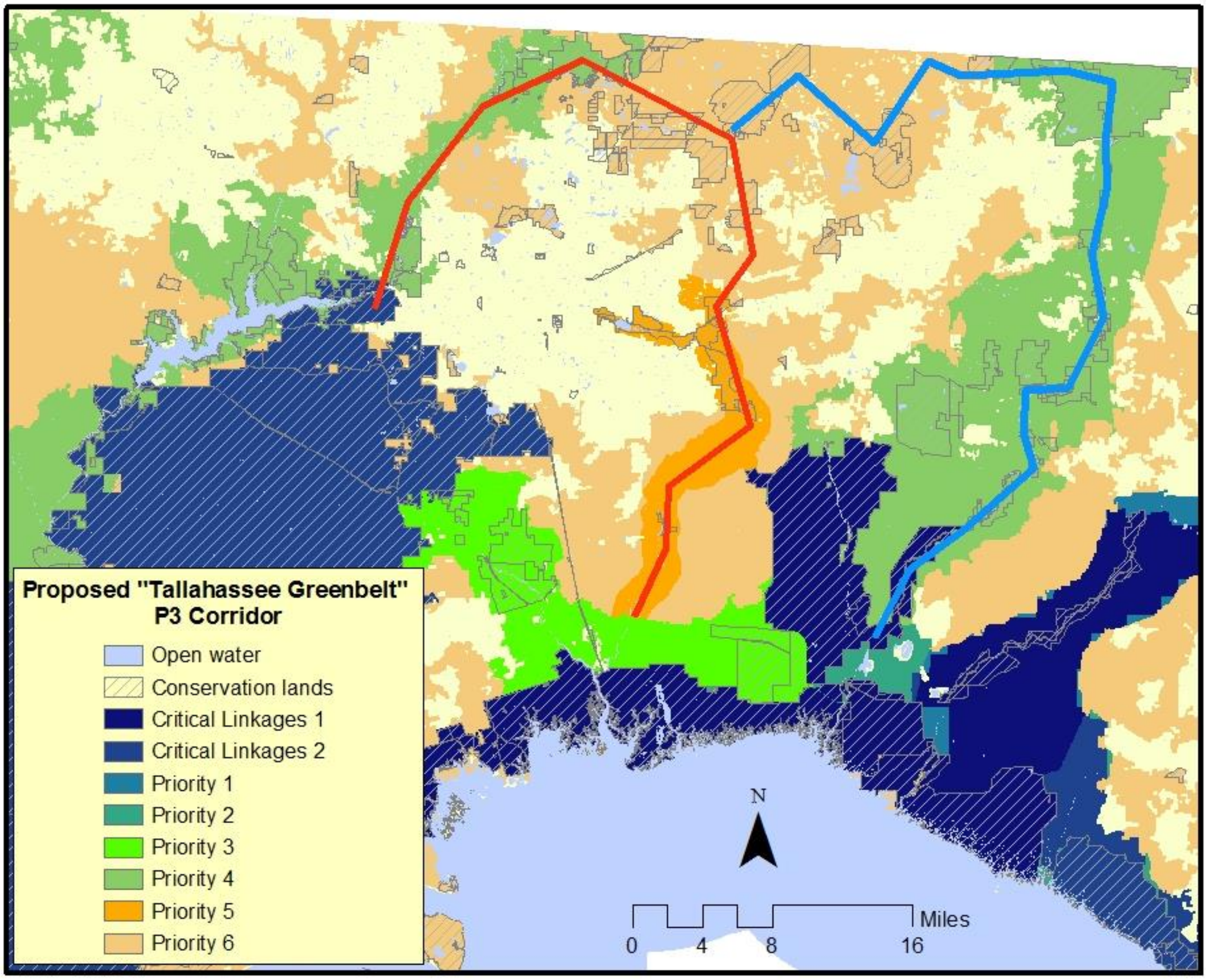

Figure 41. Candidate Area 2: Consider at least P3 status for the corridor that circles Tallahassee to the north (to serve as an alternate for St. Marks Critical Linkage). The St. Marks Critical Linkage between the Aucilla conservation areas and the Apalachicola National Forest (ANF) is all very close to the coast and within areas projected to be inundated 1-2 meter SLR. Although expansion of the current Critical Linkage through the Wakulla area will better address SLR impacts, a functional corridor east and north of Tallahassee (through the St. Marks River corridor and adjacent areas) and then southwest through the Ochlockonee River basin provides an even more secure option, while also providing potential connectivity to areas of conservation significance in southwest Georgia. Another option for this corridor is one that starts further east in the Aucilla River basin. St. Marks River option is in red; Aucilla River option is in blue.

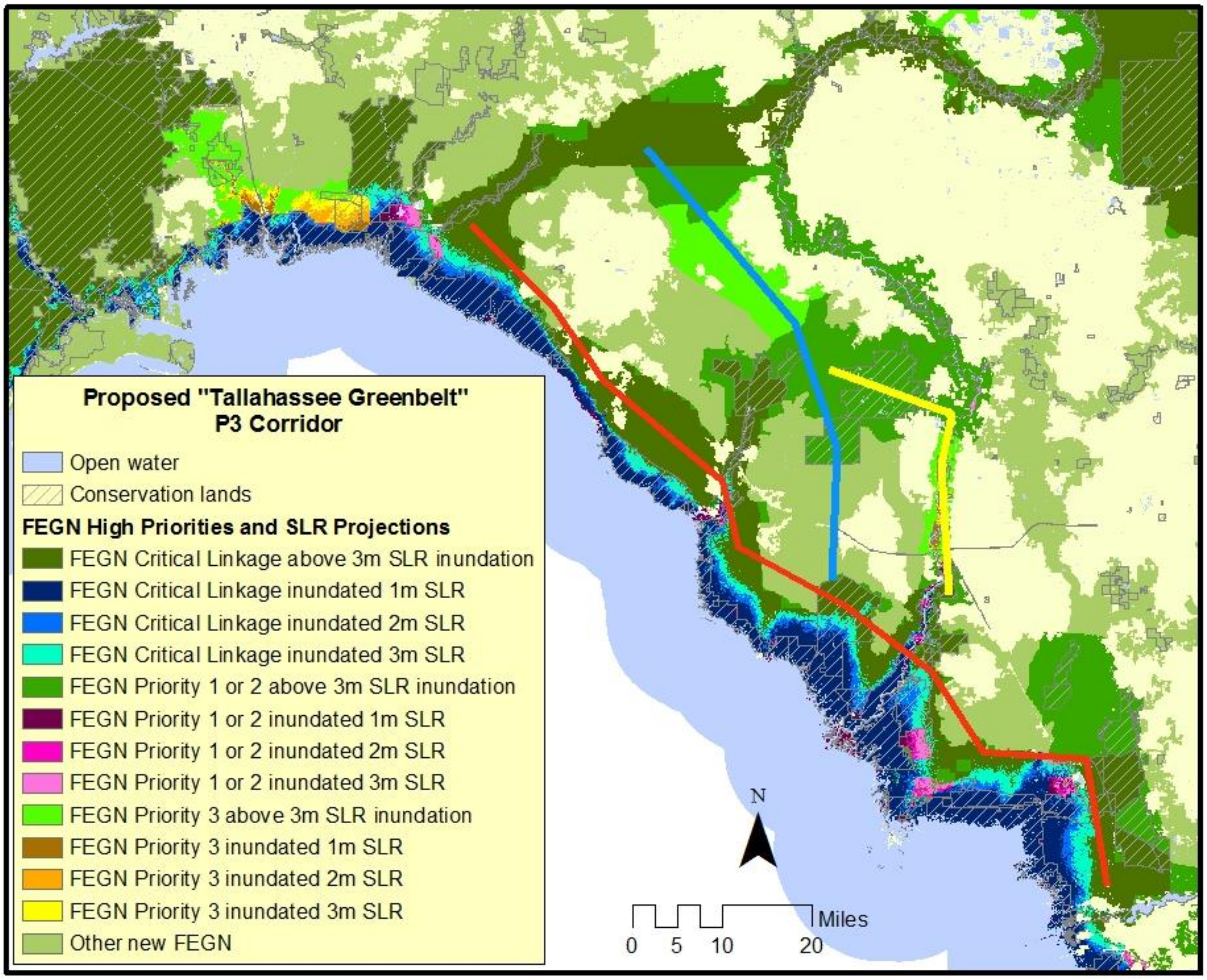

Figure 42. Candidate Area 3: Expand Coastal Big Bend Critical Linkage and consider elevating priority of inland Big Bend corridor to address SLR. The Big Bend Critical Linkage, although broader than in the St. Marks NWR to the west, is also potentially threatened by significant sea level rise. Options include expanding the Critical Linkage inland beyond a 3m SLR and/or elevating the priority of the more inland Big Bend corridor traversing Mallory Swamp and San Pedro Bay. An additional option would include elevating the priority of a lower portion of the Suwannee River corridor as well. Coastal expansion option is in red; Interior Critical Linkage option is in blue; Suwannee River corridor option is in yellow.

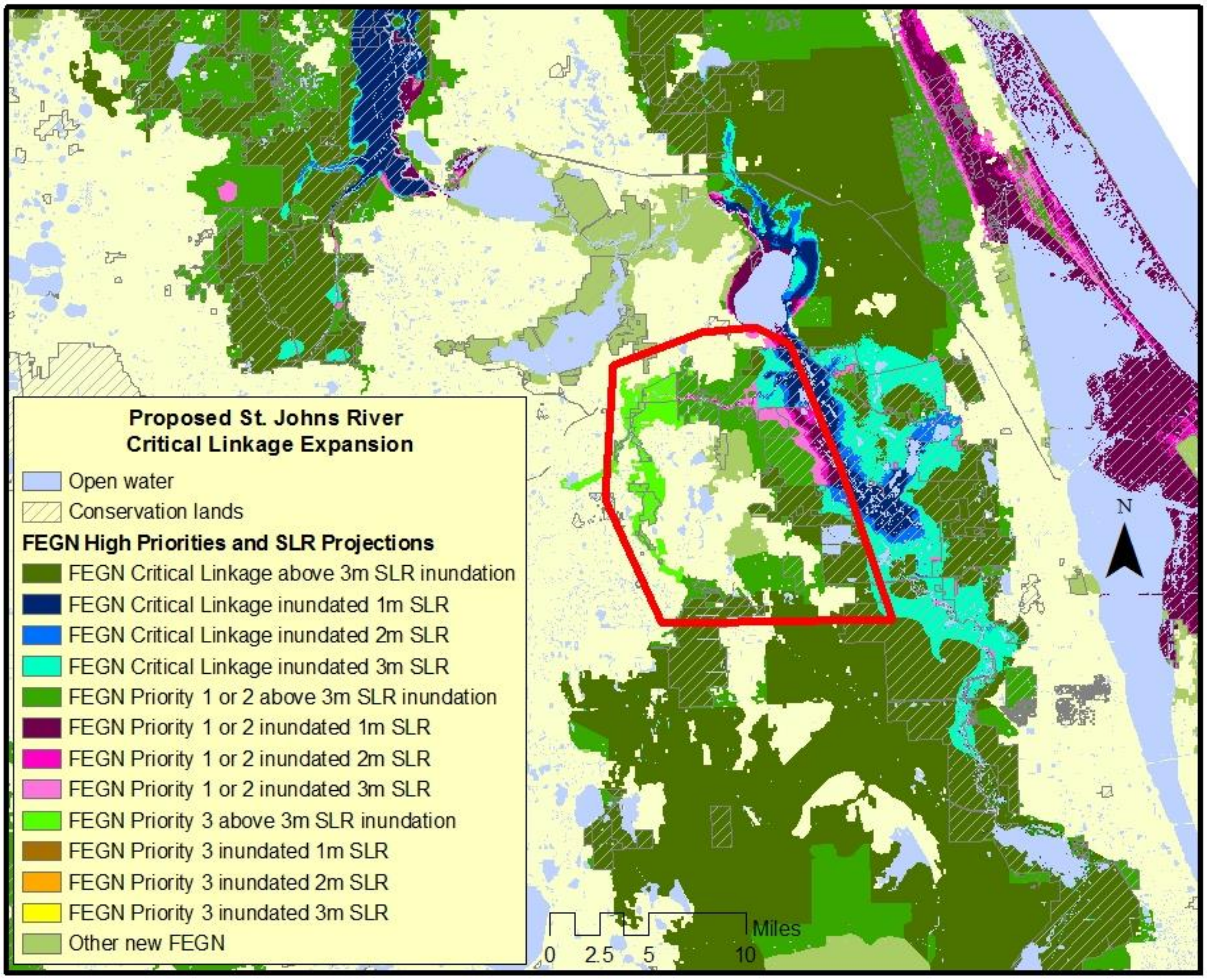

Figure 43. Candidate Area 4: Consider expanding Critical Linkage around strategic areas of the St. Johns River to address potential sea level rise (SLR) impacts. The only current Critical Linkage connected conservation lands in south Florida to those in the rest of the state runs through the middle St. Johns River basin east of Orlando. However, SLR projections suggest that portions of the St. Johns River could be much wider compared to current widths at average water levels. Essentially what is not a frequently broad herbaceous and forested floodplain could become a lake/lagoon system under moderate to high SLR projections. Though we feel the middle St. Johns River should stay as a Critical Linkage, the options for addressing the potential SLR issue are limited by development to the west and east of the river corridor, though there is some opportunity to widen the Critical Linkage to some extent. This could include elevating the lower Econlockhatchee River to Critical Linkage Status. Potential area of expansion of the middle St. Johns River portion of this Critical Linkage is in red.

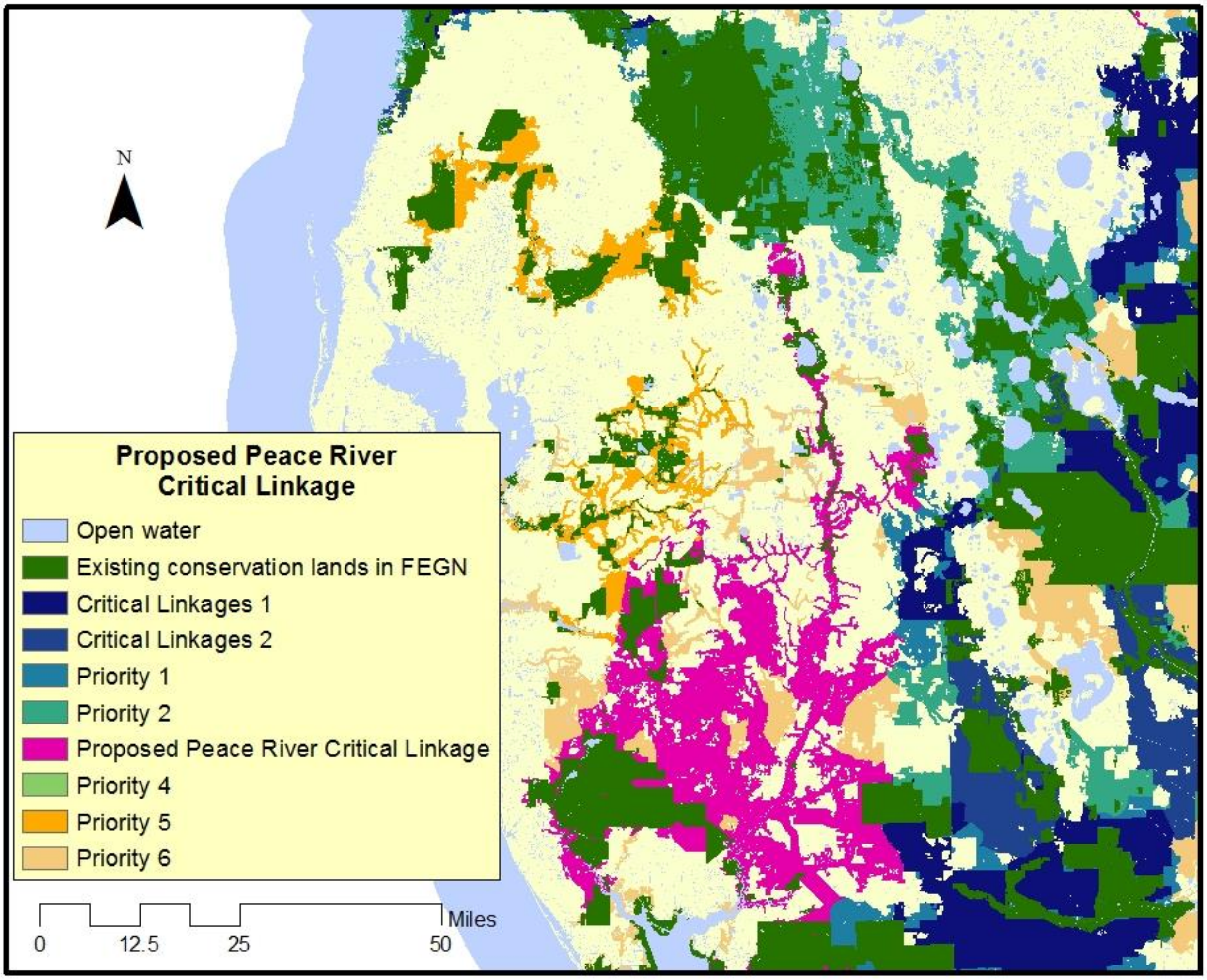

Figure 44. Candidate Area 5: Peace River from P3 to Critical Linkage to provide an additional option to connect south and north Florida. The Peace River provides one of three options for connecting conservation lands in south Florida to the rest of the state, and more specifically, conservation lands in southwest Florida to the Green Swamp and west-central Florida. It is currently a Priority 3 corridor, since it is a potential alternative to the more easterly Critical Linkage ranging from the Babcock-Fisheating Creek area northeast through the Kissimmee and upper St. Johns River basins to the Ocala National Forest. The major issue with the Peace River corridor is the limited current opportunity for a wide corridor and important bottlenecks especially in the Lakeland area. One future option is an expanded corridor that both relies on a more extensive regional ecological network (such as the phosphate mining region Integrated Habitat Network) and possibly restored pasture and mining lands to widen the primary river corridor. Potential Peace River Critical Linkage is in pink though some of the "fringe" areas would likely not be included.

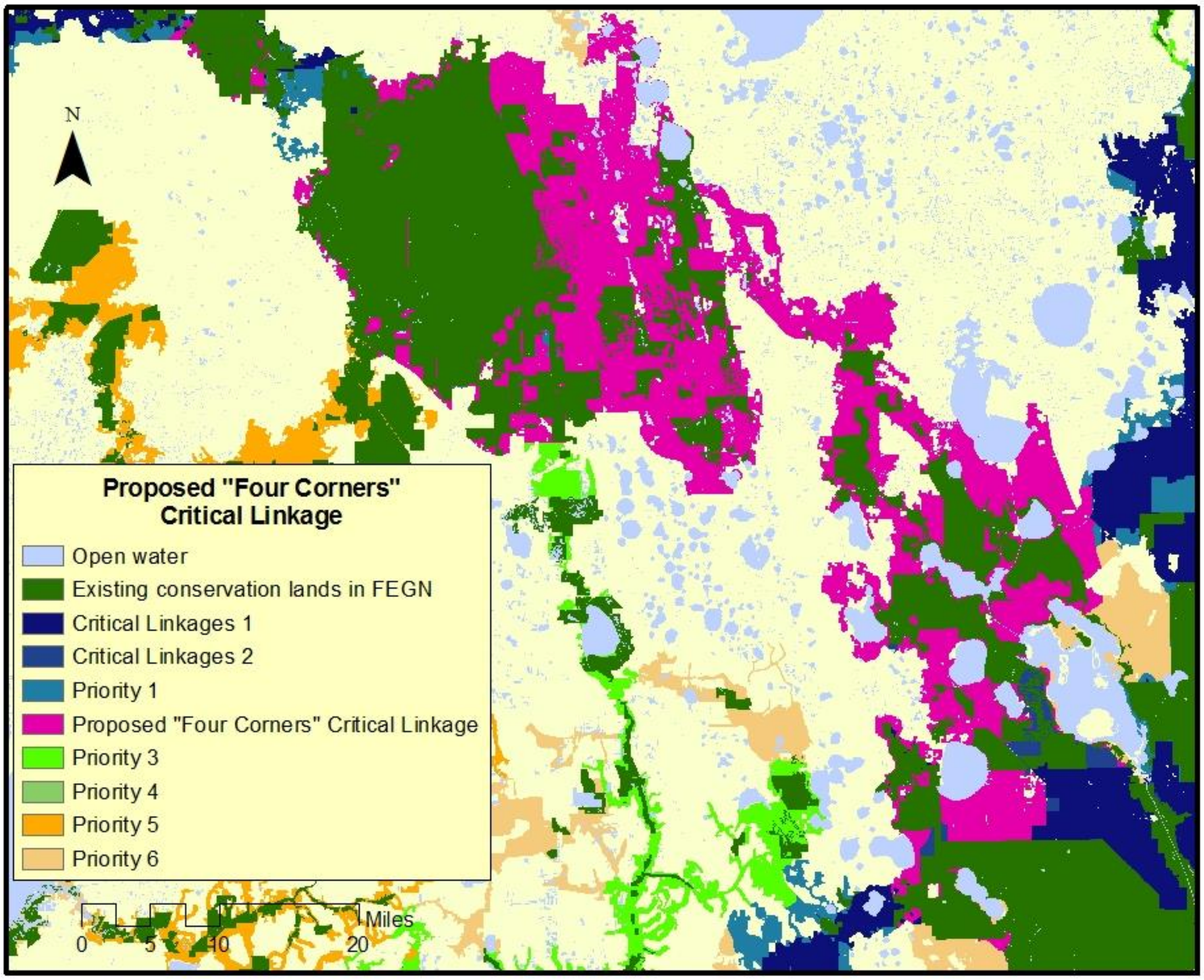

Figure 45. Candidate Area 6: Kissimmee to Green Swamp (Four Corners) corridor from P1 to Critical Linkage to provide an additional option to connect south and north Florida. The “Four Corners” Corridor is named after the critical potential bottleneck in this corridor near I-4 where Osceola, Polk, Orange, and Lake counties all meet. Like the Peace River, it provides one of three options for connecting conservation lands in south Florida to the rest of the state. Its primary advantage over the Peace River is its relationship with the current Critical Linkage to its south, larger current conservation land hubs, and potentially better crossing options for I-4. The primary issue for the Four Corners Corridor is the increasingly intense existing development and future land use plans especially for the western Orange County portion of this corridor. Potential Four Corners Critical Linkage is in pink though some of the “fringe” areas would likely not be included.

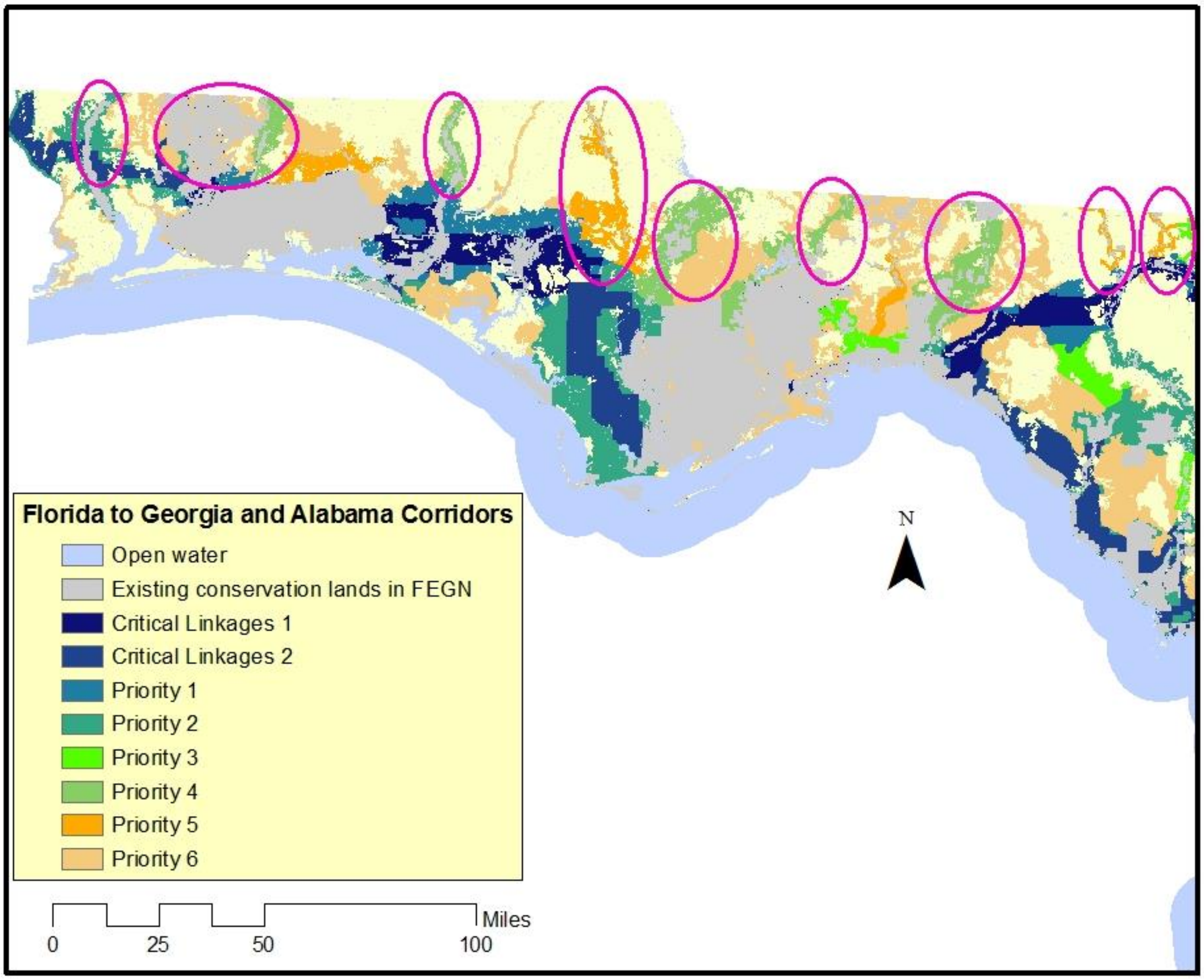

Figure 46. Candidate Area(s) 7: Consider assigning higher priority to south to north corridors within north Florida that connect to areas of conservation significance in Georgia and Alabama. FEGN Critical Linkages have up to this point emphasized protecting functional ecological connectivity across Florida. However, adaptation to climate change should include protection or restoration of options to facilitate northward migration/retreat. Though this is addressed by Critical Linkages in the Florida peninsula, it is not addressed directly by Critical Linkages in the Panhandle, which are primarily oriented east-west versus south-north.

One option for addressing this issue is to consider elevating various river corridors or other strategic areas in north Florida from current moderate priority status to Critical Linkages when they provide significant opportunities to connect to conservation lands or other conservation priorites in both southern Georgia and Alabama (and potentially beyond). Potential Florida to Alabama or Georgia corridor options is in pink; St. Mary’s River in northeast Florida is another option not depicted on this map.

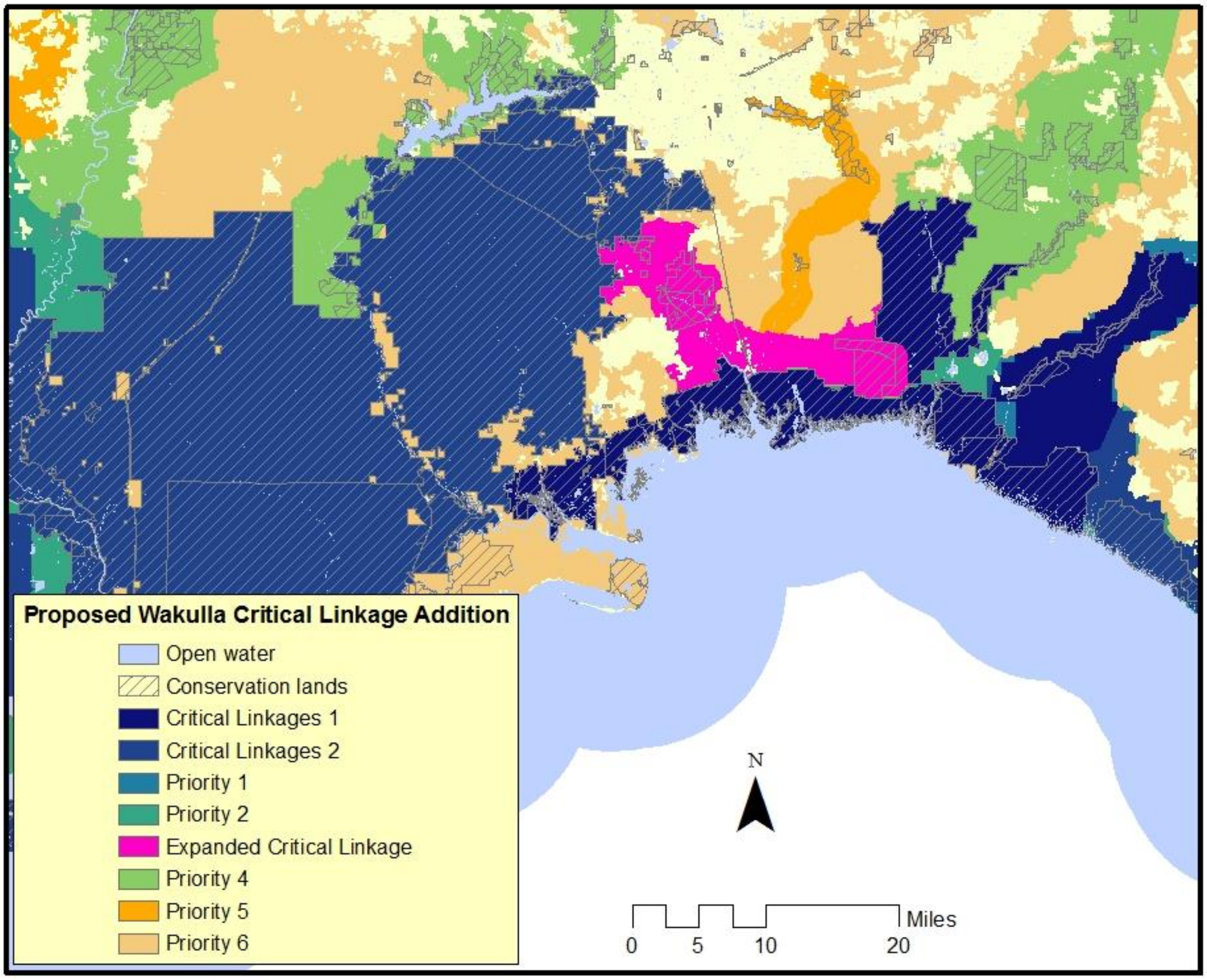

Figure 47. The Wakulla Priority 3 corridor that was changed to a Priority 1 Critical Linkage in the final new FEGN priorities.

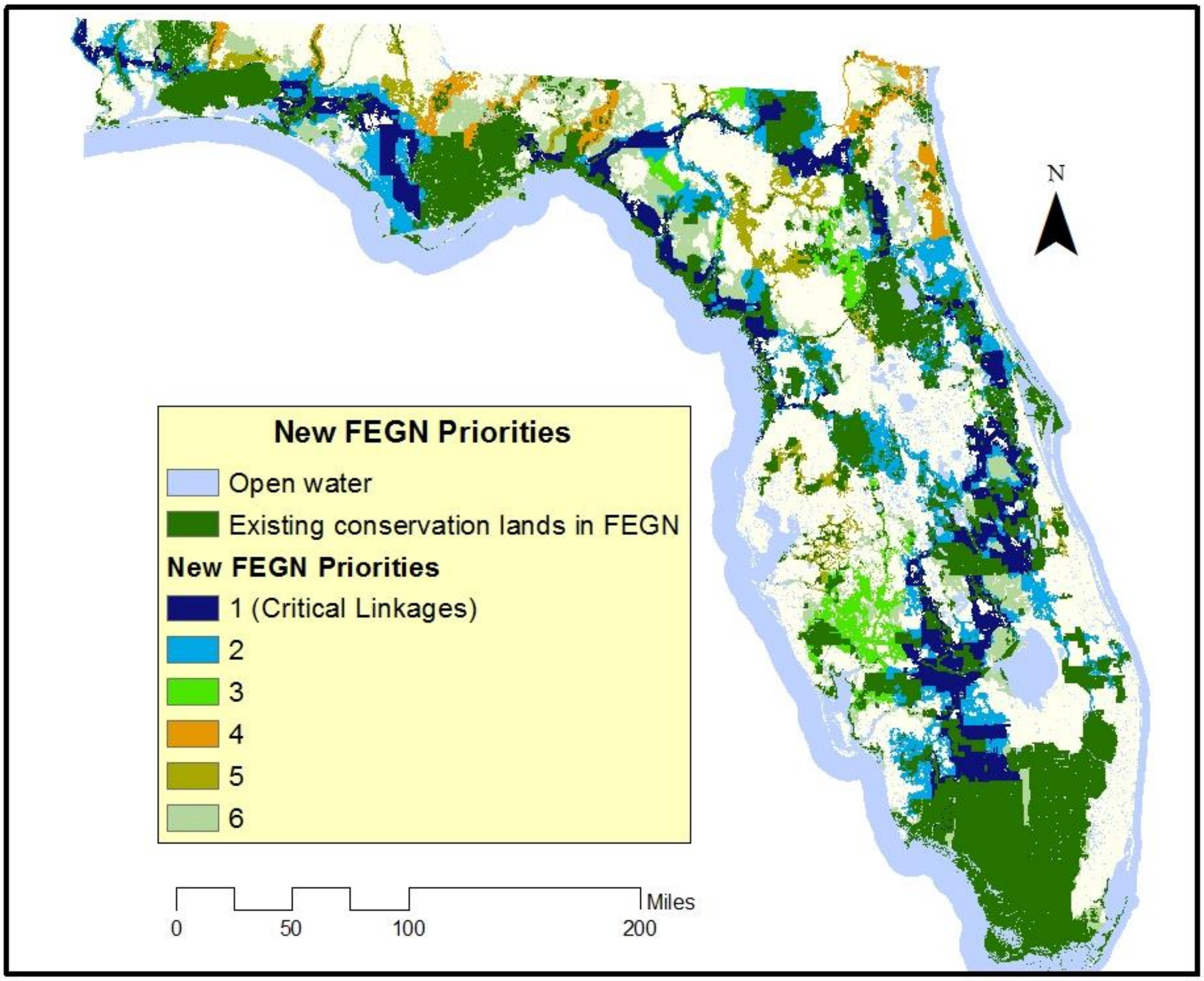

Figure 48. The new final FEGN prioritization based on the change to the Wakulla corridor and the consolidation to 6 priority levels.

Table 11. Land use category statistics for the new final FEGN priority levels.

Land Use Category	FEGN Priority Level	Acres	Percent
Open Water	Priority 1 (Critical Linkage)	1,078,086	4.7%
Existing Conservation Lands	Priority 1 (Critical Linkage)	7,278,356	31.7%
Florida Forever Projects	Priority 1 (Critical Linkage)	939,537	4.1%
Other Private Wetlands	Priority 1 (Critical Linkage)	669,474	2.9%
Other Private Land	Priority 1 (Critical Linkage)	1,465,675	6.4%
Open Water	Priority 2	266,906	1.2%
Existing Conservation Lands	Priority 2	1,102,105	4.8%
Florida Forever Projects	Priority 2	450,427	2.0%
Other Private Wetlands	Priority 2	769,167	3.3%
Other Private Land	Priority 2	1,799,252	7.8%
Open Water	Priority 3	41,990	0.2%
Existing Conservation Lands	Priority 3	291,363	1.3%
Florida Forever Projects	Priority 3	74,536	0.3%
Other Private Wetlands	Priority 3	250,989	1.1%
Other Private Land	Priority 3	558,105	2.4%
Open Water	Priority 4	83,472	0.4%
Existing Conservation Lands	Priority 4	229,606	1.0%
Florida Forever Projects	Priority 4	89,456	0.4%
Other Private Wetlands	Priority 4	259,395	1.1%
Other Private Land	Priority 4	385,829	1.7%
Open Water	Priority 5	22,657	0.1%
Existing Conservation Lands	Priority 5	260,732	1.1%
Florida Forever Projects	Priority 5	57,593	0.3%
Other Private Wetlands	Priority 5	177,378	0.8%
Other Private Land	Priority 5	565,365	2.5%
Open Water	Priority 6	574,878	2.5%
Existing Conservation Lands	Priority 6	544,584	2.4%
Florida Forever Projects	Priority 6	196,422	0.9%
Other Private Wetlands	Priority 6	825,921	3.6%
Other Private Land	Priority 6	1,653,250	7.2%

DISCUSSION

Purpose of the FEGN

The Florida Ecological Greenways Network (FEGN) is part of the legislatively adopted Florida Greenways Plan administered by the Office of Greenways and Trails (OGT) in the Florida Department of Environmental Protection (Florida Statutes, Chapter 260). The FEGN was serves as the ecological component of a Statewide Greenways System plan developed by the DEP Office of Greenways and Trails (OGT) and the University of Florida, under guidance from the Florida Greenways and Trails Council. The FEGN guides OGT ecological greenway conservation efforts, and promotes public awareness of the need for and benefits of a statewide ecological greenways network. The FEGN also is one of the core data layers in the Critical Lands and Waters Identification Project (CLIP) database used by various governmental and non-governmental entities to aid conservation and land use planning. Finally, the FEGN serves as a primary data layer to inform the Florida Forever and other state and regional land acquisition programs regarding the location of the most important conservation corridors and large, intact landscapes in the state.

The FEGN identifies areas of opportunity for protecting a statewide network of ecological hubs and linkages designed to maintain large landscape-scale ecological functions including focal species habitat and ecosystem services throughout the state. The FEGN aggregates various data identifying areas of ecological significance from the Florida Natural Areas Inventory, Florida Fish and Wildlife Conservation Commission, existing conservation lands, and other relevant data from the Florida Geographic Data Library (FGDL), the Florida Department of Environmental Protection and other sources. These data were combined to identify large, landscape-scale areas of ecological significance (ecological hubs), and a network of landscape linkages and corridors connecting the hubs into a statewide ecological greenways system (ecological greenways and wildlife corridors). An important goal of the FEGN is to protect a functionally connected network of public and private conservation lands from the tip of south Florida to the tip of the Florida panhandle while also providing functional connectivity to conservation lands in Georgia and Alabama, which includes a system of south to north corridors and coastal to inland landscapes to potentially facilitate adaptation to climate change and sea level rise.

FEGN Update Significance

The original boundaries of the FEGN were delineated in 1997 after two years of work with a large Technical Advisory Group (TAG). Since then, the FEGN has been prioritized, had a basic boundary update in 2004, and priorities were refined in 2008. However, new and updated GIS data layers on Florida wildlife and ecological conservation priorities continue to be developed with time, and land use continues to change from natural and semi-natural land cover or land uses that could potentially support protection of large, connected landscapes to more intensive land uses. GIS modeling techniques including connectivity modeling also have continued to progress since the original FEGN delineation in 1997.

This project is the first attempt to rebuild the FEGN using the original goals and principles, but with updated or new input GIS data and modeling techniques that have emerged since the original delineation. Therefore, this project provided an important opportunity to make sure that the FEGN was still addressing wildlife and ecosystem conservation goals within Florida's remaining intact, large-scale, and functionally connected natural and rural landscapes across the state.

Comparison between Previous and New FEGNs

The new FEGN, when comparing terrestrial habitats (i.e., all areas not considered open water) is approximately 200,000 acres (80,000 hectares) smaller than the previous iteration; major differences include some additional area included in southwest and south-central Florida and less area included in north Florida compared to the previous FEGN (See Figure 31 and Table 9). However, the primary areas of ecological connectivity, i.e., the largest intact rural landscapes remaining throughout the state were are shared by both the new and previous FEGNs, with a few small changes based primarily on peripheral modification of the boundaries due to new higher intensity land uses. This is not an unexpected result and an indicator that primary areas supporting large, functionally connected landscapes identified in the previous FEGN also address wildlife and ecosystem conservation priorities identified by the Florida Fish and Wildlife Conservation Commission, Florida Natural Areas Inventory, and others. Florida still has good opportunities to protect a functionally connected statewide ecological network if we have the funding for voluntary land conservation acquisition and incentive programs such as Florida Forever, the Rural and Family Lands Protection program, and others.

Coastal Aquatic Ecosystem Inclusion

It is important to note that the previous FEGN included much more coastal open water than the new FEGN, which was created with more emphasis on terrestrial landscapes and connectivity based on input from the TAG. So the comparison between the previous and new FEGN only compares terrestrial (both upland and wetland) acres, and the previous FEGN includes many more estuarine and marine open waters than the new FEGN. One of the items discussed in detail with the TAG in the beginning of this project was whether there should still be a significant coastal estuarine and marine component to the FEGN. In the previous FEGN, we included designated water bodies such as Aquatic Preserves, National Estuarine Research Reserves, and shellfish harvesting areas as Priority Ecological Area (PEA) criteria, whereas we decided (based on TAG consensus) not to use purely aquatic criteria in PEA criteria in the new FEGN. In addition, in the previous FEGN there was a coastal-to-coastal connectivity model that primarily identified virtually all near shore coastal waters and some terrestrial buffers throughout Florida's coastal areas.

For this update project, we explored development of a coastal blueway analysis to complement our other connectivity analyses. However, based on our review of the results and issues, input from the TAG, and input from additional staff in FWC's Fish and Wildlife Research Institute, we determined that the coastal aquatic wildlife and ecosystem properties, data, and issues were sufficiently different from the rest of our work to warrant additional attention beyond the scope of the this project. Despite this, the new FEGN analysis does include some specifically coastal criteria as well as others that have the potential to include coastal areas including: Coastal Barrier Resource Act lands, existing conservation lands, FNAI rare species habitat, FNAI rare natural communities, FNAI functional wetlands, FWC Strategic Habitat Conservation Areas, landscape species habitat, and the coastal to inland connectivity analysis. In addition, we think that continued discussion, and potential pursuit, of developing a coastal blueway analysis and database is a useful goal that might be addressed through continued collaboration between FWC, FNAI, UF, and other partners. Development of a coastal blueways conservation priorities data layer(s) could also be integrated with the FEGN in future update efforts.

Florida Forever Project FEGN Incorporation and Evaluation Process

We discussed many issues with the TAG throughout this project, and the FEGN modeling processes and results represent general agreement among all participating TAG members. However, there are a couple points that were discussed where we had disagreement, especially towards the end of the project. The first issue regarded the final optimization of the network when the Hubs and connectivity analysis results were combined and then spatially optimized by adding additional data, closing gaps, and deleting peripheral areas. The issue discussed with the TAG was the inclusion of Florida Forever projects in the final optimization process, where some TAG members felt that Florida Forever projects should not be included when they overlapped and added to the FEGN. The argument for exclusion was that Florida Forever projects, though they are evaluated for conservation significance in the Florida Forever Conservation Needs Assessment, do not necessarily address important conservation goals, or more specifically, the goals of the FEGN. In addition, since the FEGN is used to evaluate Florida Forever projects, there was a concern that this optimization step would bias Florida Forever evaluation towards projects that happened to be adjacent to the FEGN but not identified in the PEA or connectivity analyses.

First, it should be noted that Florida Forever projects were used as a PEA criterion in the previous FEGN, whereas in the new version we agreed not to include them as a PEA criterion, but were added later as part of the optimization process only when Florida Forever projects were adjacent to the new ecological network. In addition, our position and that of other TAG members, is that once the interim FEGN had been identified, that it makes sense spatially and programmatically to add all Florida Forever projects connected to the network. There are specific landscapes such as the Green Swamp, where the Florida Forever projects help complete the network and provide additional landscape area for providing habitat and functional connectivity. Finally, we agreed to continue to work with FNAI on how the FEGN is used in the Florida Forever Conservation Needs Assessment, to ensure that only the Florida Forever projects that are most important or strategic for completing the high priorities in the FEGN would rank highly for protecting landscapes and corridors in the Florida Forever evaluation process.

Prioritization Process

The prioritization of the new FEGN is complete for the purposes of use in the CLIP database and related processes including the Florida Forever Conservation Needs Assessment. The new prioritization included: 1) assigning the previous FEGN priorities to the new FEGN base boundary; 2) consolidating the previous 8 FEGN priority levels into 6 priority levels by combining the previous Critical Linkages 1 and Critical Linkages 2 into one Priority 1 Critical Linkage category and then lumping the previous Priority 1 and Priority 2 levels into a new Priority 2 category; 3) elevating the Wakulla River corridor from its previous Priority 3 level to a Priority 1 Critical Linkage as an initial attempt to address projected sea level rise impacts within the St. Marks National Wildlife Refuge Critical Linkage. However, it is the consensus of the TAG to continue to discuss other proposed revisions to the new FEGN priorities, which are discussed both in the Methods and Results sections above.

We agree that consideration of additional prioritization edits should continue, and we have the opportunity to do so as part of both the currently and future funded updates to the CLIP database (through 2014) and the ongoing statewide sea level rise biodiversity impact assessment being conducted by the University of Central Florida, FNAI, and UF. We anticipate a scheduled goal to complete this round of additional revisions to the priorities by June 2014. This discussion will also include consideration of further refinements to FEGN Critical Linkages or other priority levels specifically to address their use in the Florida Forever Conservation Needs Assessment and potentially other evaluation processes.

FEGN Database

Development of an FEGN GIS database was another point of discussion with our TAG. We agree that an FEGN database, beyond just the new FEGN base boundary and new FEGN prioritization, is potentially important and will augment existing available GIS data on Florida conservation priorities. Though we expect that the FEGN database will evolve over time (in similar fashion to CLIP), the PEA data layer, the optimized Hubs, each of the connectivity analysis results, and all of the major Florida black bear and Florida panther habitat and connectivity model results will be included in the FEGN database for this project. One of the reasons this is important is that, as noted above, some elements identified during the FEGN process including some PEAs, some Hubs, and some of the connectivity analysis results, do not get included in the new FEGN base boundary. However, these areas still have potential conservation significance and provide additional, more specific information about landscape-scale and connectivity conservation beyond what is represented in the compilation of the new

FEGN base boundary. We expect that this FEGN database will either be part of the CLIP database and/or housed as part of the Florida Geographic Data Library.

FEGN Database Usage Caveats

Finally, it is important to note that the FEGN and all of its component data layers are intended for planning purposed only. This issue is covered both within the relevant state greenways program legislation (Florida Statutes, Chapter 260) and in the caveats attached to CLIP data (see the Critical Lands and Waters 2.0 Technical Report).

RECOMMENDATIONS

Our recommendations include:

- The FEGN should continue to be maintained, including updates to the base boundary and priorities by incorporating new or revised data such as land use data changes as they become available.
- The primary data layer for this project is the new prioritized FEGN. However, the FEGN database includes other component data layers that address related conservation priorities and more specific ecological or wildlife connectivity priorities including the PEAs, Hubs, Florida black bear and Florida panther habitat analyses, and all of the connectivity analyses that should be considered in relevant conservation and land use planning applications.
- Consider further refinement of FEGN Critical Linkages both to add areas that address potential future impacts such as sea level rise and to ensure that the most strategic

areas for completing functional corridors between existing conservation areas are identified.

- Consider additional revisions to the FEGN priorities to address potential future impacts including sea level rise and land use change. This should include consideration of the upcoming results of the statewide sea level rise biodiversity impact assessment being conducted by the University of Central Florida, FNAI, and UF.
- Consider developing a GIS data layer that indicates why specific areas were included within the new FEGN, i.e. was an area a PEA/Hub, added during Hub optimization, in a connectivity analysis result, or added during the final optimization.
- Consider separating the higher priority corridors (and especially Critical Linkages) into discrete units, with a description of each regarding its specific resources and goals.
- Determine whether additional landscape and connectivity analyses could be added to the FEGN Update as new data, analyses, and funding opportunities arise.
- Consider developing a coastal blueway analysis and database through continued collaboration between FWC, FNAI, UF, and other partners.
- Work with FNAI to continue to refine how the FEGN priorities are used in the Florida Forever Conservation Needs Assessment.

CONCLUSIONS

The FEGN identifies areas of opportunity for protecting a statewide network of ecological hubs and linkages designed to maintain large landscape-scale ecological functions including focal species habitat and ecosystem services throughout the state. GIS modeling techniques including connectivity modeling also has continued to progress since the original FEGN delineation in 1997. This project is the first attempt to rebuild the FEGN using the same goals and principles with updated or new input GIS data and modeling techniques since the original delineation. Therefore, this project provided an important opportunity to make sure that the FEGN was still addressing wildlife and ecosystem conservation goals within Florida's remaining intact, large-scale, and functionally connected natural and rural landscapes across the state. The new FEGN ensures that the FEGN and its priorities are up-to-date and is based on the best available data identifying areas of conservation significance within a functional landscape context. In addition, the expansion of the FEGN database to include specific PEA, Hub, connectivity analysis, and other relevant landscape-scale conservation priority data will enhance the ability of scientists and planners to identify, assess, and incorporate Florida's intact landscape and ecological connectivity priorities in a variety of research and planning applications. Finally, we will continue to work with technical advisors from this and related projects (CLIP and the statewide SLR biodiversity impact assessment) to consider additional revisions to the FEGN priorities to address both potential future impacts such as sea level rise and to ensure that the most strategic areas for completing functional corridors between existing conservation areas are identified.

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APPENDIX A: DISCUSSION OF THE PEA AND HUB CRITERIA REVISION ITERATIONS

We used the methods for identifying Priority Ecological Areas (PEAs) and Hubs from the original Florida Ecological Greenways Network (FEGN) delineation (completed in 1997) and the FEGN base boundary update in 2004 as the starting point for developing the new criteria. Some of the original data are out-of-date and were not expected to be useful for delineating the new FEGN (Hoctor et al. 2000). Other data have been updated since the original FEGN delineation so that they are still suitable, or likely suitable, for use in the FEGN Update. For example, Florida Fish and Wildlife Conservation Commission Strategic Habitat Conservation Areas recently went through an extensive update and modification. Other GIS layers that were not available for the original FEGN delineation were incorporated in the 2004 base boundary update (Hoctor 2004). Such data layers include some of the data from the Florida Natural Areas Inventory Florida Forever Needs Assessment. These data layers are updated approximately annually and therefore are likely still suitable for inclusion in the FEGN Update. **Table 1** outlines the draft PEA criteria for the FEGN Update that are based on the original FEGN delineation and the 2004 boundary revision with relevant updates. **Table 1** also shows the draft "exclusion" rules used with each PEA input data layer, which are criteria to delete areas from inclusion in the PEA model based on overlap with more intensive land uses (using the new FNAI and FWC Cooperative Land Cover data) that are not compatible with the various PEA input layers.

In this draft process, PEA criteria are separated into two sets of exclusion rules as shown in **Table 1**. The "Remove only developed lands" rule, which involves only excluded intensive development such including residential, commercial, or industrial land uses, is used for those

PEA criteria where either 1) the original selection process for the PEA criterion removes areas that are not compatible with the type of resource being identified or 2) the PEA criterion could include agricultural or other less intensively developed lands that are compatible with the resource being identified. The "Do not include any intensive agriculture or developed lands" rule is used for PEA criteria where intensive development or more intensive agriculture (such as cropland, citrus, and nurseries) is incompatible with the identified resource.

PEAs are areas of statewide ecological significance that are based on established GIS data for identifying areas important for conserving biodiversity and ecosystem services. PEAs are the base building block of the FEGN that are used to help identify large, intact, and potentially functionally connected natural and semi-natural landscapes with higher ecological significance across the state. Identification of Hubs is the next step of the FEGN delineation process. Hubs are connected areas of PEAs that are 5,000 acres or larger. This size criterion was developed after much discussion during the work of the original FEGN TAG. Hubs also are spatially assessed to ensure inclusion of suitably wide internal connections (when delineating areas that meet the 5,000 acre or larger threshold) and spatially optimized by closing internal gaps containing natural or semi-natural land uses and potentially smoothing/buffering external edges where suitable land uses also occur. This draft version of Hubs included all PEA areas that are 5,000 acres or larger where minimally suitable connections have to be at least 120 meters wide, and no spatial optimization of Hubs was completed.

The results of this draft iteration of PEA and Hub identification are shown in **Figure 1** and **Figure 2**. **Figures 3-5** show various relevant comparisons including: between Hubs and PEAs (**Figure 3**), the new draft Hubs compared to the current FEGN (**Figure 4**), and the overlap of PEA criteria within the draft Hubs (**Figure 5**). This initial draft indicates that there are still widespread opportunities to functionally connect and protect high priority conservation areas across the state. It also indicates that protection of a functional ecological network from the Everglades in south Florida north and west to the tip of the Florida panhandle is still feasible. The draft Hubs are also similar to the existing FEGN, though there are some new areas identified and old areas not included (**Figure 4**). Although similar, the new draft Hubs include approximately 1.9 million more acres of private land than the entire existing FEGN. The land category statistics comparing the current FEGN with the draft Hubs are included in **Table 2**. Finally, to aid the TAG discussion regarding the amount of contribution each draft PEA criterion made to delineating the draft Hubs, **Table 3** shows the number of acres included in the draft Hubs based on single PEA criteria. For example over 840,000 acres are included within the Hubs based solely on the black bear habitat model criterion used in the draft model.

Table 1. Draft Updated Criteria for selecting Priority Ecological Areas for the Florida Ecological Network

Data layer	Priority area criterion	Exclusion criteria
Existing public and private conservation lands	All such lands	Remove only developed lands
FWC Strategic Habitat Conservation Areas (SHCA)	All SHCAs P1-P3	Remove only developed lands
FWC Species Richness	Areas containing potential habitat for 7 or more focal species	Remove only developed lands
FNAI Rare Species Habitat	Priority 1 and 2	Remove only developed lands
FNAI Rare Natural Communities	All identified communities	Remove only developed lands
FNAI Natural Floodplains	All natural riparian floodplains	Remove only developed lands
FNAI Functional Wetlands	Priority 1 and 2	Remove only developed lands
Proposed conservation lands	All such lands	Remove only developed lands
USFWS Florida panther conservation zones	All areas except intensive development within the Primary and Dispersal Zones for the Florida panther. Areas identified as panther habitat within the Secondary Zone.	Remove only developed lands
Florida black bear habitat model	All areas having a habitat quality index of 6 or higher	Remove only developed lands
FNAI Potential Natural Areas (PNAs)	All PNAs except those receiving the lowest rank	Do not include any intensive agriculture or developed lands
Roadless areas (all roads)	Areas 5,000 acres or larger containing no roads of any kind	Do not include any intensive agriculture or developed lands
Roadless areas without major Roads (FDOT maintained roads)	Areas 100,000 acres or larger containing no major roadways such as interstate, federal, or state highways, and large capacity county roads	Do not include any intensive agriculture or developed lands
FNAI surface water priorities model	Priority 1 and 2	Do not include any intensive agriculture or developed lands
Lands identified as part of the Coastal Barrier Resources Act	All such lands	Do not include any intensive agriculture or developed lands
State Aquatic Preserves, National Estuarine Research Reserves, Outstanding Florida Waters, Shellfish Harvesting Waters, Wild and Scenic Rivers (and 1000 foot buffer)	All such designated aquatic ecosystems	Do not include any intensive agriculture or developed lands
Bumpup criteria	All areas within 100 year floodplains, high velocity zones, or high aquifer recharge (priorities 1-3) that also contain lowest ranked FNAI PNAs, smaller roadless areas (2500 acres or greater and 50,000 acres or greater respectively), SHCA P3-P5, FWC species richness (5-6 species), or FNAI moderate species habitat priorities (priority level 3-4), Panther Secondary Zone, Value 5 in the Florida black bear habitat model, Priority 3 of the FNAI surface water priorities, or Priority 3 or 4 FNAI functional wetlands	Do not include any intensive agriculture or developed lands

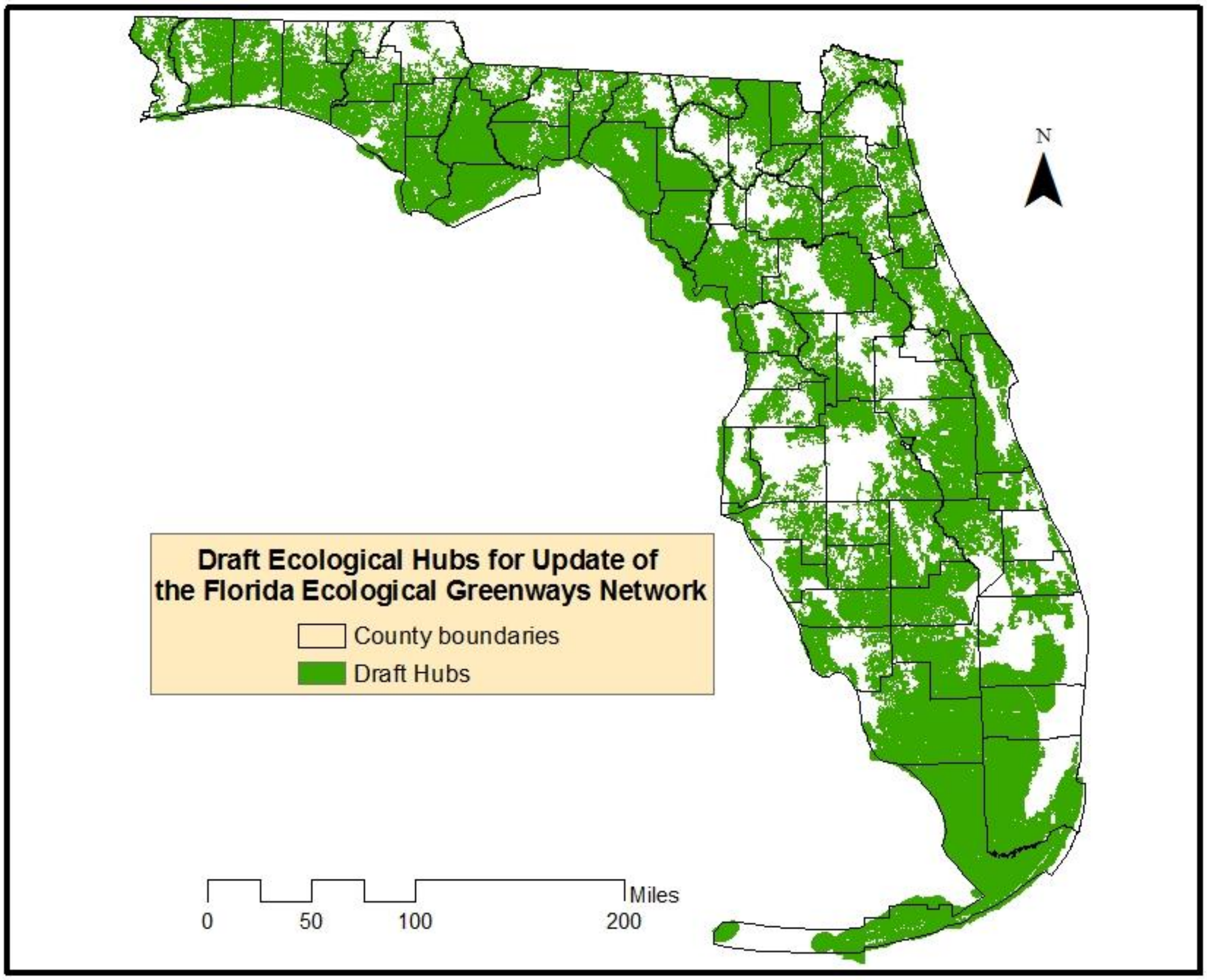

Figure 1. Draft Hubs for the Florida Ecological Greenways Network Update. Hubs are based on the Priority Ecological Areas (PEAs) where all PEAs that are connected into landscape blocks that are 5,000 acres or larger are delineated as Hubs.

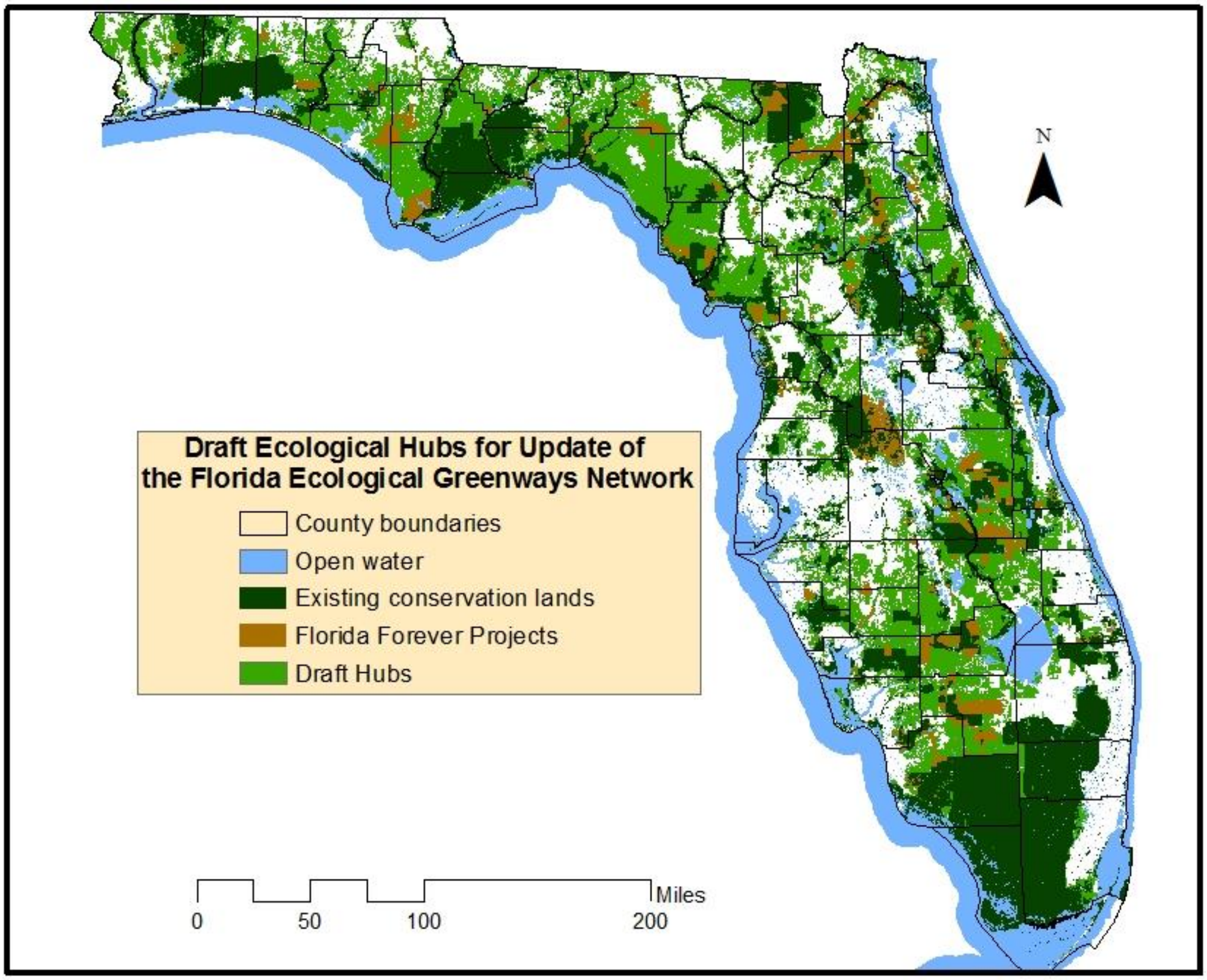

Figure 2. Draft Hubs for the Florida Ecological Greenways Network Update with Existing public and private conservation lands included.

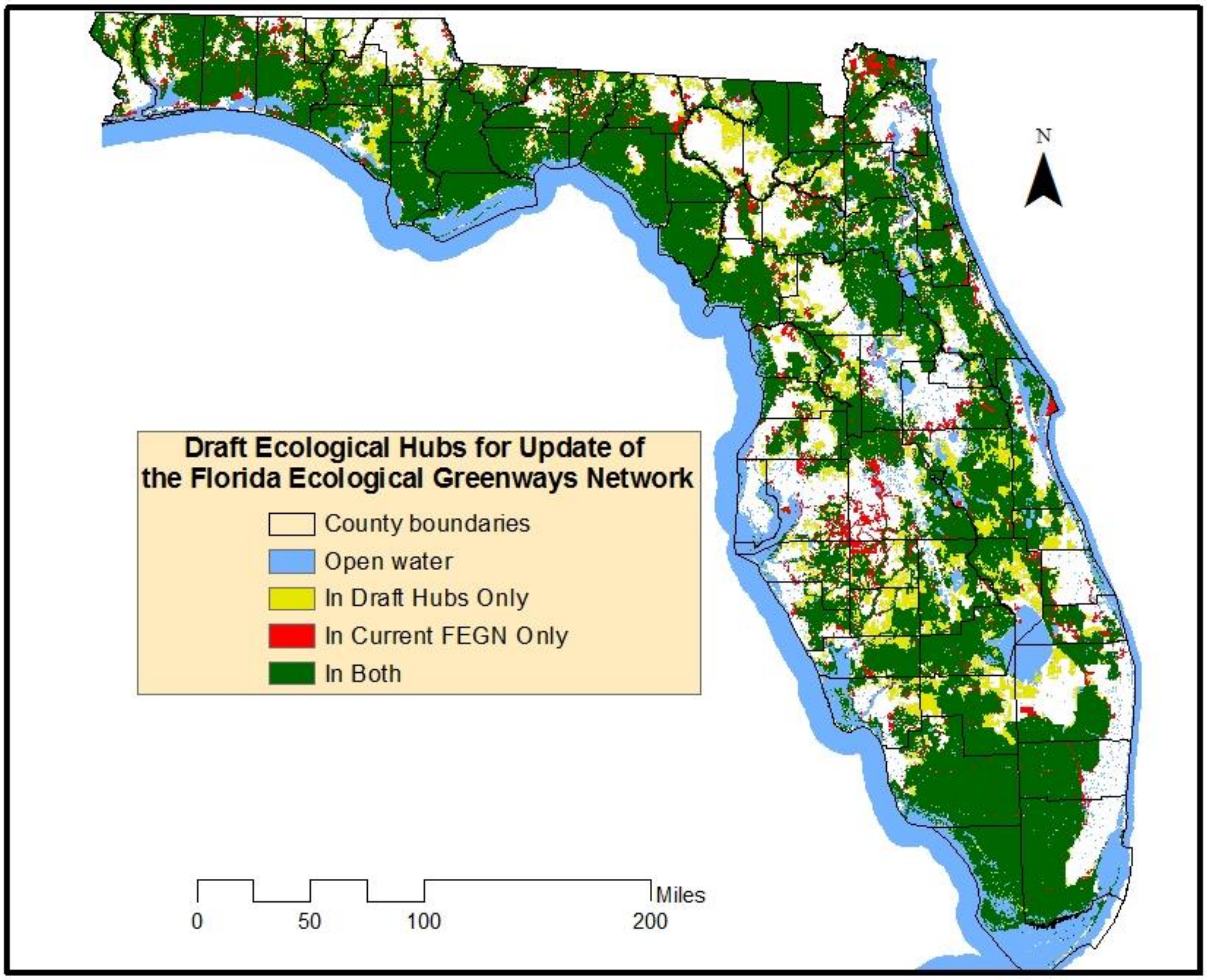

Figure 3. This map compares the current Florida Ecological Greenways Network (FEGN) to the new draft Hubs on land (all water is blue on this map). Green represents areas that are in both the current FEGN and the draft Hubs; red represents areas that are in the current FEGN but not in the draft Hubs; and yellow represents areas that are in the draft Hubs but not in the current FEGN. The most obvious differences are significant consolidation of conservation priority landscapes in south-central and southwest Florida with additional consolidation in north Florida and the panhandle.

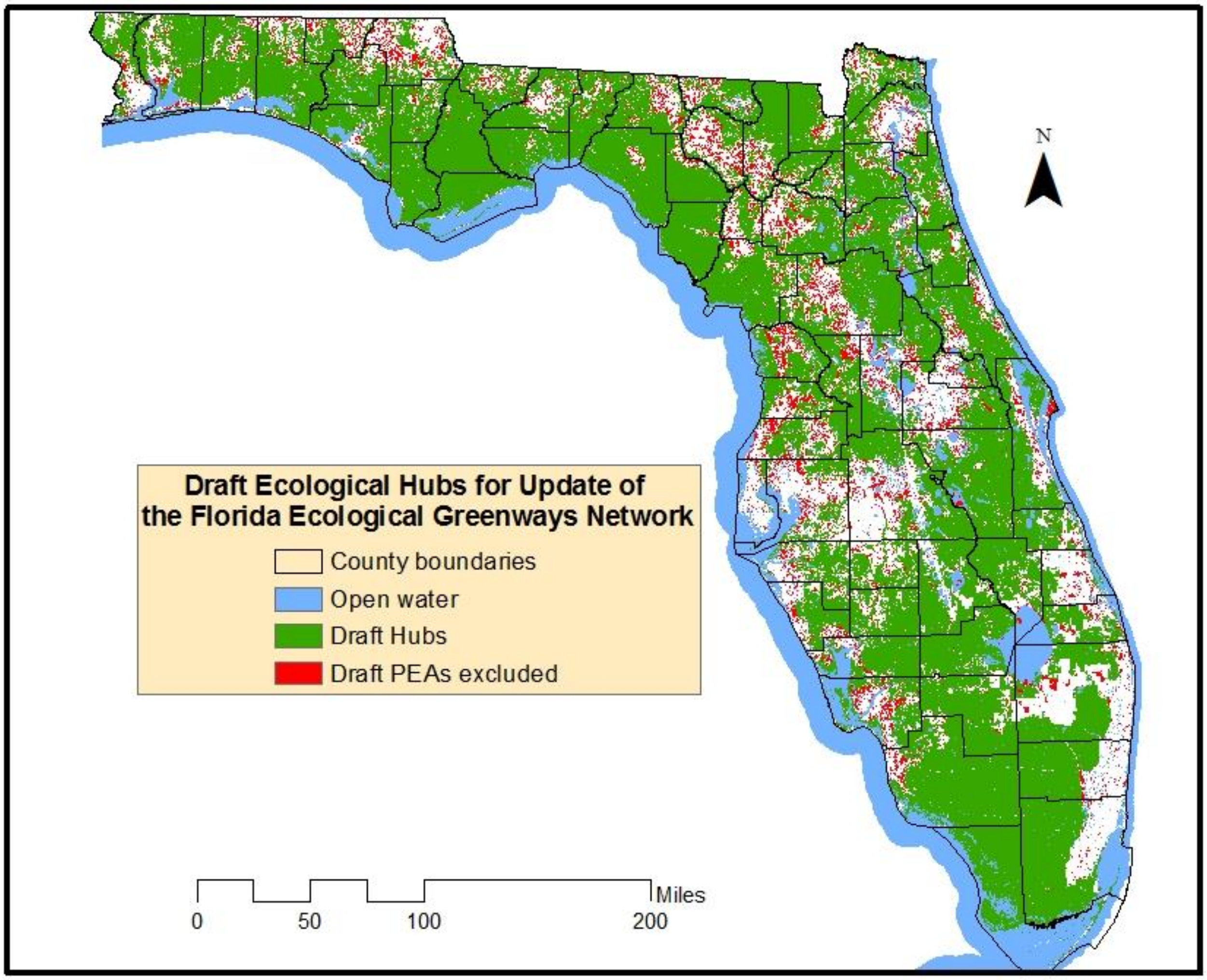

Figure 4. This map shows the PEA exclusion rules including removing intensive development and/or intensive agriculture (see Table 1), removal of narrow connections less than 120 meters wide, and the selection of Hubs that have to be at least 5,000 acres in size.

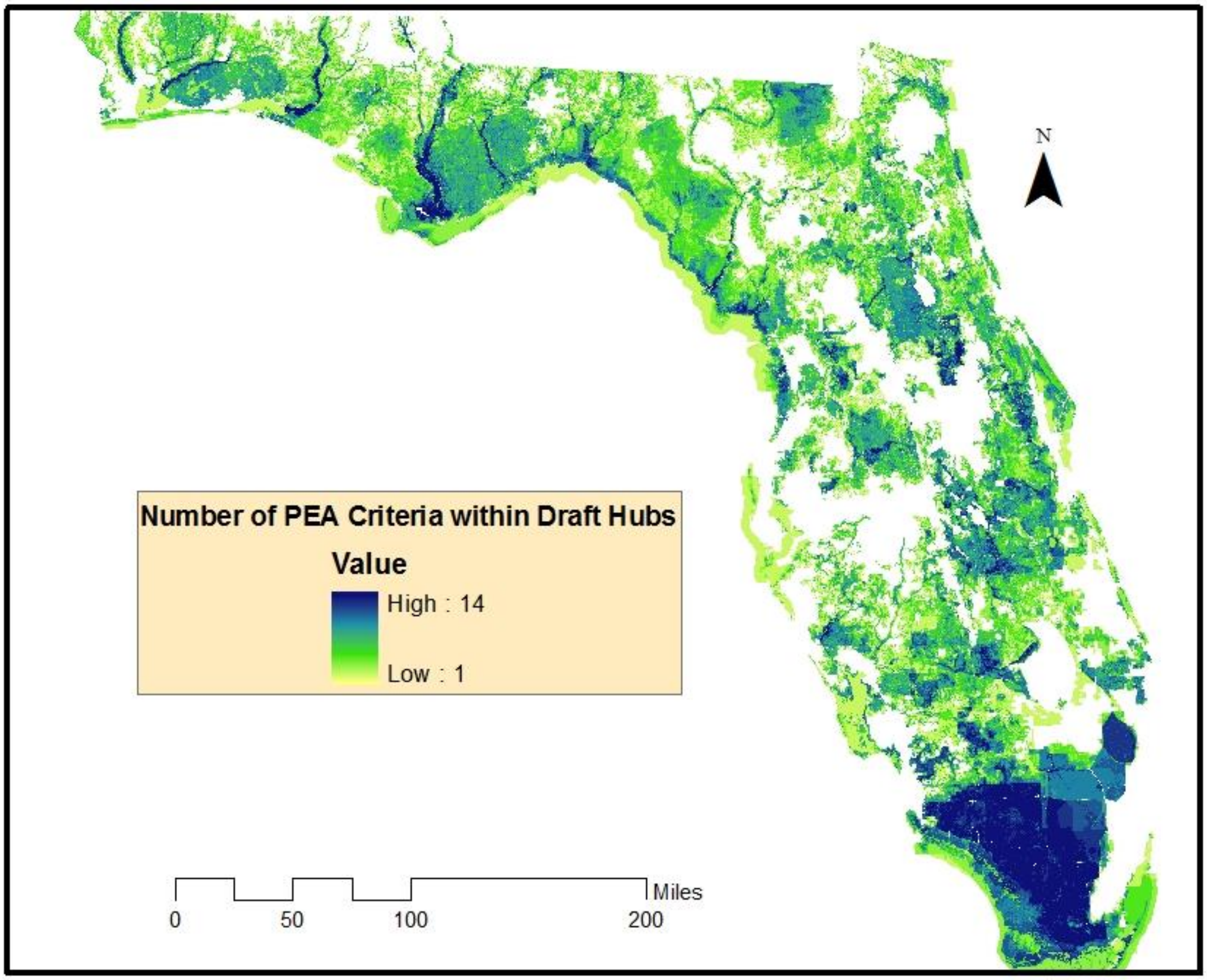

Figure 5. This map shows the overlap of PEA criteria within the draft Hubs. Areas that are dark blue have overlap of almost all PEA criteria. The light green-yellow are areas that are within Hubs only due to one PEA criterion.

Table 2. This table includes three subtables. The first two show the breakdown of the draft Hubs and the current FEGN into land/water categories including open water, existing conservation, private wetlands, and private uplands. The third subtable compares total land acres (including conservation lands, private wetlands, and private uplands) that are within either the draft Hubs, current FEGN, or both.

Draft Hubs in Protection Status Categories	
Status Category	**Acres**
Submerged/Open Water	4,290,218
Existing conservation lands	9,805,406
Private wetlands	4,442,556
Private uplands	9,630,073
Existing FEGN in Protection Status Categories	
Submerged/Open Water	3,891,199
Existing conservation lands	9,931,735
Private wetlands	4,116,022
Private uplands	7,920,204
Comparison in Total Land Acres	
Land Acres in Draft Hubs Only	3,597,620
Land Acres in FEGN Only	1,687,228
Land Acres in Both	20,280,416

Table 3. This table shows the number of acres included in the draft Hubs based on single PEA criteria. This is one method for determining whether any PEA criteria might be dropped or modified in use in the final PEA and Hub model.

Acres in Draft Hubs based on only one PEA Criterion	
PEA Criterion	**Acres**
Designated Water Bodies	1,803,543
Ranked Bear Habitat	843,089
PEA Bumpup	754,333
FNAI Surface Water Model	535,026
Proposed Conservation Land	261,936
FNAI PNAs	154,784
Roadless Area	152,669
Major Roadless Area	111,804
COBRA	84,271
FWC Species Richness	83,145
FNAI Species Habitat	82,614
Existing Conservation Land	74,657
FWC SHCA	55,328
FNAI Rare NCs	42,548
Panther Conservation Areas	19,036
FNAI Natural Riparian Floodplain	12,661
FNAI Wetlands	9,957
Total Hub Acres from single PEA Criteria	3,277,859

A TAG meeting was held on April 6, 2011 in Tallahassee to discuss the draft PEA and Hub model data and criteria. There were seven TAG members present at the April 6 meeting. However, all TAG members received materials describing the project, draft PEA and Hub modeling rules, and maps and tables showing the results. In addition all TAG members received a version of this report that again highlights the draft rules and results while also discussing the consensus decisions to guide revisions to the PEA and Hub modeling and upcoming connectivity analysis. In addition, we met with the TAG members who are experts in Florida panther or Florida black bear ecology to further address habitat and connectivity analysis for those two focal species. Overall, all TAG members were kept apprised of progress through a combination of individual and face-to-face meetings as needed with the option of computer and phone conferencing for upcoming TAG meetings as well.

The TAG members agreed with the overall goals of the FEGN and the importance of updating the FEGN to incorporate new and updated data layers and more explicit consideration of climate change impacts. Most of the TAG meeting was devoted to reviewing data and criteria used in the delineation of the current FEGN and the data and criteria used to identify the draft PEAs and Hubs. We also discussed the Hub optimization rules and analyses that could be included in the connectivity analyses. Consensus recommendations from the TAG included:

1) Do not use proposed conservation lands as a PEA criterion.
2) Consider dropping the Bump up PEA criterion.
3) Consider modifying the Bear Habitat model criterion.

4) Consider adding additional existing conservation lands such as deeded easements in Collier County or other places where such data is readily available. FNAI staff recommended checking with their conservation lands person for any data from south Florida that might not be included (at least not yet) in the FNAI managed areas database.

5) Use the Integrated Habitat Network as was done in the current FEGN since it represents a riparian network that emphasizes protecting and restoring ecological connectivity.

6) The most important recommendation from the TAG involves recasting PEA criteria to emphasize or only use PEA criteria that are specifically or generally related to large landscape and ecological connectivity conservation. This would include identification of large, intact landscapes that address criteria such as:

--large natural and seminatural landscapes that are least impacted by human activity

--habitat for species that require large, intact areas to support viable populations, are area-sensitive, or fragmentation-sensitive

--identification of appropriate types of ecological connectivity or corridors including riparian networks (including in watersheds important for rare fish species) and coastal systems connectivity

6) Consider using additional "non-landscape" conservation priority criteria after either landscape-based Hub or both Hub and connectivity modeling is completed to determine whether these areas fit into optimizing or enhancing identified Hubs/cores and corridors.

7) Consider developing various data products similar to the Critical Lands and Waters Identification Project, which would include the new aggregated FEGN, but could also include specific landscape data or models including landscape integrity, landscape intactness, roadless areas, “landscape” species habitat, riparian ecological networks, coastal connectivity and/or networks, and corridors or connectivity identified for specific reasons.

These recommended modeling process changes and products would expand the scope of the FEGN Update project but are a logical extension of the FEGN into a database with multiple layers and benefits, and these additional data layers would likely greatly expand the utility of the FEGN.

After the TAG meeting the work on PEA and Hubs input data continued with coordination between PEAs/Hubs delineation and connectivity modeling continued into the next phase of the project (the connectivity assessment). There are three tasks towards revised PEAs that were accomplished in the fourth quarter of year one:

1) A revised list of proposed PEA criteria (**Table 4**);
2) A preliminary list of species with habitat models created by either the Florida Fish and Wildlife Conservation Commission or Florida Natural Areas Inventory that can be considered “landscape dependent” species, such as species requiring large areas to

support viable populations, other area sensitive species, or fragmentation sensitive species (**Table 5**).

3) Various draft landscape indices, which were included or considered for inclusion in the new CLIP 2.0 Landscape Context analysis, though ultimately the FEGN version of these layers may be different or combined in a way that best suits identification of PEAs and Hubs.

1) Second iteration/draft of PEA and Hub delineation and TAG Review and Recommendations

In the fifth quarter, we discussed the proposed revised PEA criteria (**Table 4)** with two TAG team members, Jon Oetting and Amy Knight from Florida Natural Areas Inventory in August and September, 2011. Based on that discussion and other work being currently done as part of the Cooperative Conservation Blueprint Regional Pilot Project in south-central and southwest Florida, the proposed revised PEA criteria were altered slightly (**Table 6**). These changes included:

1) Added Florida Scrub-jay as a landscape dependent species.
2) Added scrub and upland hardwood forest as potential matrix natural communities.
3) Added the University of Tennessee Panther Habitat Model from the USFWS.
4) Deleted consideration of Landscape Intactness and Interior Habitat.

The new PEA criteria data were combined, optimized (deleted narrow areas and closed small gaps) and then PEAs in patches 5,000 acres or larger were identified as Hubs using the same methods as in the original draft Hubs described above. The changes in PEA criteria (compared to the original draft version discussed above and in **Table 1**) results in a very similar Hub pattern compared to both the original FEGN and the original draft hubs. There appear to be similar "core" areas identified in both the original FEGN and both versions of the new draft PEAs and Hubs, and the primary differences appear to be mostly limited to areas that could be considered "peripheral" from a spatial perspective (See **Figure 6**, **Figure 7**, **Table 7**, and **Table 8**).

One important concern with both iterations of the new criteria is the additional acreage compared to the original FEGN. It is important to keep in mind that we are comparing draft Hubs, only one of the two main parts of the FEGN (the other being the connectivity analysis/corridors), to the completed original Florida Ecological Greenways Network. This version of draft Hubs has more than 1.6 million additional acres of land compared to the original FEGN (See **Table 7**; open water was excluded from this comparison since the original FEGN has many open water acres that have not been incorporated in the new draft version of Hubs). However, the new version of draft Hubs does reduce the acreage included slightly in comparison to the first iteration of Hubs by approximately 200,000 acres (**Table 8**). Although more than 60 percent of the new draft Hubs are in open water, existing conservation lands, Florida Forever projects, or other wetlands (outside wetlands within existing and proposed conservation lands), almost 60% of the Hubs and over 13 million acres are unprotected (**See Table 9 and Figure 8**).

One key element of the TAG recommended changes in the FEGN identification process was a less discrete process for identification of PEAs, Hubs, and corridors. So tweaking of the entire

PEA, Hub, and connectivity analysis process continued until the base boundary of the FEGN was completed. For example, Florida panther and Florida black bear criteria have been included in the draft PEA and Hub identification but the connectivity analysis for each of these species may result in some combination of the identification of priority habitat cores (or Hubs) and connectivity analyses, at least for these species.

Probably the most important priority for completing a final draft version of PEAs and Hubs is considering further refinement or restriction of PEA criteria and Hub area. There is a lot of correspondence between the current FEGN and both of the first two draft iterations of Hubs in "core areas" and the primary differences are in spatially peripheral areas (See **Figure 6** and **Figure 7**); this suggests that there are additional opportunities to refine the current criteria in a third draft set of PEA/Hub delineation. Furthermore, these peripheral areas are often included in the new draft version of Hubs based on only one PEA criterion (**See Figure 9**); there are almost 4.5 million acres of Hubs included based on only one PEA criterion (**See Table 10**). **Table 11** was used as a starting point for evaluating the existing PEA criteria to determine changes that might result in a more refined Hub identification. One important difference in the second draft PEA criteria compared to the first iteration (and the original FEGN) is the inclusion of individual landscape-dependent FNAI species habitat models versus the cumulative FNAI Rare Species Habitat model. Although only moderate and high priority habitat was used from these landscape-dependent species models, Table 11 suggests that further refinement of FNAI species model criteria are warranted. Other changes considered (but not necessarily limited to and not in priority order) included:

1) Evaluate whether any species should be deleted or added as landscape-dependent.
2) Use only high priority habitat from FNAI landscape-dependent species habitat models.
3) Evaluate whether any natural communities should be deleted or added as matrix communities or whether the size criterion should be modified.
4) Consider modifying the inclusion of Panther Secondary Zone and University of Tennessee low habitat priority areas.
5) Further restrict the Florida black bear habitat quality ranking included and evaluate use of the Florida black bear population priority conservation areas for the Highlands-Glades, Chassahowitzka, and Eglin bear populations.
6) Potentially combine and refine the inclusion of more general landscape integrity criteria including the CLIP Landscape Integrity layer, the roadless criteria, landscape intactness, distance from intensive development, road density, etc. This evaluation would include the possibility of replacing the Landscape Integrity and roadless area models currently used with the new CLIP Landscape Context layer that combines these and other landscape criteria into one model, which may further refine identification of core landscape areas with the highest integrity.
7) Potentially add riparian and coastal ecosystem criteria.
8) Consider restricting PEA areas used to identify Hubs to areas that are identified by at least two PEA criteria.
9) Consider using Landscape Integrity criteria to limit inclusion of landscape-dependent species and natural community PEA criteria when identifying Hubs.

10) Consider separating PEA criteria into Species, Natural Community, and Landscape criteria both for user database flexibility and utility purposes but also to potentially require combinations of PEA categories for identifying Hubs.

We conducted a TAG committee meeting on January 10, 2012 to discuss the new draft version of PEA and Hub criteria, results and various potential modifications. We also discussed the proposed connectivity analyses. The TAG meeting was very productive, and set a strong foundation for finalizing PEA and Hub criteria. The most important change was the recognition that both more strictly defined landscape criteria as attempted in the second draft PEAs/Hubs AND a more general approach are warranted. The more general approach COMBINES less specific PEA criteria (like other species habitat in FNAI rare habitat and FWC SHCAs, and other rare natural communities) with landscape indices such as the CLIP Landscape Integrity and Landscape Context layers to determine areas of high ecological priority that are also within areas with higher landscape integrity/context. Based on the list of potential revisions included above, TAG members recommended the following actions regarding revisions for finalizing PEAs/Hubs:

1) **Evaluate whether any species should be deleted or added as landscape-dependent:** We had a long discussion about how to define landscape dependent species. We are going to proceed by likely limiting the final list to species that are consensus landscape species including Florida panther and Florida black bear with other species selected using criteria such as home range size. FNAI staff have agreed to review the criteria

used in their habitat models for candidate landscape species (**Table 5 in this report**) to help determine what species should remain or be added. Florida grasshopper sparrow and flatwoods salamander are likely to be removed from the list.

2) **Use only high priority habitat from FNAI landscape-dependent species habitat models:** FNAI staff agreed to work with us to determine species by species regarding to evaluate current habitat priority and levels and decide whether only high priority habitat should be used or whether it will depend by species.

3) **Evaluate whether any natural communities should be deleted or added as matrix communities or whether the size criterion should be modified:** There was a long discussion about defining landscape or matrix natural communities, especially regarding scrub and whether new natural community coverage maps might be available for upland (hardwood) forest and upland pine forest. Scrub was dropped. Dry prairie was also added.

4) **Consider modifying the inclusion of Panther Secondary Zone and University of Tennessee low habitat priority areas:** These decisions were made in consultation with the panther expert TAG members (Darrell Land, David Shindle, and John Cox) as well as other habitat and connectivity data and modeling methods.

5) **Further restrict the Florida black bear habitat quality ranking included and evaluate use of the Florida black bear population priority conservation areas for the Highlands-Glades, Chassahowitzka, and Eglin bear populations:** These decisions were made in consultation with the bear expert TAG members (Walt McCown, Brian Scheick, and John Cox) as well as other habitat and connectivity data and modeling methods.

6) **Potentially combine and refine the inclusion of more landscape integrity criteria including the CLIP Landscape Integrity layer and the new CLIP Landscape Context layer**: We explored using one or both of these layers as a filter in the PEA selection process for more general PEA criteria. The most likely option is that only PEAs for more general ecological criteria would be included within Hubs only if they are also in areas with landscape integrity and/or context scores that are high or moderately high. We worked with TAG members to determine what combination and threshold from these landscape layers should be used to filter selected PEA criteria.

7) Potentially add riparian and coastal ecosystem criteria: TAG members agreed that riparian and coastal ecosystems should be included in the FEGN. The more general PEA identification suggested above would likely lead to both riparian, coastal, and riparian priority areas being included. However, riparian and coastal ecosystems may be best addressed in coastal and riparian connectivity models proposed as part of the next task, and TAG members agreed that such models should at least be explored for inclusion in the FEGN delineation process.

8) **Consider restricting PEA areas used to identify Hubs to areas that are identified by at least two PEA criteria:** The TAG decided to table this proposed revision, except regarding the likelihood that landscape integrity/context models would be used to filter some PEA criteria in the revised PEA and/or Hub process. But there was agreement that there should probably not be an explicit requirement for there to be at least two overlapping PEA criteria for an area to potentially be included as part of a Hub.

9) **Consider using Landscape Integrity criteria to limit inclusion of landscape-dependent species and natural community PEA criteria when identifying Hubs:** This recommendation may be adopted, but as discussed above, the current concept is to include more specific and refined landscape-dependent species and natural community criteria potentially regardless of overlap with CLIP Landscape Integrity (or Landscape Context) while also including general PEA criteria that would be only be included when combined with high landscape integrity/context.

10) **Consider separating PEA criteria into Species, Natural Community, and Landscape criteria both for user database flexibility and utility purposes but also to potentially require combinations of PEA categories for identifying Hubs:** This recommendation was still be considered, but solely to organize an FEGN database into useful categories for user database flexibility/utility purposes.

Other specific recommendations from the TAG included:

11) FNAI PNAs should still be included. Options could include using the overlay with landscape integrity/context criteria above or to also identify PNAs based on size and/or connection with existing conservation lands.

12) Clarify current status of the Integrated Habitat Network and its inclusion in the FEGN with Tim King from FWC.

13) Consider adding pine snake, burrowing owl, and crocodile to landscape dependent species list.

14) Patch size thresholds in FNAI and FWC habitat models could be used to determine whether “borderline” landscape dependent species are included in the final list.

15) Consider a lower size threshold for landscape/matrix natural communities including 500 or even 100 acres.

16) The goal for Hubs is to include those areas either that are clearly important for landscape dependent biodiversity and/or have important ecological resources within areas with high landscape integrity. Then gaps between these Hubs can be closed using the selected results from the connectivity analyses in the next task.

One of the considerations discussed above in this task, both in work done in previous quarters and in this quarter, is the pattern of "core areas" that appear in common among the current FEGN, both of the draft PEA/Hub iterations, and in the CLIP Landscape Integrity and Landscape Context layers. We and the TAG consider this to be an important result of the analyses so far regarding how this might inform final PEA/Hub selection criteria. These results are also relevant to determining whether both the Landscape Integrity and Landscape Context layers should be used as a filter for more general PEA criteria. To further the evaluation of this observed relationship between all of these data, **Figures 10-12** and **Table 12** are provided below.

2) Final draft of PEA and Hub delineation

We held three additional meetings relevant to making decisions about the final draft PEA criteria based on the TAG recommendations from the January 10, 2012 meeting. First, we met with TAG members and Florida panther biologists Darrell Land (Florida Fish and Wildlife Conservation Commission) and Dave Shindle (Conservancy of Southwest Florida) to discuss

Florida panther PEA criteria, habitat modeling, and connectivity analysis on January 31, 2012. We met with TAG members Jon Oetting and Amy Knight from Florida Natural Areas Inventory on March 1, 2012 to discuss landscape species, landscape natural communities, the CLIP Landscape Integrity and Landscape Context models, and revisions to general PEA criteria when combining them with Landscape Integrity and Landscape Context models in the final draft of PEAs. Finally, we met with TAG members and Florida black bear biologists Walt McCown and Brian Scheick from the Florida Fish and Wildlife Conservation Commission to discuss Florida panther black bear PEA criteria, habitat modeling, and connectivity analysis on March 2, 2012. The recommendations from the January 10, 2012 TAG meeting plus the discussion in these three additional meetings were the basis for developing the following recommendations:

1) Landscape-dependent species:

    Eastern indigo snake

    Crested caracara

    Florida sandhill crane

    Short-tailed hawk

    Swallow-tailed kite

    Sherman’s fox squirrel

    Big Cypress fox squirrel

    Florida panther

    Florida black bear

2) Use only high priority habitat from the FNAI habitat models and/or all FWC SHCAs for landscape-dependent species.

3) Landscape/matrix natural communities (either 500 acres or larger or 1000 acres or larger):

Sandhill

Flatwoods

Upland pine forest

Upland hardwood

Dry prairie

4) Florida Panther: Keep the same criteria for the Primary and Dispersal Zones. Revise Secondary Zone criteria to non-urban areas with higher Landscape Integrity and Landscape Context values. Consider using Maxent model results in final version of PEA criteria.

5) Florida Black Bear: Revise Population Priority Conservation Areas to match conservation goals for each Florida black bear population working with FWC bear biologists Walt McCown and Brian Scheick. Continue to use the black bear habitat model unless Maxent model results are preferred.

6) CLIP Landscape Integrity and Landscape Context: Landscape Integrity index scores of 9 or 10 and Landscape Context scores of 8 or 9 were included as PEAs. In addition, all general (non-landscape) PEA criteria would only be included if they overlap with Landscape Integrity and Landscape Context scores of values of 6 or higher.

7) FNAI PNAs: Use PNAs 1-4 and 100s.

8) Surface Water Resource Data: Use FNAI wetlands but not FNAI Floodplains or FNAI Surface Water priorities.

9) Delete road specific criteria since they overlap with Landscape Integrity and Landscape Context models.

10) Use COBRA lands to represent potentially important coastal landscapes.

Based on additional data exploration and interim results, a few minor tweaks were added to the list of criteria above while creating the Final Draft PEAs and Hubs:

1) Eastern indigo snake was dropped from consideration as a landscape species due to the lack of a currently suitable habitat model.

2) FNAI Habitat and FWC SHCAs for landscape dependent species were also run through a filter requiring that they occur in areas with both Landscape Integrity and Landscape Context index values of 5 or higher.

3) University of Tennessee USFWS panther habitat low priorities and Florida black bear habitat quality model were also run through a filter requiring that they occur in areas with both Landscape Integrity and Landscape Context index values of 5 or higher.

4) Since Sherman's fox squirrel does not have an FNAI Habitat model or designated SHCAs, we decided to use the FWC potential habitat model for this species and include it with FWC SHCAs in the final draft PEA Criteria.

5) Based on recommendations from FWC's Walt McCown and Brian Scheick and the new Florida Black Bear Statewide Management Plan, we decided to use the Florida black bear population priority conservation areas developed by Tom Hoctor that came closest

to matching the following habitat conservation goals for each of Florida's bear subpopulations:

a. West Panhandle 1,198,461 acres

b. East Panhandle 2,359,856 acres

c. Big Bend 549,809 acres

d. North 457,145 acres

e. Central 1,062,553 acres

f. South Central 580,698 acres

g. South 1,322,014 acres

All of these recommended revisions of the PEA criteria to create the final draft PEAs are included in **Table 13**.

The results of the final draft of PEAs and Hubs indicate that refinement of the criteria is bringing more focus on what could be considered "core landscape areas" while minimizing inclusion of "peripheral" areas included in some of the PEA iterations but not others (**See Figure 13, Figure 14, and Figure 15**). One important potential concern with previous iterations of the new PEA/Hub criteria was the additional acreage compared to the original FEGN. The final draft Hubs reduces this additional acreage compared to previous drafts (**See Table 2, Table 7, and Table 14**). The previous version of draft Hubs had more than 1.6 million additional acres of land compared to the current FEGN (**Table 7**), whereas the final draft has approximately 500,000 more acres than the current FEGN (**Table 14**; **Figure 14**). More specifically, the final draft Hubs contain approximately 21 million acres that the final and previous Hub drafts have in common, with the final draft Hubs containing 900,000 unique acres while still having 1.1 million acres less that the previous draft (**Table 15; Figure 15**). **Table 16** compares the current FEGN to the final and previous draft Hubs, and suggests (if you combine the top three categories of "in all three", in the FEGN and final draft Hubs, and in both iterations of draft Hubs) that there are approximately 21.5 million acres of "core areas" common across the models. Although these comparisons likely would not be used directly to finalize the Hub delineation, it suggests that these models are at least relatively robust given the high level of consistency, and that the goal of any further revisions should be further inspection and refinement of criteria that result in inclusion of "peripheral" areas that are likely not as important for achieving the goals of the FEGN. Overall, two-thirds (66%) of the final draft Hubs are in open water, existing conservation lands, Florida Forever projects, or other wetlands (private wetlands not within existing or proposed conservation lands), while the acres of other private uplands dropped over 900,000 acres in comparison to the previous Hub draft (See **Table 15 and Table 9**).

There are still approximately 12.5 million acres of private lands (including acres within Florida Forever Projects and wetlands) in the final draft Hubs. However, we consider total land acres including private land acres only one relevant consideration for determining the suitability of the draft results. The goals of the FEGN include ALL areas of ecological significance that are part of feasible opportunities to protect large, connected landscape across Florida. The PEA, Hub, and Connectivity analyses together will form the new base boundary of the FEGN. With this stated, there are still likely good opportunities for further minor refinements to the

PEA/Hub criteria, which was discussed at the next TAG meeting in October, 2012. As with previous drafts, an examination of which areas within the final draft Hubs that are determined by only one of the PEA criteria provides one useful basis for making decisions about any additional refinements. **Figure 16** shows the overall PEA "richness", i.e., within the final draft Hubs how many different PEA criteria "determined" which areas were included, and **Table 18** shows the amount of acres in the various PEA richness categories. Less than half as many acres (2.24 million acres) were included based only on one PEA criterion compared to the previous Hub draft (**See Table 10 and Table 18**). Within these 2.4 million acres included based on only one PEA criterion, the most important contributors (in terms of total acres) were CLIP Landscape Integrity, Florida black bear habitat priorities, and Florida panther habitat priorities (**See Table 19 and Figure 17**).

Based on these results and earlier recommendations, additional refinements to consider for finalizing Hub delineation include:

1) Removing Landscape Integrity and Landscape Context as independent criteria for determining PEA/Hubs. The emphasis in this final draft was to use these layers as filters for other more specific criteria. That may be the best way to use them versus also as independent criteria. Another option is to include Landscape Integrity and Landscape Context as independent criteria ONLY when they both overlap with each other regarding highest priorities. For example, instead of including either Landscape Integrity index values of 9 and 10 or Landscape Context values of 8 and 9, the final PEA criteria could

require that areas be included only if they **BOTH** have a Landscape Integrity index value of 9 or 10 **AND** a Landscape Context index value of 8 or 9.

2) Further refine or remove the potentially less important bear and panther habitat priorities including the habitat quality model for the Florida black bear and the low habitat priority areas from the University of Tennessee panther model.
3) Discuss once again whether a minimum of two PEA criteria be required for inclusion within a Hub.
4) Discuss whether any additional criteria should be added if filtered by Landscape Integrity and Landscape Context, such as CLIP Natural Floodplains, CLIP Surface Water, CLIP Species Richness, FEMA floodplains, other priority natural communities, or additional SGCN species habitat models.
5) Revisit whether additional, predominantly aquatic criteria should be added such as Outstanding Florida Waters, Aquatic Preserves, National Estuarine Research Reserves, etc. However, these potential criteria and aquatic systems in general might be adequately or best addressed in the current or revised Riparian Connectivity and Coastal Blueways analyses discussed below in the next section.
6) Potentially be more aggressive with the filtering between PEA criteria and identification of Hubs. Currently, the resulting PEAs are simply run through a Boundary Clean process in ESRI ArcGIS to remove very narrow connections while closing small gaps. However, in the final version of Hub delineation, we may want to be more aggressive in removing less consolidated, narrowly connected, or other potential spatially peripheral areas that don’t represent the more intact, large landscapes that should be primarily represented.

7) Discuss a Hub optimization process that at least closes internal gaps of suitable land uses surrounded by Hubs, but also discuss whether other optimization techniques, such as adding all existing conservation lands and Florida Forever Projects that can be considered functionally connected to the final Hubs. Additional natural community and species priorities could also be considered during the Hub optimization stage.

We held a TAG meeting on October 2, 2012 to discuss both the final draft PEA/Hub criteria and the draft connectivity analyses. Although we expect to have additional discussions with the TAG between October and December 2012, we developed a set of considerations for developing the final version of PEAs and Hubs at this TAG meeting. These include:

1) Should the Integrated Habitat Network be included as part of the Connectivity analyses and not as a PEA criterion?
2) Consider deleting the Landscape Integrity and Landscape Context layers as independent PEA criteria. In other words, use them only as “filters” for other PEA criteria that must be in areas with sufficient Landscape Integrity/Context to be included as PEAs.
3) Consider either deleting the non-landscape based PEA criteria (i.e., those that are not specifically about landscape species, matrix natural communities, or landscape integrity) OR further restrict the Landscape Integrity and Landscape Context filter.
4) Consider including a category of priorities that are potential conservation priorities BUT did not meet the Landscape Integrity/Context filter. This would mean including this as part of the proposed FEGN Update GIS database but not using them as part of the new PEAs. However,

another option is to use these areas as part of a Hub optimization process, where they could be added to Hubs to close gaps or enlarge Hubs in areas with sufficient connectivity.

5) Consider either removing the Florida black bear habitat model as a PEA criterion, or eliminate areas that are beyond moderate dispersal range of Florida black bears.
6) Further discuss with TAG members who are panthers experts whether the low priority category from the University of Tennessee habitat model should be removed as a PEA criterion and/or if other tweaks should be adopted.
7) The TAG agrees that more aggressive spatial filtering during the Hub identification process makes sense to ensure that only larger, more consolidated, functionally connected areas are included in Hubs.
8) The discussion in #4 above is relevant to a potentially broader process of Hub optimization, where additional priority criteria could be used to justify adding areas to Hubs beyond just a simple process of closing gaps and potentially smoothing edges.

We also had additional discussion with FNAI staff and our bear and panther experts to discuss these considerations to develop the final set of criteria and methods to finalize identification of the Hubs.

Since the Technical Advisory Committee (TAG) meeting on October 2, 2012, we have had additional discussions with FNAI and FWC staff about the PEA/Hub criteria based on the considerations provided at the TAG meeting. The goal was to further refine PEA and Hub criteria to restrict Hub area, with consideration that additional area would be added from the various connectivity analyses plus potentially from optimization of the Hubs and/or the combination of Hubs and selected Connectivity results. Therefore, we created a “final” version of PEA criteria and Hubs with both minor changes to the PEA criteria and the rules for determining the level of connectivity to be included as part of Hubs. The changes to the PEA criteria included:

1) Deleted the University of Tennessee USFWS panther habitat area of low habitat suitability. These low habitat suitability areas often surround and provide connectivity between areas of high or moderate habitat suitability. However, we determined that other PEA criteria and the panther habitat connectivity analysis would likely address these corridors sufficiently without adding some of the peripheral areas included in the low suitability category.

2) Added the “North Area” included in the U.S. Fish and Wildlife Service’s Florida Panther Focal Areas data layer from the Florida Geographic Data Library. This North Area is an addition to the Primary, Secondary, and Dispersal Zones (which are all south of the Caloosahatchee River except for a small part of the Dispersal Zone), and it covers an area from Cecil Webb Wildlife Management Area east through Babcock Ranch and the lower Fisheating Creek basin to Lake Okeechobee. The North Area is based on the University of Tennessee panther habitat model results and incorporates a large area of connected high, moderate, and low suitability habitat that is closest to the occupied breeding range south of the Caloosahatchee River. It was added based on the general acknowledgement that this area is likely the most important for supporting panther recovery outside current breeding range.

3) The Florida black bear habitat quality model use was further limited by only including areas with bear habitat quality scores of 7 or greater (which is the same as the last draft) in areas that are within 30 kilometers of primary or secondary bear range (based on the 2008 FWC bear range map and additional range determined by recent telemetry data from the Highlands-Glades subpopulation). The 30 kilometer distance is based on a general higher average male bear dispersal distance.

4) For all non-landscape criteria such as CLIP habitat and natural communities, existing conservation lands, FNAI Potential Natural Areas, and Coastal Barrier Resources Act areas, increased the Landscape Integrity/Landscape Context filter to an index rank of 7 or higher.

5) Deleted the Landscape Integrity and Landscape Context layers as independent PEA criteria. In other words, they are still used as a “landscape filter” for other layers, but are not used as PEAs on their own.

Table 20 contains the final PEA criteria and **Figure 18** show the final Hubs.

After PEAs are identified, they are filtered for minimum levels of connectivity before identifying areas 5,000 acres or larger as Hubs. In the previous drafts, the resulting PEAs were simply run through a Boundary Clean function in ESRI ArcGIS to remove very narrow connections while also closing small gaps. However, in the final version of Hub delineation, we were more aggressive in removing less consolidated, narrowly connected, or other potential spatially peripheral areas that do not represent the more intact, large landscapes that should be primarily represented. This was accomplished by using a sequence of Shrink and Expand functions in ArcGIS to first remove all narrow connections 120 meters or less wide (based on having to work with a 30 meter cell size) and then closing small gaps 60 meters or narrower surrounded by PEAs.

Together, these revisions to PEA criteria and minimum connectivity thresholds for identifying Hubs significantly reduced the acres in final Hubs compared to the last Hub draft and in comparison to the existing Florida Ecological Greenways Network. There are almost 3.5 million acres less within the final Hubs and the previous draft (**Table 21; Figure 19**), and approximately 4.3 million acres less than in the current Florida Ecological Greenways Network (**Table 22; Figure 20**). In addition, approximately half of the final Hubs are either open water (public domain) or existing conservation lands (**Table 23**).

Figure 21 shows the overall PEA "richness", i.e., within the final Hubs how many different PEA criteria determined which areas were included; **Table 24** shows the amount of acres in the various PEA richness categories; **Table 25** shows the acres contribution of each PEA criterion to Hubs determined by only one criterion. There was only a small drop in acres within Hubs based on only one PEA criterion, but this is likely due to dropping the Landscape Integrity and Landscape Context criteria, which likely overlapped with the other landscape criteria and especially bear habitat, since the acres within Hubs based solely on bear habitat criteria increased in the final Hubs compared to the last draft. In addition, it is intuitive that as the number of independent PEA criteria drops, the likelihood of overlap between criteria also drops. Overall, these PEA richness criteria for the final Hubs are provided for comparison purposes with previous drafts.

In the October 2012 TAG meeting, we also discussed the possibility of a Hub optimization process that might include adding all existing conservation lands and possibly Florida Forever Projects that can be considered functionally connected to the final Hubs. Additional natural community and species priorities could also be considered during the Hub optimization process. **Table 26** includes a draft list of potential criteria that could be used to close gaps or add well-connected additional priority areas to the final hubs during the optimization process.

Table 4. Proposed Criteria for selecting Priority Ecological Areas for the Florida Ecological Greenways Network based on the recommendations of the TAG at the April, 2011 TAG meeting.

Data layer	Priority area criterion	Exclusion criteria
Existing conservation lands	All such lands	Remove only developed lands
FWC Strategic Habitat Conservation Areas (SHCA)	All SHCAs for landscape, area sensitive, or fragmentation sensitive species	Remove only developed lands
FNAI Rare Species Habitat	All habitat for landscape, area sensitive, or fragmentation sensitive species	Remove only developed lands
FNAI Rare Natural Communities	Patches of matrix communities 1,000 acres or larger (sandhill and flatwoods)	Remove only developed lands
USFWS Florida panther conservation zones	All areas except intensive development within the Primary and Dispersal Zones for the Florida panther. Areas identified as panther habitat within the Secondary Zone.	Remove only developed lands
Florida black bear habitat model	All areas having a habitat quality index of 7.5 or higher	Remove only developed lands
Florida black bear PPAs	All such areas needed to address population habitat requirements	Remove only developed lands
CLIP Landscape Integrity	All areas with index values of 9 or 10	Do not include any intensive agriculture or developed lands
Roadless areas (all roads)	Areas 5,000 acres or larger containing no roads of any kind	Do not include any intensive agriculture or developed lands
Roadless areas without major Roads (FDOT maintained roads)	Areas 100,000 acres or larger containing no major roadways such as interstate, federal, or state highways, and large capacity county roads	Do not include any intensive agriculture or developed lands
Intactness Index Priority Areas	All Areas with an Intactness Index score of 9	Do not include any intensive agriculture or developed lands
Interior Habitat	Larger blocks (1,000 acres or larger) of natural and semi-natural habitat unaffected by edge effects from development, intensive agriculture, or roads	Do not include any intensive agriculture or developed lands
Integrated Habitat Network	All areas within the network	Remove only developed lands (determine whether active mining should be included)

Other potential draft PEA criteria:

--Large FNAI PNAs or PNAs known to contain large, high quality examples of matrix natural communities.

--Major River riparian corridors

--Large stretches of intact coastline defined by both length and width (maybe starting with FNAI Fragile Coastal Resources as a base)

--Large areas of natural or semi-natural land cover far from large areas of intensive development including major roads

--Areas with very low road densities

Table 5. List of potential “landscape dependent” species, such as species requiring large areas to support viable populations, other area sensitive species, or fragmentation sensitive species

Eastern indigo snake
Flatwoods salamander
Crested caracara
Snail kite
Wood stork
Florida sandhill crane
Red-cockaded woodpecker
Florida scrub-jay
Short-tailed hawk
Swallow-tailed kite
Florida grasshopper sparrow
Sherman’s fox squirrel
Big Cypress fox squirrel
Florida panther
Florida black bear
Burrowing owl

Table 6. New Draft Criteria for selecting Priority Ecological Areas for the Florida Ecological Greenways Network based on input from TAG members Jon Oetting and Amy Knight.

Data layer	Priority area criterion	Exclusion criteria
Existing conservation lands	All such lands	Remove only developed lands
FWC Strategic Habitat Conservation Areas (SHCA) for Landscape Species	All SHCAs for landscape, area sensitive, or fragmentation sensitive species	Remove only developed lands
FNAI Rare Species Habitat for Landscape Species	All habitat for landscape, area sensitive, or fragmentation sensitive species ranked six or higher	Remove only developed lands
FNAI Rare Matrix Natural Communities	Patches of matrix communities 1,000 acres or larger (sandhill, flatwoods, scrub, upland forest)	Remove only developed lands
USFWS Florida panther conservation zones	All areas except intensive development within the Primary and Dispersal Zones for the Florida panther. Areas identified as panther habitat within the Secondary Zone.	Remove only developed lands
University of Tennessee USFWS panther habitat	All areas identified as potential habitat in areas with low to high habitat potential	Remove only developed lands
Florida black bear habitat quality model	All areas having a habitat quality index of 7 or higher	Remove only developed lands
Florida black bear PPCAs for the three smallest bear populations	All such areas needed to address population habitat requirements	Remove only developed lands
CLIP Landscape Integrity	All areas with index values of 9 or 10	Do not include any intensive agriculture or developed lands
Roadless areas (all roads)	Areas 5,000 acres or larger containing no roads of any kind	Do not include any intensive agriculture or developed lands
Roadless areas without major Roads (FDOT maintained roads)	Areas 100,000 acres or larger containing no major roadways such as interstate, federal, or state highways, and large capacity county roads	Do not include any intensive agriculture or developed lands
Integrated Habitat Network	All areas within the network	Remove only developed lands (determine whether active mining should be included)

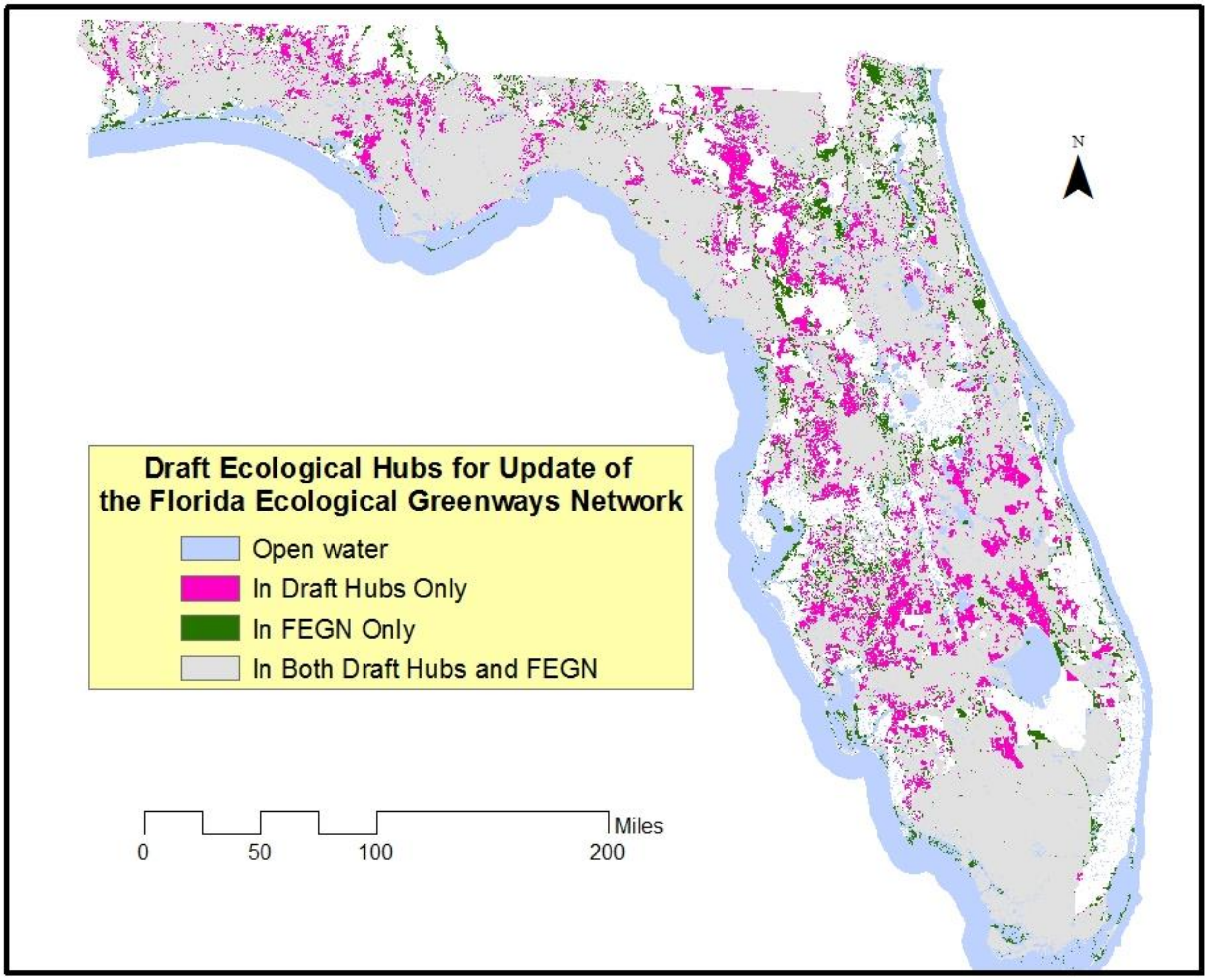

Figure 6. New Draft Hubs compared to the original Florida Ecological Greenways Network.

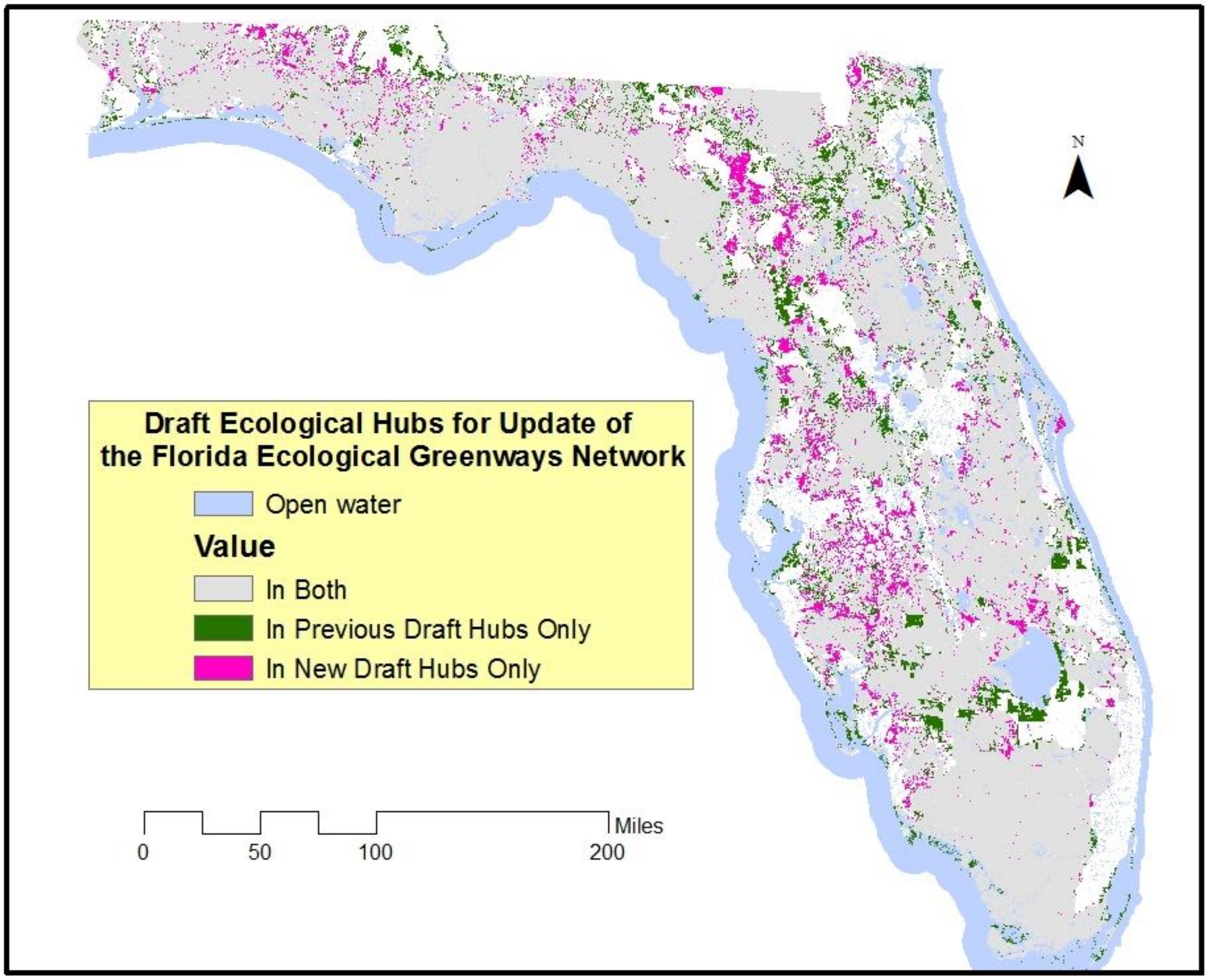

Figure 7. New Draft Hubs compared to the first iteration of Draft Hubs.

Table 7. Comparison of Revised Draft Hubs and the original Florida Ecological Greenways Network

FEGN	New Draft Hubs	Acres
Not in FEGN	In Draft Hubs	3,714,817
In FEGN	Not in Draft Hubs	2,080,285
In FEGN	In Draft Hubs	19,232,612

Table 8. Comparison of Revised Draft Hubs and the first iteration of Draft Hubs

New Draft Hubs	Old Draft Hubs	Acres
In	In	20,930,428
Out	In	2,277,675
In	Out	2,015,966

Table 9. New Draft Hubs separated into various land Protection and land use categories.

Land Use Category	Acres	Percent
Open Water	234,094	1.0%
Existing Conservation Lands	9,487,717	40.9%
Florida Forever Projects	1,666,163	7.2%
Private Wetlands	3,423,145	14.8%
Other Private Land	8,373,703	36.1%
Total Acres	23,184,823	

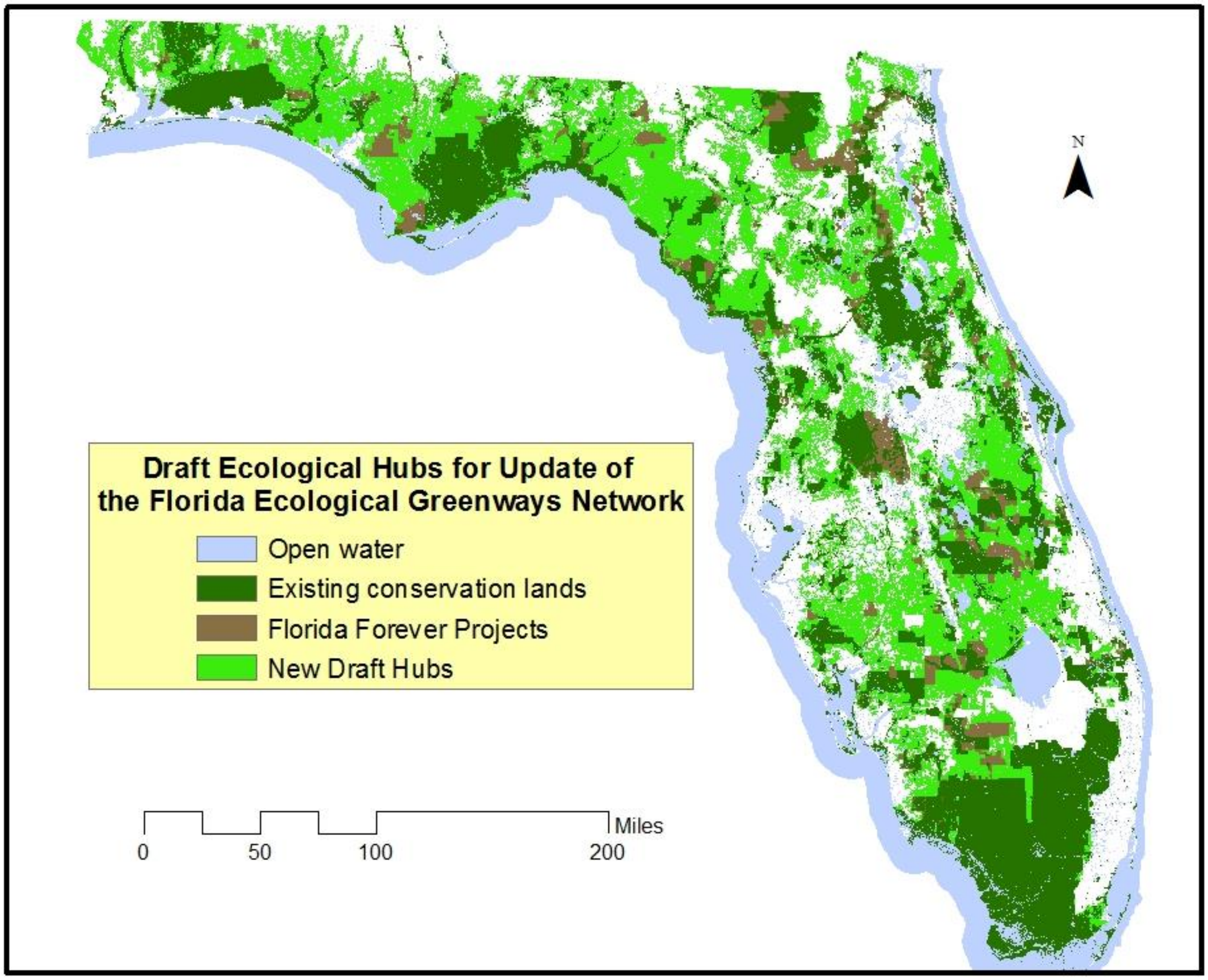

Figure 8. The new draft Hubs with existing conservation lands and Florida Forever projects

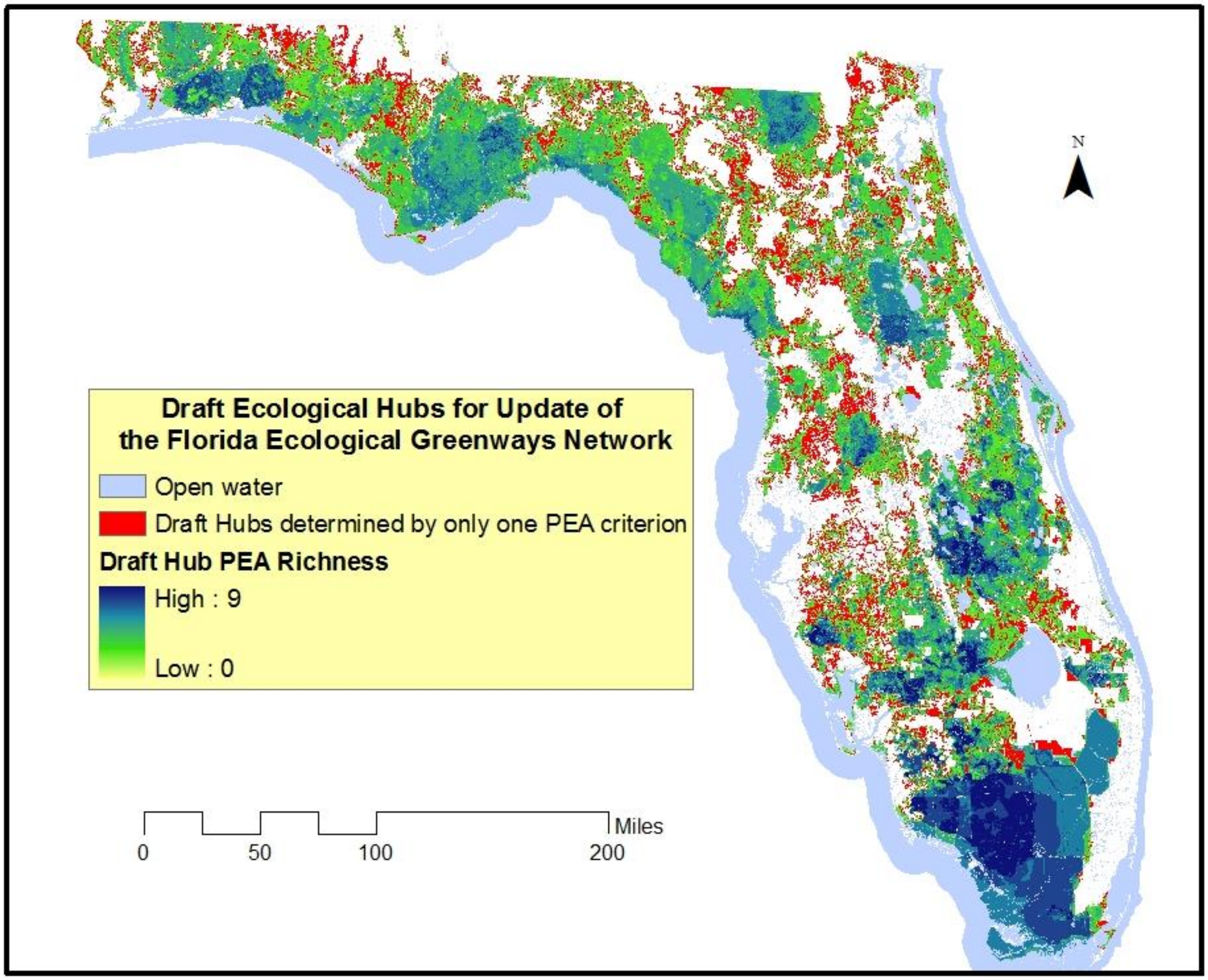

Figure 9. The new draft Hubs separated into "richness" categories showing which Hubs are identified by few or many PEA criteria. This map was created by lumping the two panther PEA criteria together and the bear PEA criteria together to result in ten separate PEA criteria to determine Hubs (compared to the 12 criteria listed in Table 6). Potentially most importantly, the red areas on the map indicate areas that were included as parts of Hubs based on only a single PEA criterion. It should be noted that many of these areas could be considered spatially peripheral and therefore suggest that further careful honing of PEA criteria might result in a final draft version of Hubs that is more focused on the areas with the highest landscape integrity and significance.

Table 10. Hubs separated into "richness" categories showing acres of Hubs identified by few or many PEA criteria.

PEA Criteria Overlap	Acres
0	202,828
1	4,474,809
2	4,506,992
3	4,202,251
4	3,694,878
5	2,975,319
6	1,943,079
7	874,212
8	73,347
9	1,336
10	0

Table 11. Acres of each PEA criterion found in areas identified as Hubs based on only one PEA criterion

PEA Criterion	Acres
FNAI Landscape Species Habitat	1,557,427
Landscape Integrity	890,980
SHCAs for Landscape Species	717,011
Bear habitat	424,722
Conservation Lands	360,499
Roadless areas	161,336
Integrated Habitat Network	160,841
Major roadless areas	119,513
Panther habitat	74,377
FNAI Matrix Natural Communities	8,103
Total Acres of Hubs based on 1 PEA Criterion	4,474,809

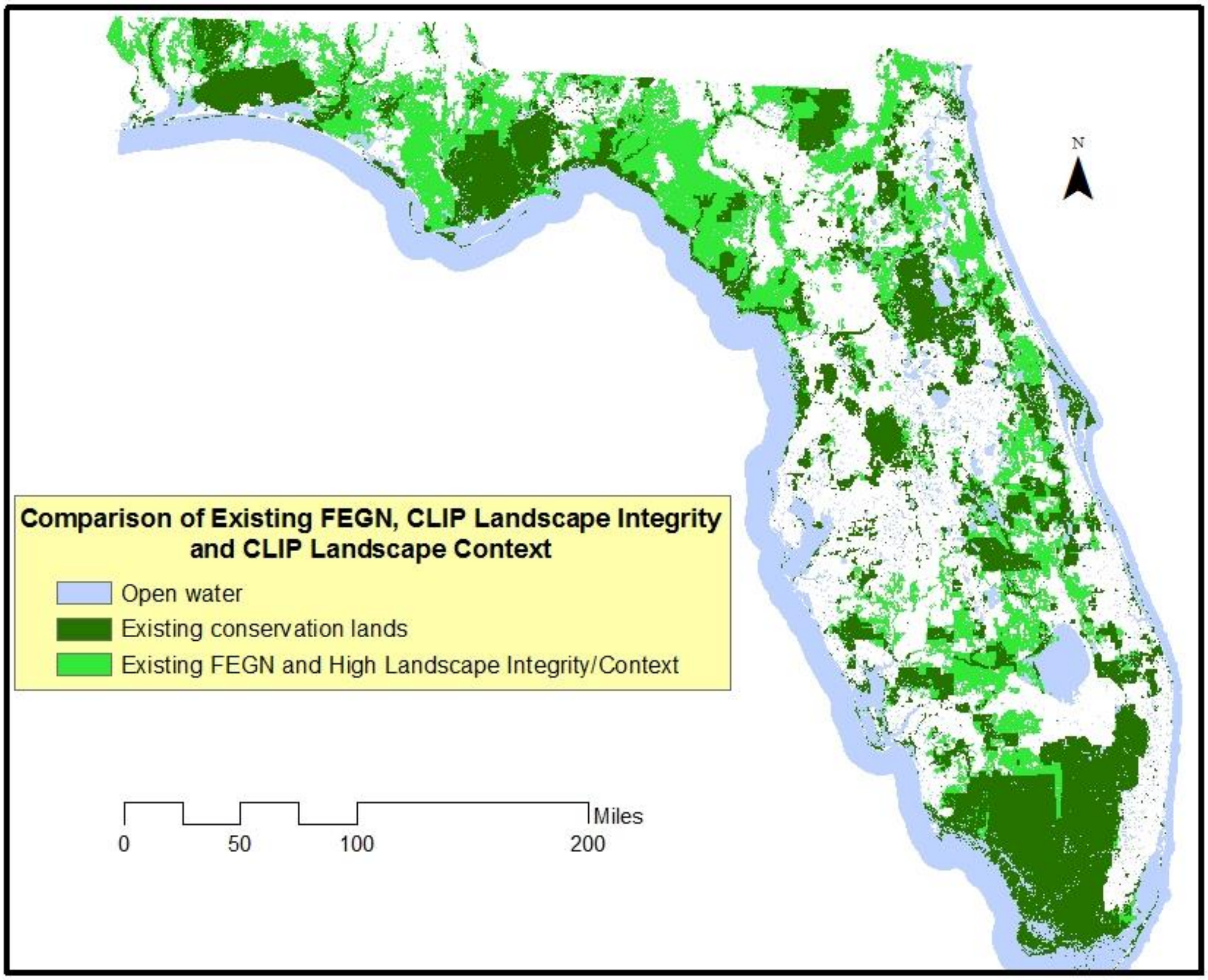

Figure 10. This shows the overlap between the current Florida Ecological Greenways Network and areas with higher landscape integrity in both CLIP Landscape Integrity and Landscape Context (defined initially here as areas with values of 7-10 in Landscape Integrity and 7-9 in Landscape Context. This analysis suggests that 72% of the current FEGN are in areas that still have high landscape integrity, and the spatial pattern of these results are indicative of the observation that there is still a core network of natural and rural lands across the state available to support a statewide ecological greenways network.

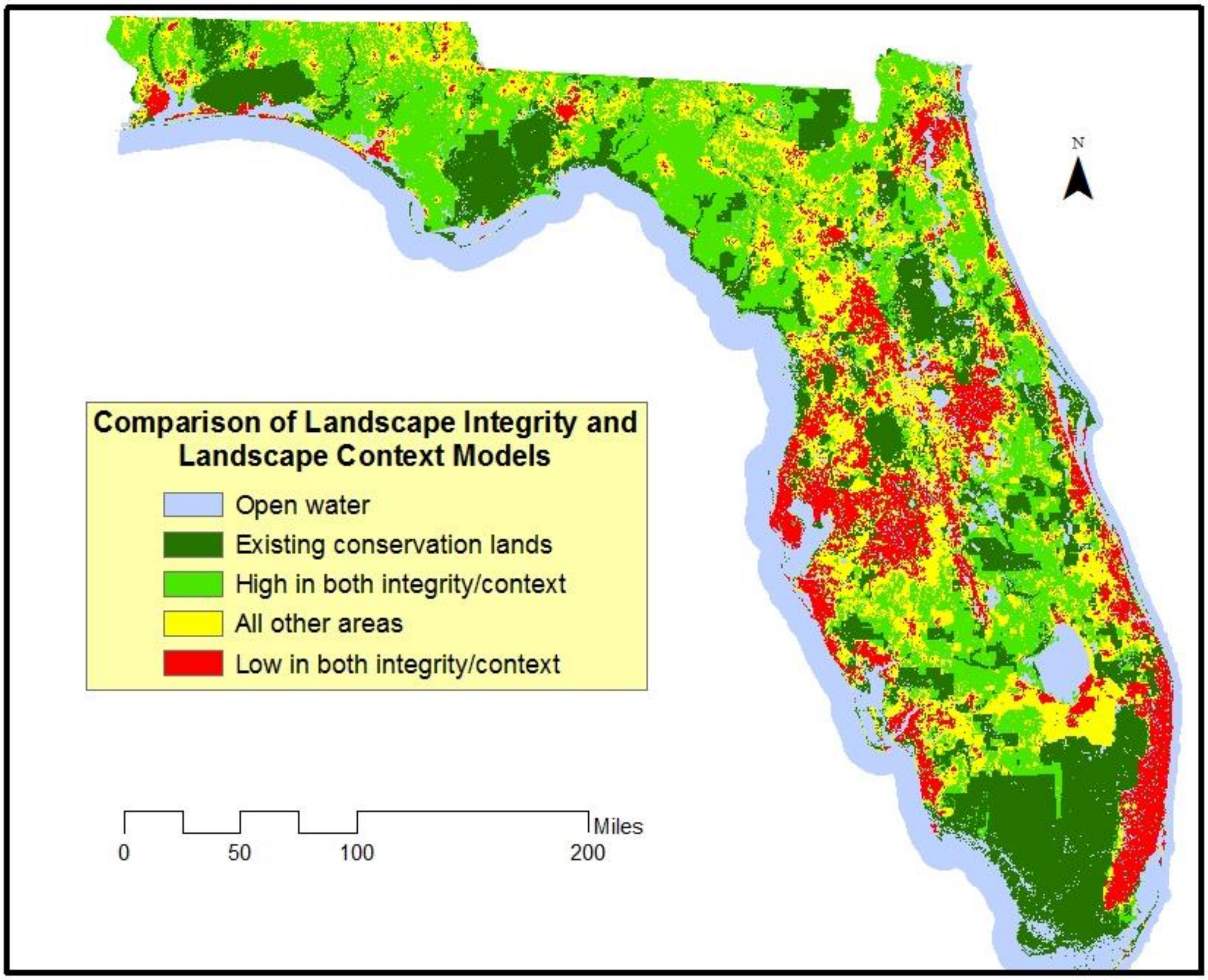

Figure 11. This shows a comparison of the CLIP Landscape Integrity and Landscape Context models, where the bright green represents agreement between both models regarding high potential landscape integrity, red represents agreement on low landscape integrity, and yellow represents either agreement on moderate landscape integrity or disagreement/conflict between the models.

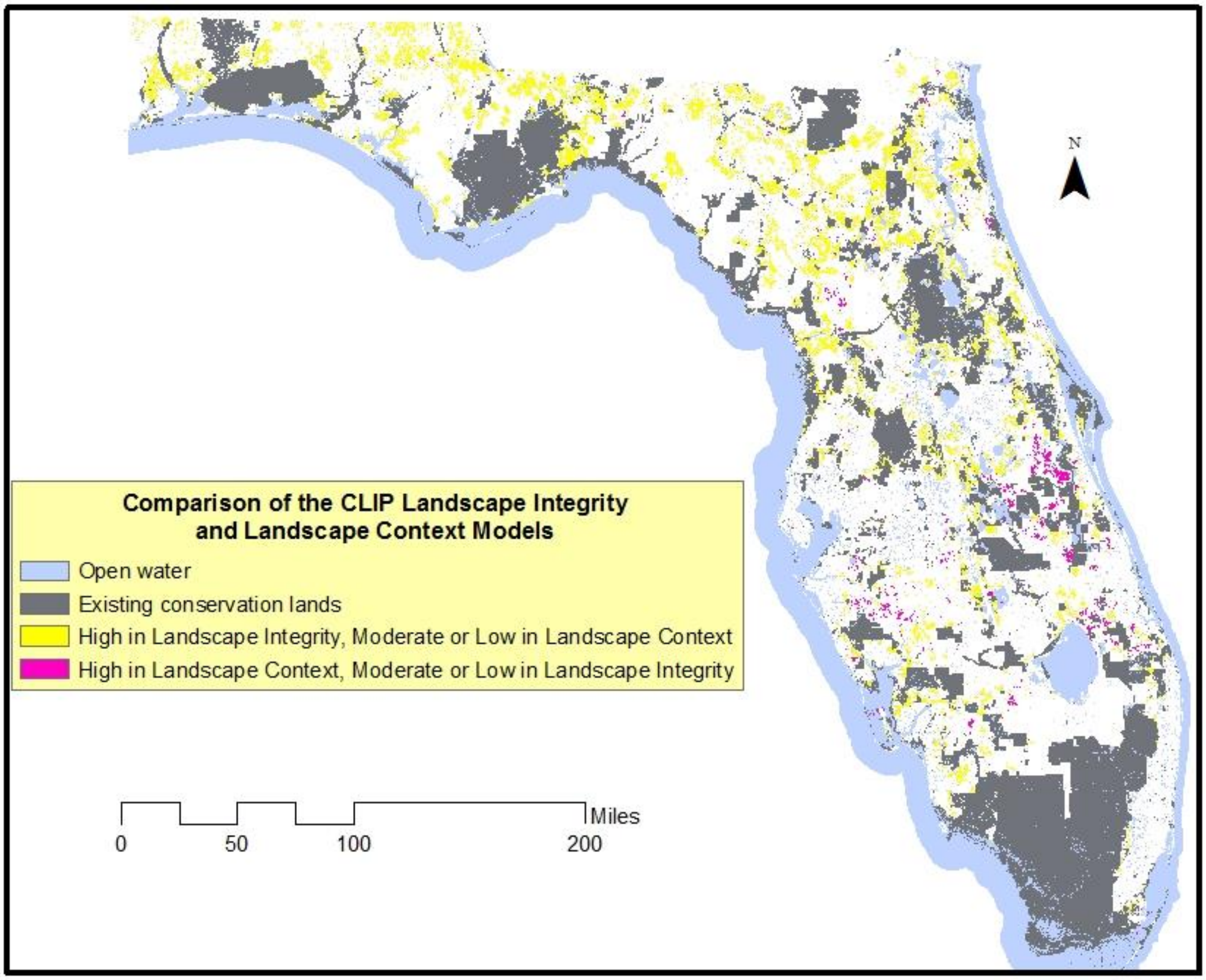

Figure 12. This shows the areas of disagreement/conflict between the CLIP Landscape Integrity and Landscape Context models.

Table 12. The number of land acres with high landscape integrity for both the CLIP Landscape Integrity and Landscape Context models, acres in various combinations where one model has high integrity and the other does not (plus total acres of "disagreement"), moderate and low integrity agreement, and then moderate disagreement between the model.

CLIP Landscape Integrity	CLIP Landscape Context	Acres
High	High	19,012,973
High	Moderate	3,189,750
High	Low	10,995
Moderate	High	318,217
Low	High	682
		3,519,644
Moderate	Moderate	2,506,678
Moderate	Low	257,013
Low	Moderate	3,403,928
Low	Low	4,959,612

Table 13. Final Draft Criteria for selecting Priority Ecological Areas for the Florida Ecological Greenways Network.

Data layer	Priority area criterion	Exclusion criteria
Landscape Species	All high priority FNAI habitat and SHCAs or FWC potential habitat (for Sherman's fox squirrel only) with Landscape Integrity and Landscape Context index values or 5 or higher.	Remove only developed lands
FNAI Rare Matrix-Landscape Natural Communities	Patches of matrix communities 500 acres or larger (sandhill, flatwoods, dry prairie, upland hardwood forest, upland pine)	Remove only developed lands
USFWS Florida panther conservation zones	All areas except intensive development within the Primary and Dispersal Zones for the Florida panther. All areas except intensive development within the Secondary Zone criteria that also have with Landscape Integrity and Landscape Context index values or 5 or higher.	Remove only developed lands
University of Tennessee USFWS panther habitat	All areas identified as potential habitat in areas with moderate to high habitat potential. Low habitat potential included with Landscape Integrity and Landscape Context index values or 5 or higher.	Remove only developed lands
Florida black bear habitat quality model	All areas having a habitat quality index of 7 or higher also with Landscape Integrity and Landscape Context index values or 5 or higher.	Remove only developed lands
Florida black bear PPCAs	All such areas needed to address population habitat requirements for each Florida black bear subpopulation	Remove only developed lands
CLIP Landscape Integrity	All areas with index values of 9 or 10	Do not include any intensive agriculture or developed lands
CLIP Landscape Context	All areas with index values of 8 or 9	Do not include any intensive agriculture or developed lands
Integrated Habitat Network	All areas within the network	Remove only developed lands other than current mining
Existing conservation lands	All such lands with high LI-LC scores	Remove only developed lands
FWC Strategic Habitat Conservation Areas (SHCA)	SHCAs P1-P3 with high LI-LC scores	Remove only developed lands
FNAI Rare Species Habitat	Priority 1-3 with high LI-LC scores	Remove only developed lands
FNAI Rare Natural Communities	All areas with high LI-LC scores	Remove only developed lands
FNAI Functional Wetlands	Priority 1-2 with high LI-LC scores	Remove only developed lands
FNAI Potential Natural Areas (PNAs)	All PNAs 1-4 and 100s with high LI-LC scores	Do not include any intensive agriculture or developed lands
Lands identified as part of the Coastal Barrier Resources Act	All such lands with high LI-LC scores	Do not include any intensive agriculture or developed lands

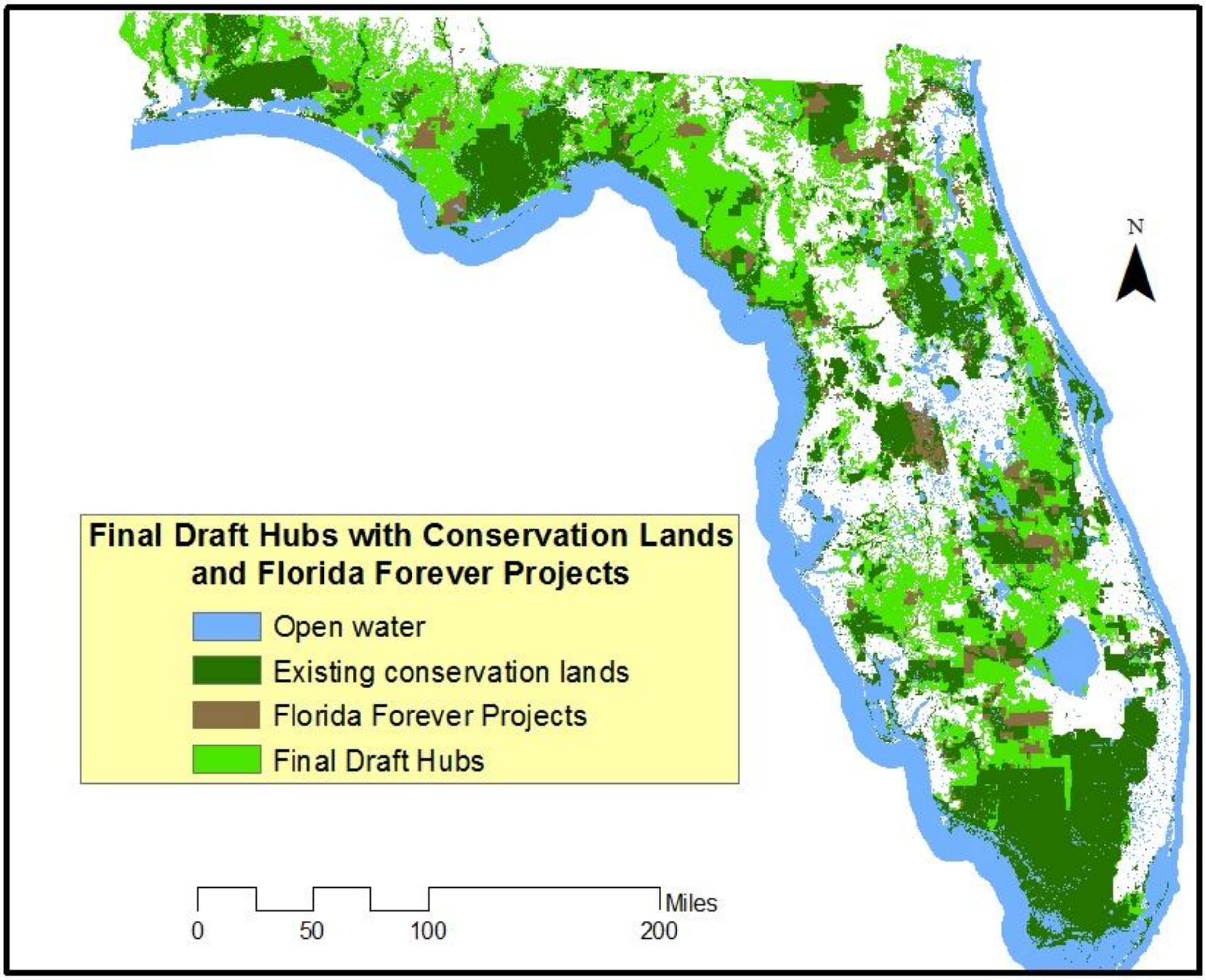

Figure 13. The Final Draft Hubs overlaid by open water, existing conservation lands, and Florida Forever Projects. It should be clear when comparing this new iteration with the current FEGN and the first two draft iterations of Hubs that the core pattern of included areas is very similar.

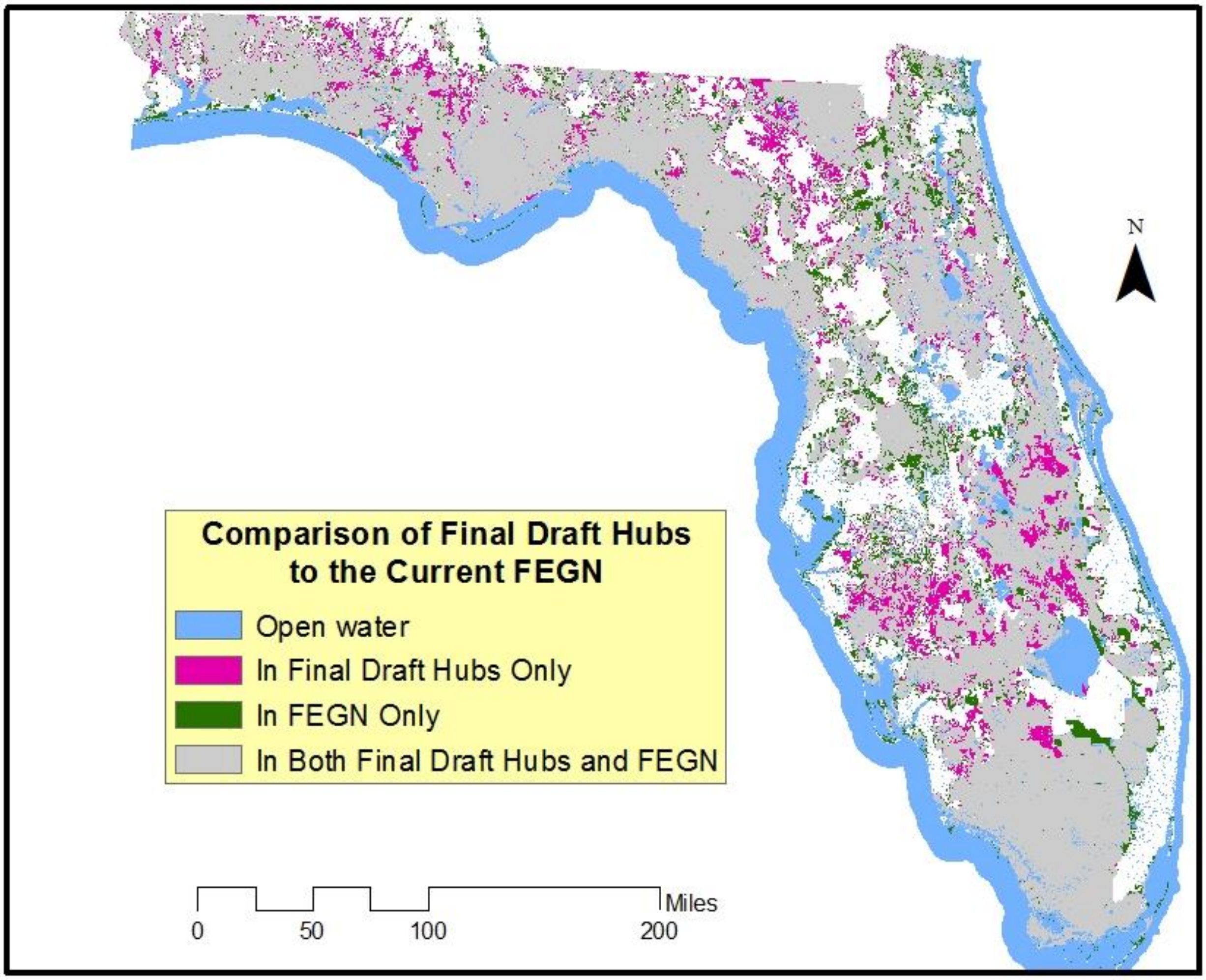

Figure 14. Comparison of the Final Draft Hubs with the current Florida Ecological Greenways Network.

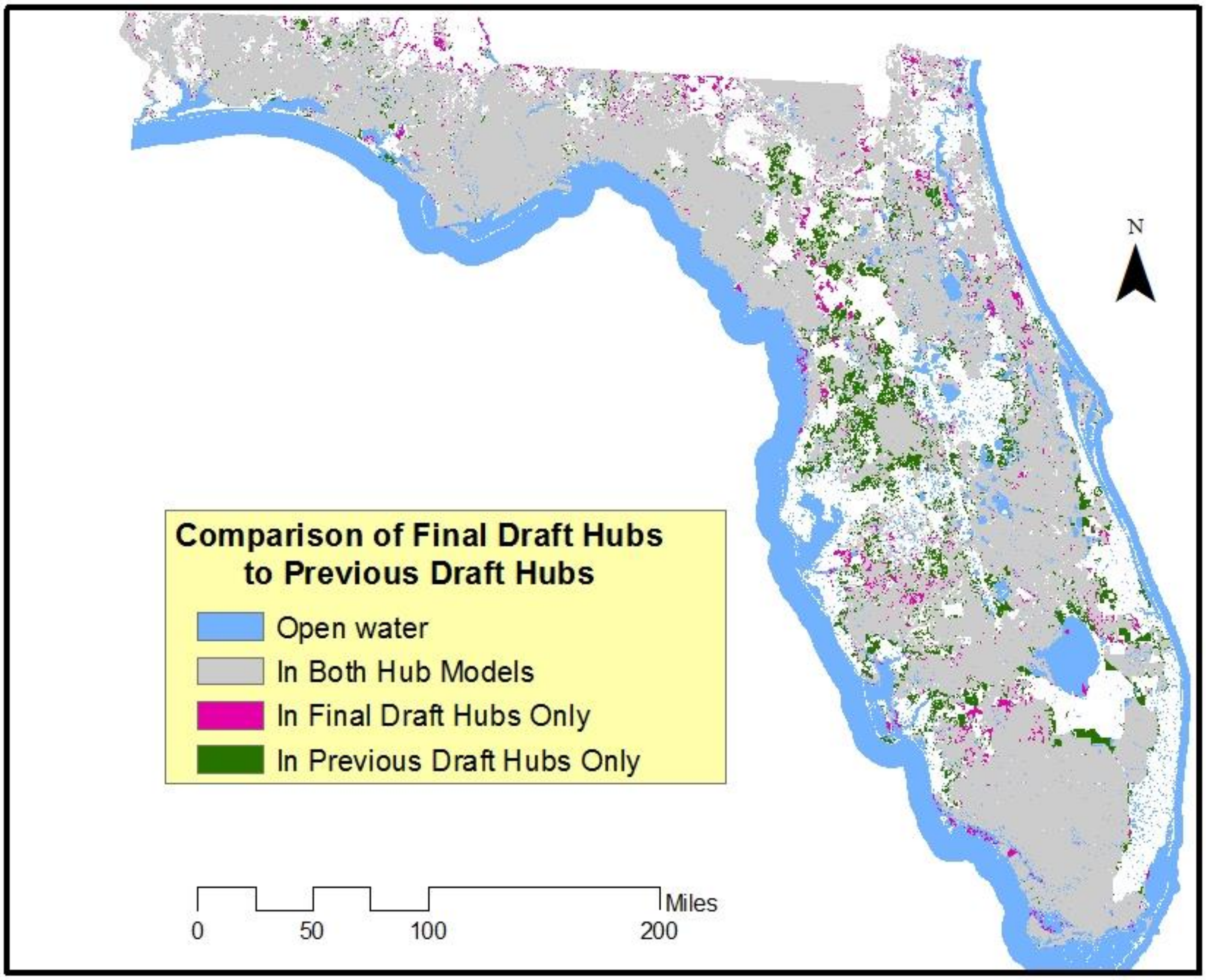

Figure 15. Comparison of the Final Draft Hubs to the previous Hub draft.

Table 14. Final Draft Hubs compared to current FEGN.

Description	Acres
In FEGN and Hubs Final Draft	19,081,037
In Hubs Final Draft Only	2,732,352
In FEGN Only	2,231,857

Table 15. Final Draft Hubs compared to previous draft Hubs.

Description	Acres
In both Hub Drafts	20,914,595
In Hubs Final Draft Only	902,539
In Hubs Previous Draft Only	2,036,089

Table 16. Combined comparison between FEGN, Final Draft Hubs and previous draft.

Description	Acres	Percent
In all three	18,542,802	73%
In FEGN and Hubs Final Draft	538,234	2%
In both Hub Drafts but not FEGN	2,368,661	9%
In Hubs Final Draft Only	363,691	1%
In FEGN and Hubs Previous Draft	689,807	3%
In FEGN Only	1,542,051	6%
In Hubs Previous Draft Only	1,346,132	5%
Total Acres	25,391,377	

Table 17. Final Draft Hubs in Land Use Categories.

Land Use Category	Acres	Percent
Open Water	575,728	2.6%
Existing Conservation Lands	9,349,127	41.8%
Florida Forever Projects	1,666,999	7.4%
Other Private Wetlands	3,352,981	15.0%
Other Private Land	7,448,028	33.3%
Total Acres	22,392,862	

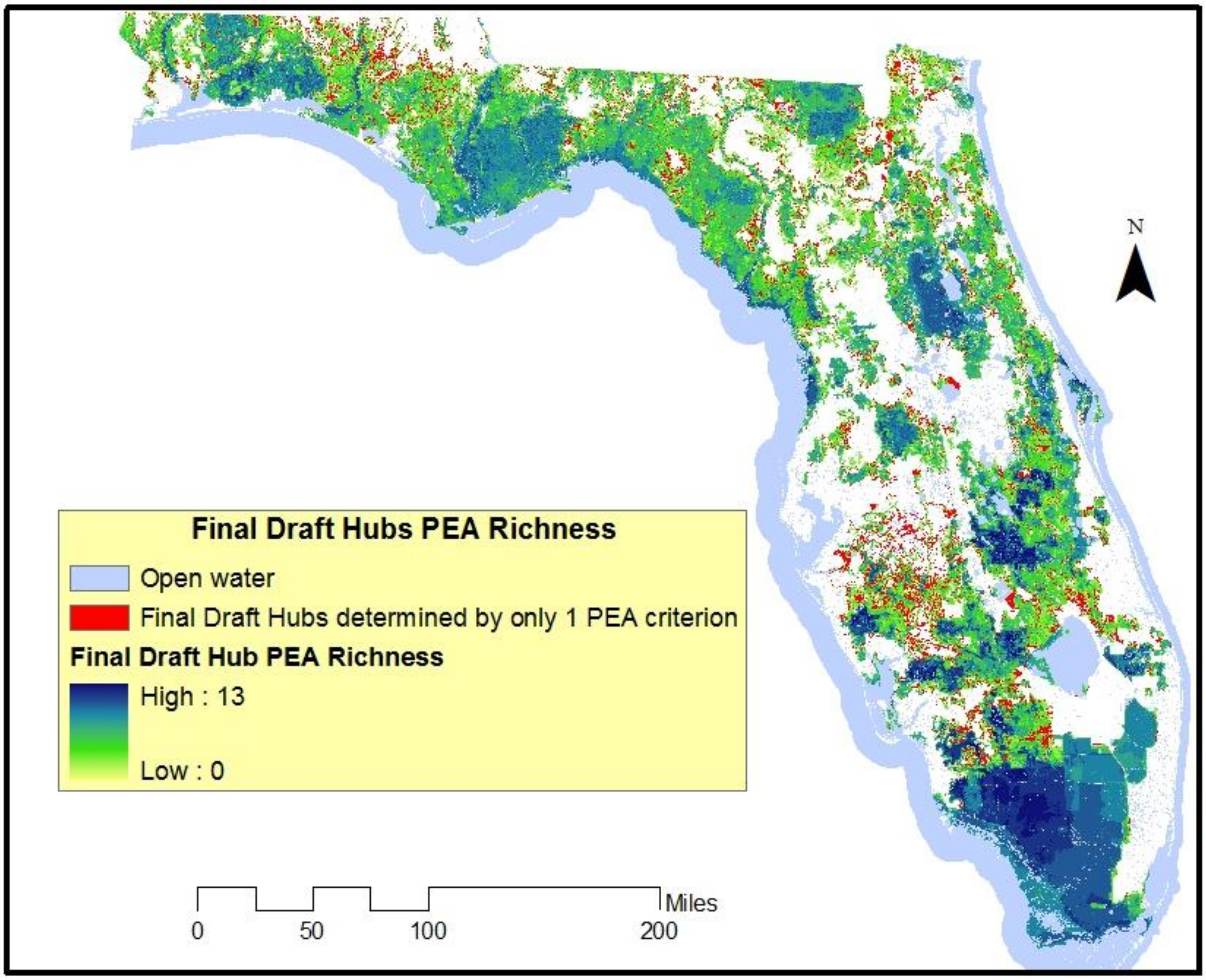

Figure 16. Map showing the number of PEA criterion responsible for Hubs included in the Final Draft. Dark blues represent the highest overlap among PEA criteria whereas red represents the areas included based on only 1 PEA criterion.

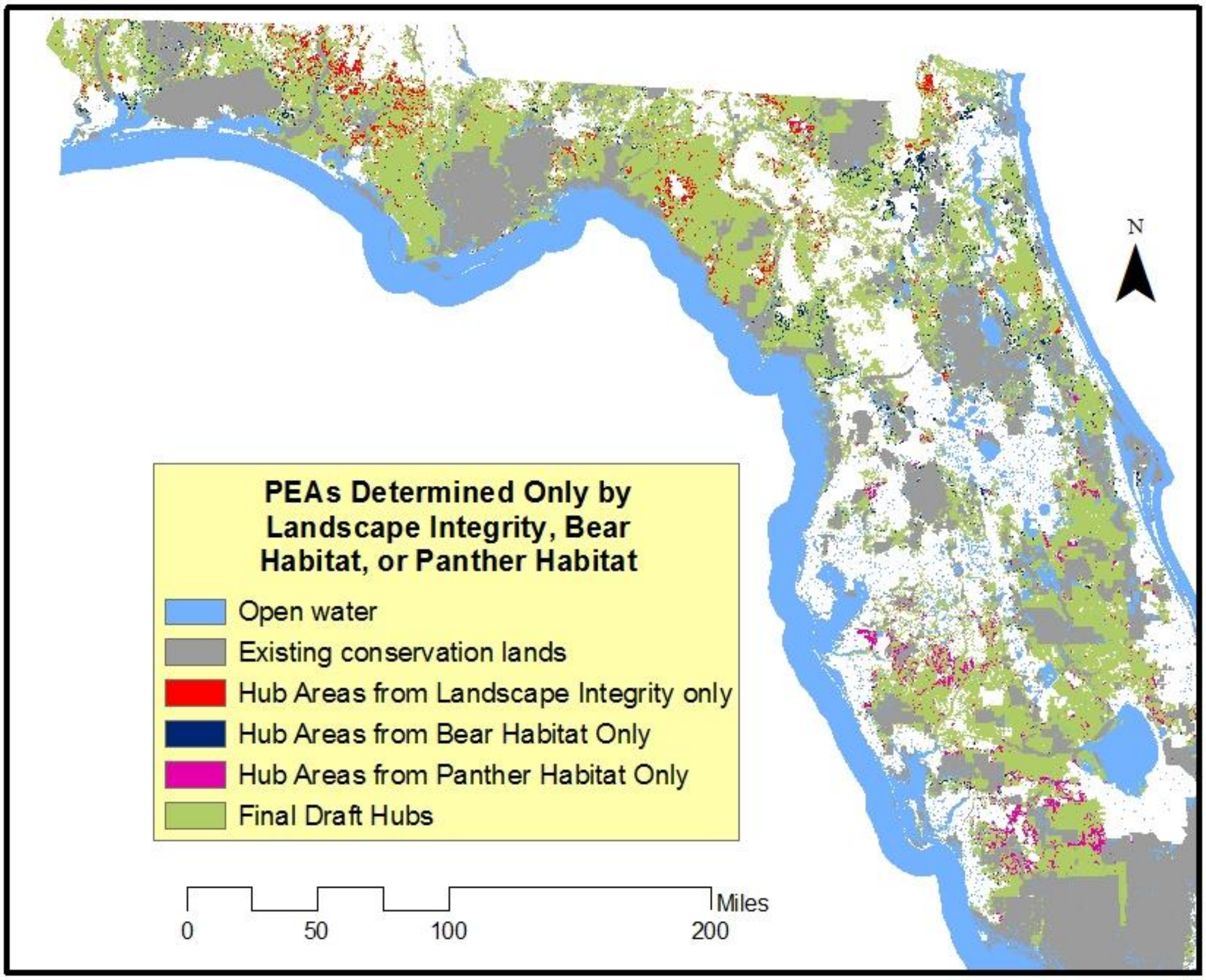

Figure 17. Map showing all other parts of Final Draft Hubs in green with existing conservation lands in gray. Then the Hub areas included based only on CLIP Landscape Integrity, bear habitat priorities, and panther habitat priorities are included in red, dark blue, and pink respectively. Panther criteria tend to dominate in the south (in Hub areas determined by only one criterion), bear criteria dominate in north-central Florida (with some Landscape Integrity areas), and Landscape Integrity dominate the panhandle (with some bear priorities).

Table 18. PEA richness for the Final Draft Hubs.

PEA Criteria Overlap	Acres
0	164,046
1	2,244,864
2	2,622,013
3	2,768,934
4	2,751,294
5	2,787,970
6	2,281,291
7	3,035,377
8	2,241,911
9	1,032,146
10	377,435
11	84,921
12	602
13	59

Table 19. Contribution of each PEA criterion to Final Draft Hub areas included based on only one PEA criterion.

PEA Criterion	Acres
CLIP Landscape Integrity	528,173
Bear Habitat Priorities	420,521
Panther Habitat Priorities	414,808
Integrated Habitat Network	188,580
FNAI Landscape Species Habitat	184,612
FNAI PNAs	174,200
Landscape Context	132,811
CLIP SHCAs	71,194
CLIP Under-represented NCs	57,082
Existing Conservation Lands	36,755
CLIP FNAI Species Habitat	27,471
FNAI Landscape/Matrix NCs	4,044
CLIP Wetlands	3,759
COBRAs	852
FWC Landscape Species SHCAs/Potential Habitat	0.4
Total Acres of Hubs based on 1 PEA Criterion	2,244,864

Table 20. Final Criteria for selecting Priority Ecological Areas for the Florida Ecological Greenways Network. Text in green represents alterations in criteria compared to the last draft and text in red represent deleted criteria.

Data layer	Priority area criterion	Exclusion criteria
Landscape Species	All high priority FNAI habitat or SHCAs or FWC potential habitat (for Sherman's fox squirrel only) with Landscape Integrity and Landscape Context index values of 5 or higher.	Remove only developed lands
FNAI Rare Matrix-Landscape Natural Communities	Patches of matrix communities 500 acres or larger (sandhill, flatwoods, dry prairie, upland hardwood forest, upland pine)	Remove only developed lands
USFWS Florida panther conservation zones	All areas within the Primary or Dispersal Zones for the Florida panther. All areas within the Secondary Zone or North Focal Area with Landscape Integrity and Landscape Context index values of 5 or higher.	Remove only developed lands
University of Tennessee USFWS panther habitat	All areas identified as potential habitat in areas with moderate to high habitat potential. Low habitat potential included with Landscape Integrity or Landscape Context index values or 5 or higher.	Remove only developed lands
Florida black bear habitat quality model	All areas having a habitat quality index of 7 or higher also with Landscape Integrity and Landscape Context index values of 5 or higher and within 30 km of bear range.	Remove only developed lands
Florida black bear PPCAs	All such areas needed to address population habitat requirements for each Florida black bear subpopulation	Remove only developed lands
CLIP Landscape Integrity	All areas with index values of 9 or 10	Do not include any intensive agriculture or developed lands
CLIP Landscape Context	All areas with index values of 8 or 9	Do not include any intensive agriculture or developed lands
Integrated Habitat Network	All areas within the network	Remove only developed lands other than current mining
Existing conservation lands	All such lands with high LI-LC scores (7 or above)	Remove only developed lands
FWC Strategic Habitat Conservation Areas (SHCA)	SHCAs P1-P3 with high LI-LC scores	Remove only developed lands
FNAI Rare Species Habitat	Priority 1-3 with high LI-LC scores	Remove only developed lands
FNAI Rare Natural Communities	All areas with high LI-LC scores	Remove only developed lands
FNAI Functional Wetlands	Priority 1-2 with high LI-LC scores	Remove only developed lands
FNAI Potential Natural Areas (PNAs)	All PNAs 1-4 and 100s with high LI-LC scores	Do not include any intensive agriculture or developed lands
Lands identified as part of the Coastal Barrier Resources Act	All such lands with high LI-LC scores	Do not include any intensive agriculture or developed lands

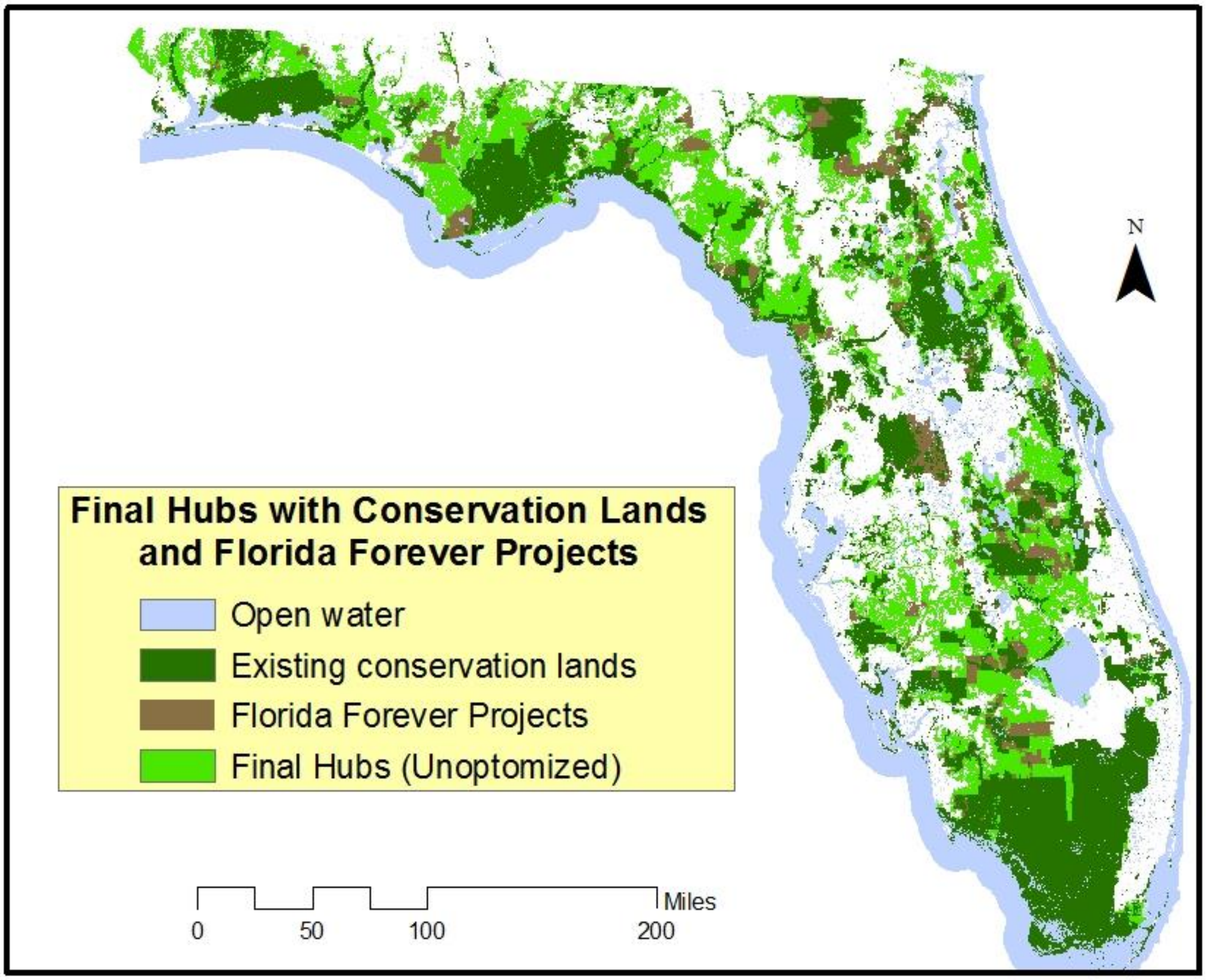

Figure 18. Final Hubs with existing conservation lands and Florida Forever Projects.

Table 21. Final Hubs compared to last draft Hubs.

Description	Acres
In both Hub Drafts	18,909,205
In Final Hubs Only	896
In Hubs Previous Draft Only	3,483,657

Table 22. Final Hubs compared to the Florida Ecological Greenways Network.

Description	Acres
In FEGN and Final Hubs	16,981,918
In Final Hubs Only	1,493,855
In FEGN Only	4,330,976

Table 23. Land Category Statistics for Final Hubs.

Land Use Category	Acres
Open Water	433,147
Existing Conservation Lands	8,962,201
Florida Forever Projects	1,480,379
Other Private Wetlands	2,651,933
Other Private Land	5,382,441
Total Acres	18,910,101

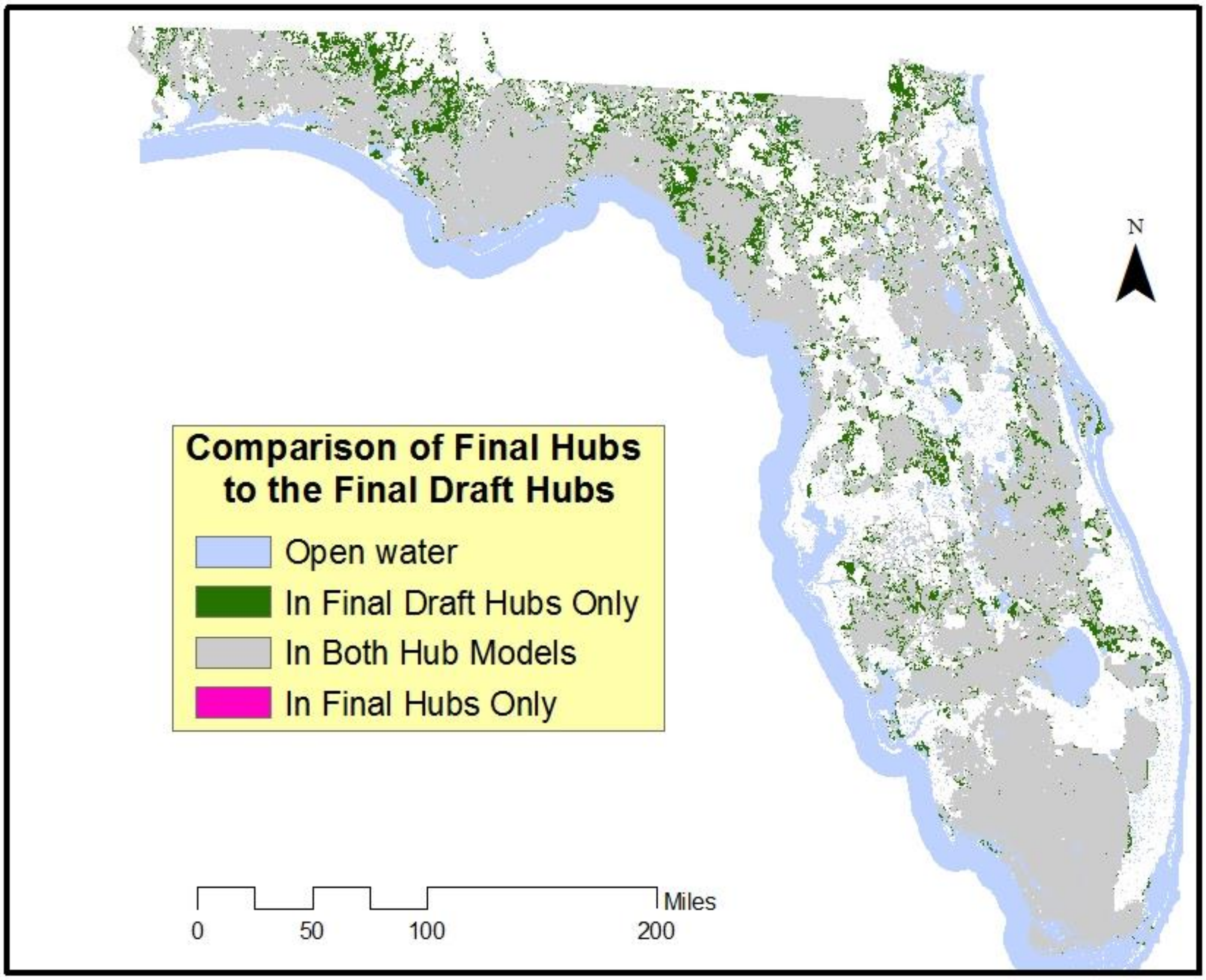

Figure 19. Final Hubs compared to previous draft Hubs.

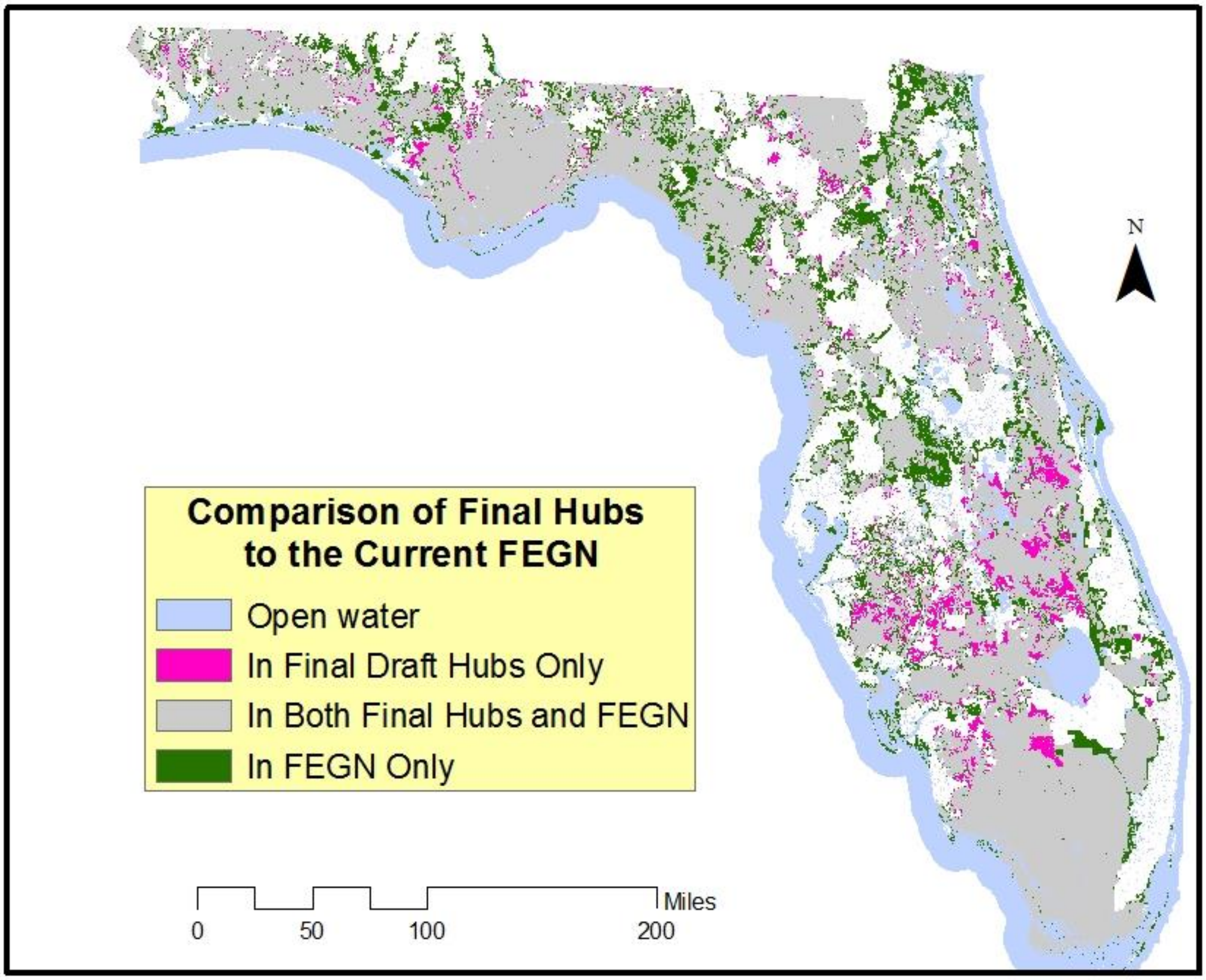

Figure 20. Final Hubs compared to the current Florida Ecological Greenways Network.

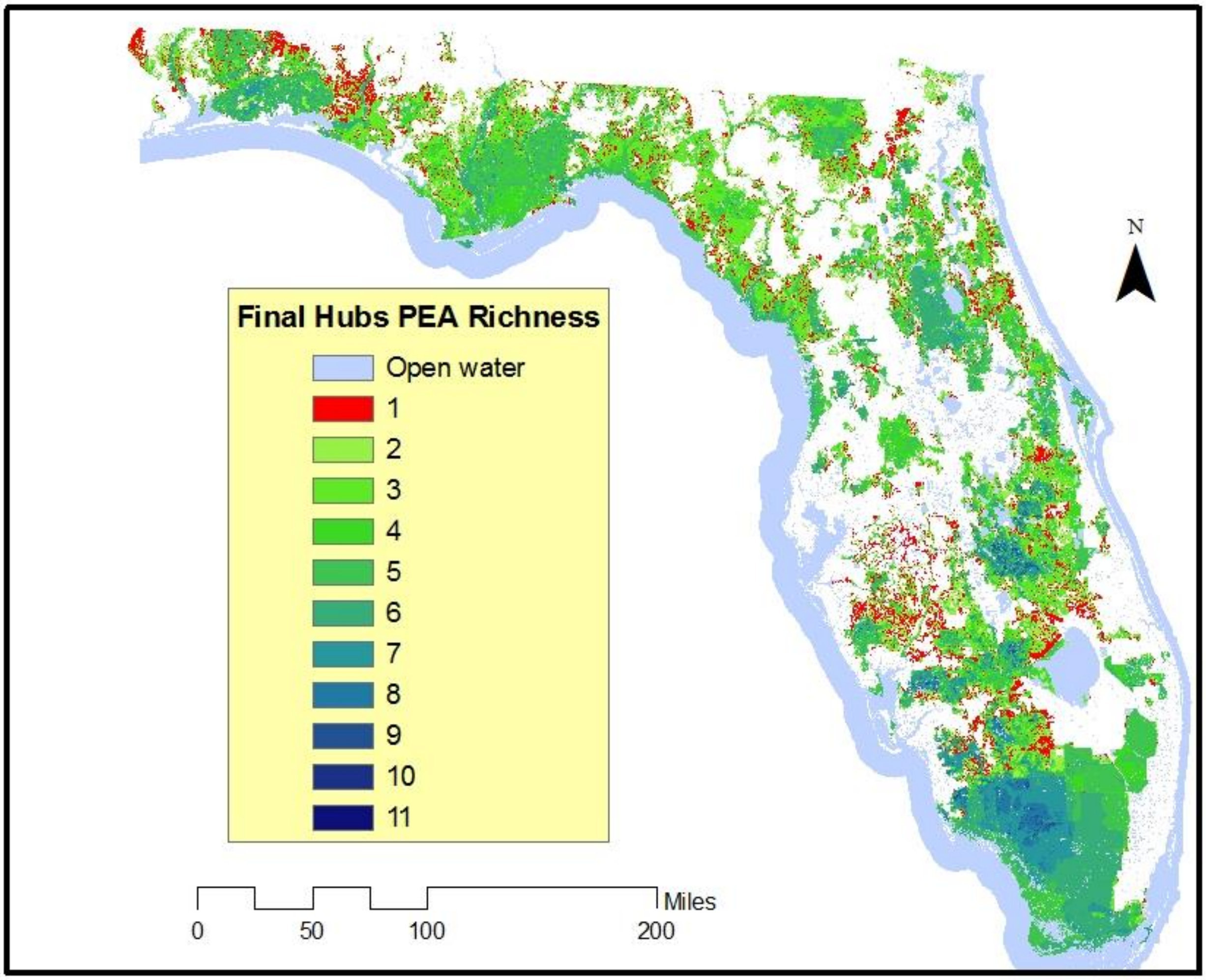

Figure 21. Final Hubs PEA Richness.

Table 24. Final Hubs PEA Richness.

PEA Criteria Overlap	Acres
0	64,093
1	2,220,839
2	2,061,131
3	3,843,238
4	2,792,112
5	3,593,586
6	2,777,424
7	1,125,746
8	361,122
9	70,548
10	262
11	0.2

Table 25. Final Hubs PEA Criteria contribution to final Hubs identified by one PEA criterion.

Pea Criterion	Acres
Bear Habitat Priorities	966,905
FNAI Landscape Species Habitat	357,739
FNAI PNAs	253,401
Panther Habitat Priorities	229,273
Integrated Habitat Network	208,482
CLIP SHCAs	61,563
Existing Conservation Lands	39,906
CLIP FNAI Species Habitat	37,334
CLIP Under-represented NCs	31,249
CLIP Wetlands	28,693
FNAI Landscape/Matrix NCs	5,251
COBRAs	616
FWC Landscape Species SHCAs/Habitat	0.4
Total Acres of Hubs based on 1 PEA Criterion	2,220,413

Table 26. Potential Criteria for Hub Optimization. Green represents criteria not used as PEAs.

Data layer	Priority area criterion	Exclusion criteria
Landscape Species	All high priority FNAI habitat or SHCAs or FWC potential habitat (for Sherman's fox squirrel only)	Remove only developed lands
FNAI Rare Matrix-Landscape Natural Communities	Matrix communities (sandhill, flatwoods, dry prairie, upland hardwood forest, upland pine)	Remove only developed lands
USFWS Florida panther conservation zones	All areas within the Secondary Zone	Remove only developed lands
University of Tennessee USFWS panther habitat	Low habitat potential	Remove only developed lands
Florida black bear habitat quality model	All areas having a habitat quality index of 7 or higher	Remove only developed lands
Existing conservation lands	All such lands	Remove only developed lands
FWC Strategic Habitat Conservation Areas (SHCA)	SHCAs P1-P3	Remove only developed lands
FNAI Rare Species Habitat	Priority 1-3	Remove only developed lands
FNAI Rare Natural Communities	All areas	Remove only developed lands
FNAI Functional Wetlands	Priority 1-2	Remove only developed lands
FNAI Potential Natural Areas (PNAs)	All PNAs 1-4 and 100s with high LI-LC scores	Do not include any intensive agriculture or developed lands
Lands identified as part of the Coastal Barrier Resources Act	All such lands with high LI-LC scores	Do not include any intensive agriculture or developed lands
Florida Forever Projects	All such lands	Remove only developed lands
FWC Species Richness	7-13 species	Remove only developed lands
State Aquatic Preserves, National Estuarine Research Reserves, Outstanding Florida Waters, National Marine Sanctuary	All such designated aquatic ecosystems	Do not include any intensive agriculture or developed lands

APPENDIX B: FLORIDA BLACK BEAR HABITAT AND CONNECTIVITY MODELING

Introduction

The Florida Black Bear (*Ursus americanus floridanus*) is a species that requires large, intact home ranges and sufficient connectivity to multiple populations to ensure genetic variability and population viability (Hellgren and Maehr 1992). Black Bear populations are still considered threatened, but populations are growing due to conservation efforts and re-occupation of suitable habitat that bears were extirpated from due to human encroachment.

To better understand the habitat needs and migratory barriers to these animals, the use of ecological modeling was employed. Two integrated modeling techniques: habitat suitability modeling and connectivity analyses were used in this study to answer questions of species distribution and connectivity. The habitat suitability analyses performed help identify areas focal species are likely to occupy based on presence records (dependent variable) and environmental layers (independent variables). Using spatial statistical tools, habitat patches of sufficient quality can be identified based on the relationship between records of species' presence and the corresponding environmental layers. Once areas of suitable size and quality are identified, connectivity analyses can be performed to assess the ability of the species to migrate throughout the current landscape from core area (or hub) to the next. This migration/dispersal potential is quantitatively based upon output from habitat suitability modeling. Using different connectivity theories, such as least cost path, network and current flow (using electrical conductance theory) can give scientists and managers a more robust model of species distribution and movements.

Methodology

Habitat Suitability Model.--To predict the extent of a species' distribution, the Maximum Entropy Model (Maxent) was applied. Maxent predicts the probability of a species' occurrence across a landscape based on presence only point data in conjunction with environmental variable layers. Maxent finds the largest spread (maximum entropy) in a geographical dataset of species presences in relation to these environmental layers. The resulting output is expressed as the log likelihood of the data associated with presence data minus a penalty term. Each environmental layer is weighted by how much complexity it adds to the model and the sum of these weightings determine how much the likelihood should be penalized for over-fitting. Maxent runs through an optimization routine where all cells start with equal probability, and the model continually improves "fit" measured by gain (Elith et al. 2010). Gain measures the likelihood of deviance, which maximizes the probability of presences in relation to the background data. The exponent of gain measures the mean probability of presence samples versus random background samples. Area Under Curve (AUC) is another metric of model performance; the maximum achievable AUC is less than one. A value of 0.50 means the model's prediction is no better than a random guess. The closer to AUC is to one, the better the model predicts species occurrence.

Data Sources and Processing.-- Data required for habitat suitability modeling were presence locations (X/Y data) and environmental layers, expressed in ASCII format. Several processes were required to convert data to the appropriate format and continuity, for use within the model. To ensure uniformity, all data required post-processing. All layers were clipped to the Florida state boundary, projected in NAD 83 HARN Albers and header information checked for uniformity to prepare for model input.

Presence Data.--Presence data was taken from either GPS or radio telemetry of tagged individuals. At a minimum, each record provided indicates species, latitude, longitude, date, time and sex. Age was not included with the data, and individuals were not assumed to be tagged from birth. Therefore juvenile Black Bears may or may not be included in the analysis.

Black Bear data was obtained through Florida Fish and Wildlife Commission and the University of Kentucky's Department of Forestry South-Central Florida Black Bear Project. Supplied data spans from 1983 – 2010. Multiple model scenarios were tested, and the most recent ten years of data was found to be of the highest statistical significance. To ensure uniformity and discourage bias, Black Bear presence locations were filtered using the following criteria:

- Most recent 10-year period (2000 – 2010)
- Both male and female bears were used
- Individuals with less than 50 records were removed
- A random subset of 50 records was selected per individual to eliminate bias of an individual with more than 50 data points
- In addition, separate scenarios were modeled using only the Highlands/Glades population to address subpopulation-specific needs. This data was re-integrated with statewide model results for further connectivity analysis.

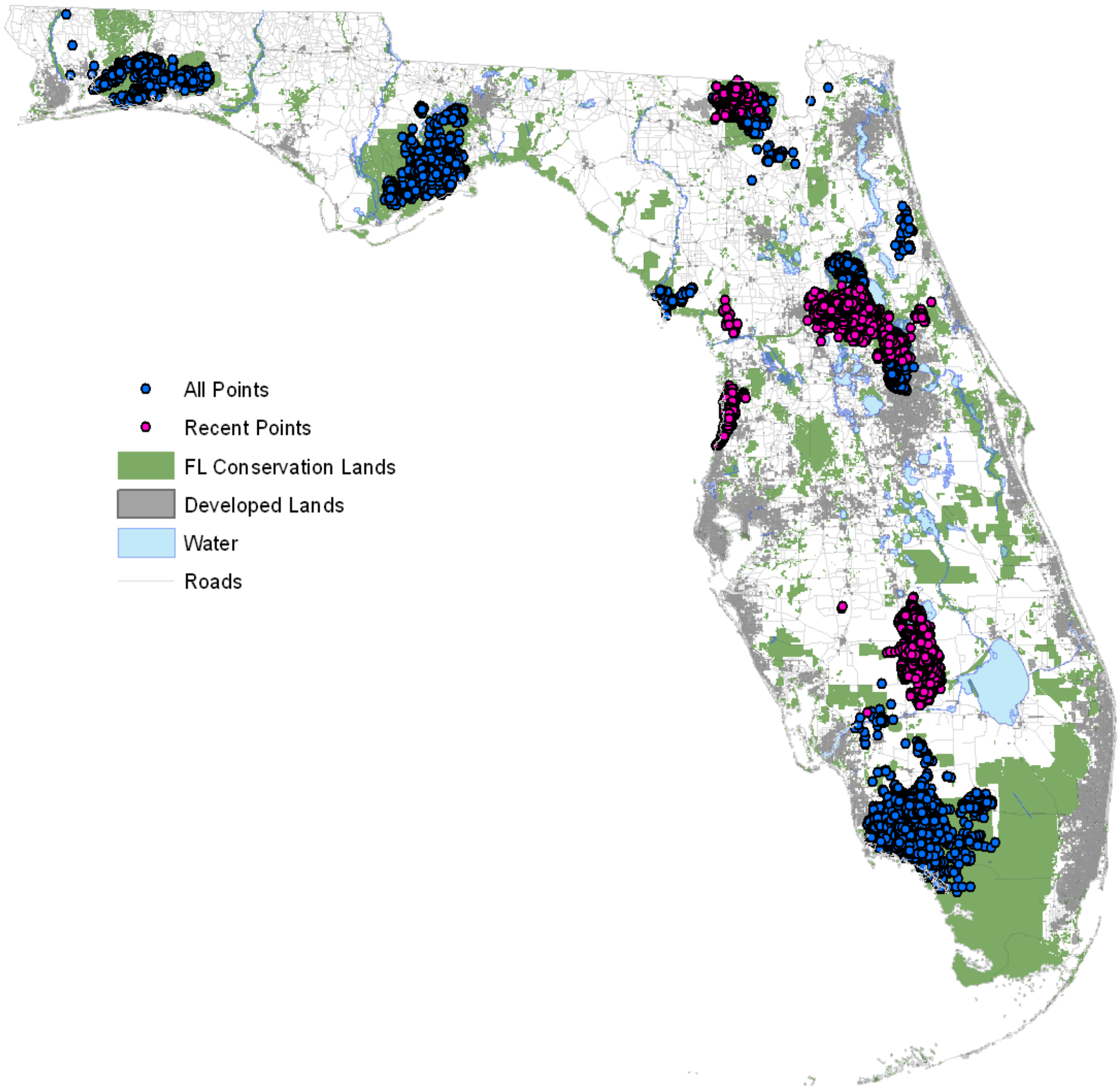

Figure 1. Presence Data for Florida Black Bear.

Training and Testing.--Maxent uses a percentage of input data to test model performance while the remaining data is used as training data to determine model parameters. Different percentage values were tested, but the general consensus in the machine learning community recommends using approximately 30% of the data for testing purposes (Witten et al. 2011). This is what was eventually decided upon. The performance of different combinations of variables was evaluated to achieve the best results for successive connectivity analyses.

Independent Variables.--Environmental variables used in the Black Bear analysis are explained below.

- Landscape context layers from the CLIP 2.0 report (Oetting et al. 2012):
    - Landscape Integrity: This layer is comprised of two related landscape indices assessing ecological integrity based on land use intensity and patch size of natural communities and semi-natural land uses. The landscape integrity layer was developed as part of the CLIP TAG process after discussion about the need for an additional landscape layer that identified areas of high ecological integrity based on land use intensity and patch size, where areas dominated by large patches of natural and semi-natural land use are assigned the highest significance.

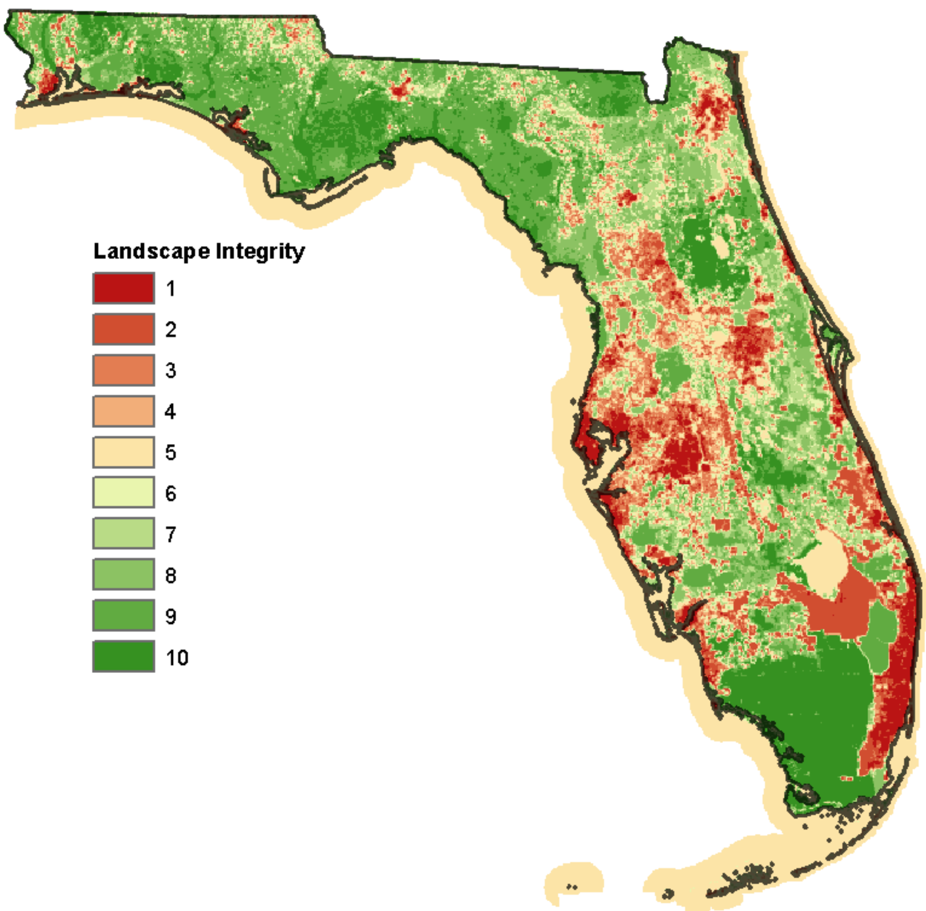

Figure 2. CLIP 2.0 Landscape Integrity.

- Intactness/Fragmentation: This is a multi-scale model of landscape intactness (in this sense, the opposite of fragmentation) where all natural and semi-natural land uses is treated as "intact" and all other land uses are treated as "not intact" (improved pasture in the south-central and southwest Florida prairie region is included as intact in this model in the same fashion as the Patch Size model in the landscape context analysis and the Landscape Integrity core data layer described above). The land use data used is from the 2009 Cooperative Land Cover Data. Then a focal sum neighborhood analysis is done at three scales (approximately 10 acres; approximately 100 acres; and approximately 1000 acres), then ranked into 9 priority classes based on percent intact, and then all three scale results are combined with equal weighting to identify the areas in the state with the most and least intact land cover.

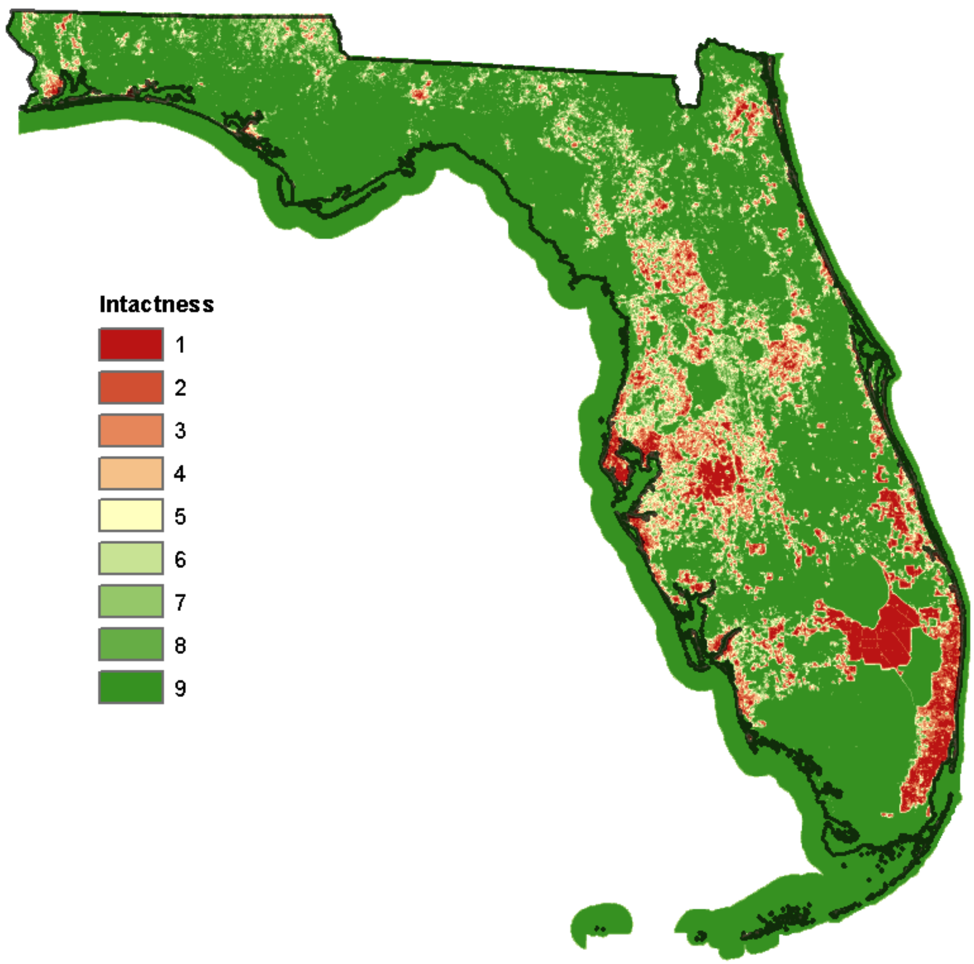

Figure 3. CLIP 2.0 Landscape Intactness/Fragmentation.

- Distance from Intensive Land Uses: Intensive development was defined as all higher density residential, commercial, and industrial land uses (including active mining operations) in patches 100 acres or larger. The land use data used is from the 2009 Cooperative Land Cover Data within Florida and Southeastern GAP land cover data.

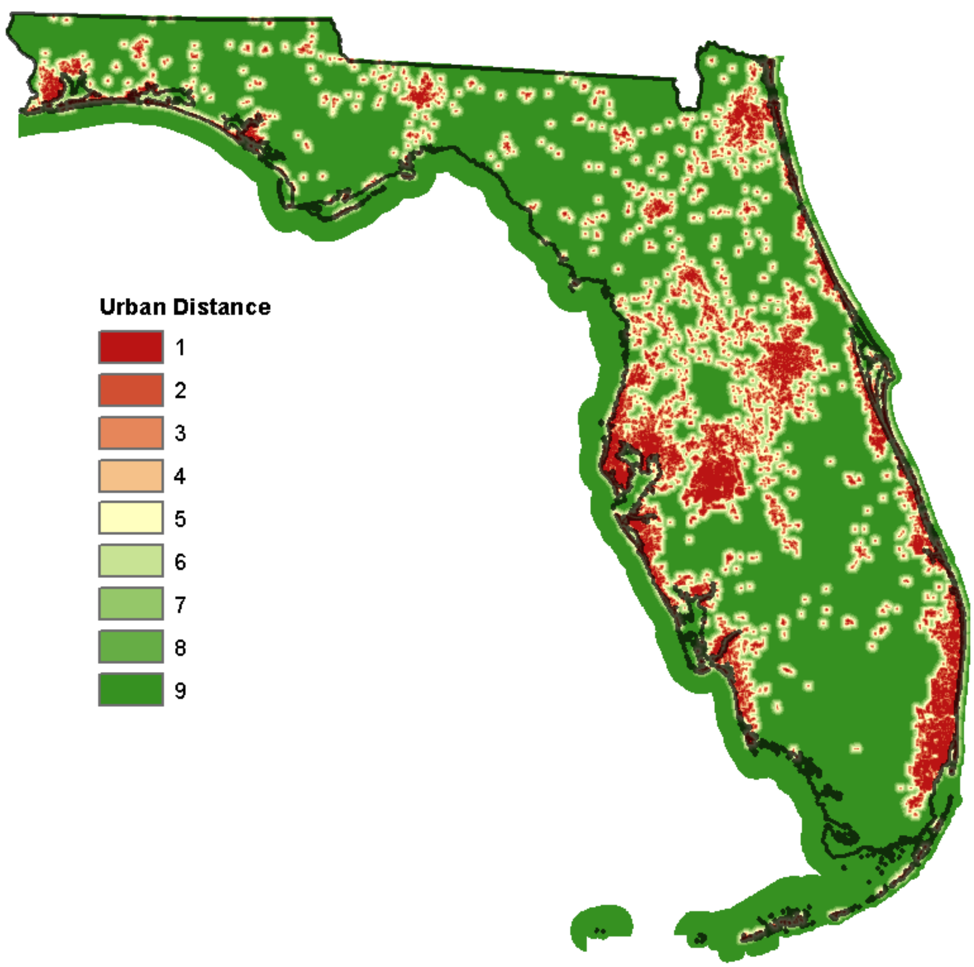

Figure 4. CLIP 2.0 Distance from Intensive Land Uses.

- Roads Context: Three road-based models (all roadless, major roadless, and road density) were combined into a Roads Context layer using equal weighting.
    - All Roadless: Used all roads within the U.S. Geological Survey 1:24,000 digital line graph roads. Only narrow areas of water (less than 90 meters wide) were included within roadless areas. Open water was not included in roadless areas because this analysis is intended to focus on terrestrial ecosystems and large water bodies tend to bias roadless analyses.
    - Major Roads Roadless: Used only the roads within the Florida Department of Transportations Major Roads data layers. This layer only includes major highways and arterial roads including interstates, toll roads, U.S. Highways, state roads, and at least most county roads. This layer does not include residential or other smaller paved roads, improved dirt or gravel roads, or jeep trails.
    - Road Density: We calculated road density using the U.S. Geological Survey 1:240,000 digital line graph roads. This index represents straight road density in miles/mile2 using a 1-mile search radius.

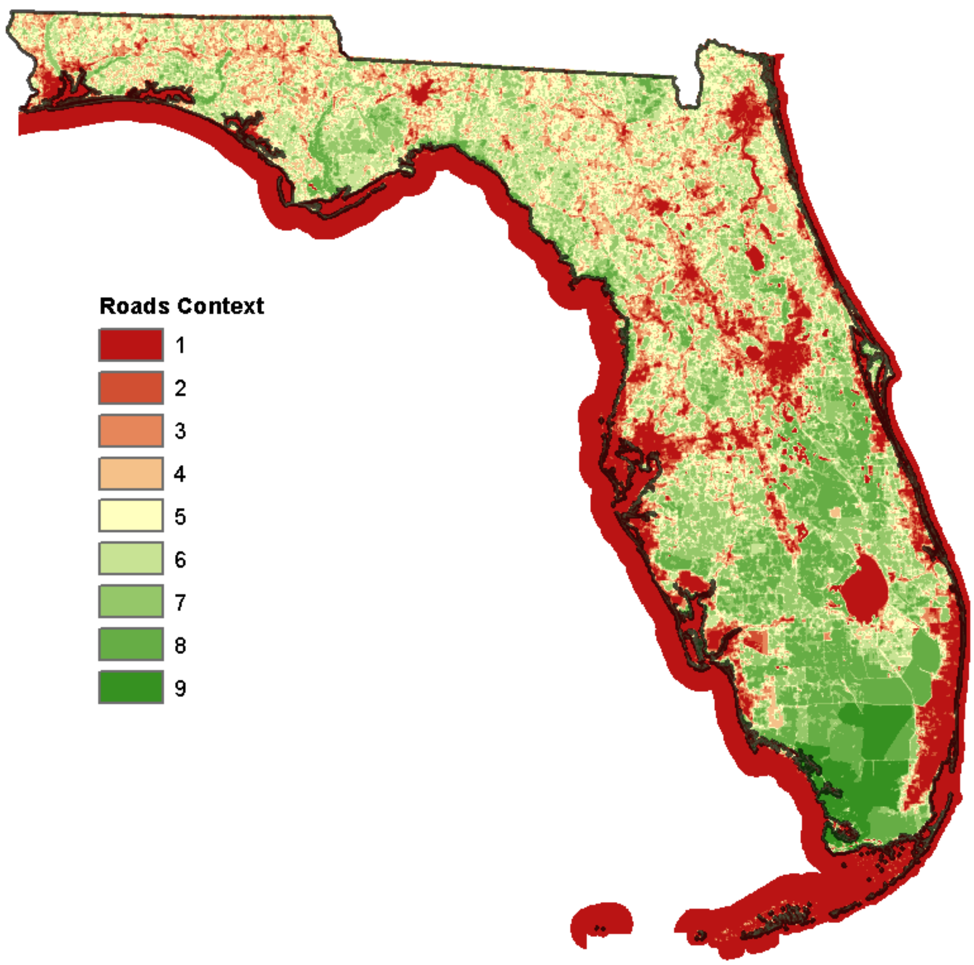

Figure 5. CLIP 2.0 Roads Context.

- Bear specific independent variables:
    - Primary and Secondary Black Bear Habitat: This variable identifies primary habitat as blocks 15.2 ha and larger and secondary habitat as all smaller blocks of preferred cover types and less preferred cover types within 1 km of primary blocks. Habitats are reclassified as either 1 (primary and secondary habitat) or 0 (non-habitat).

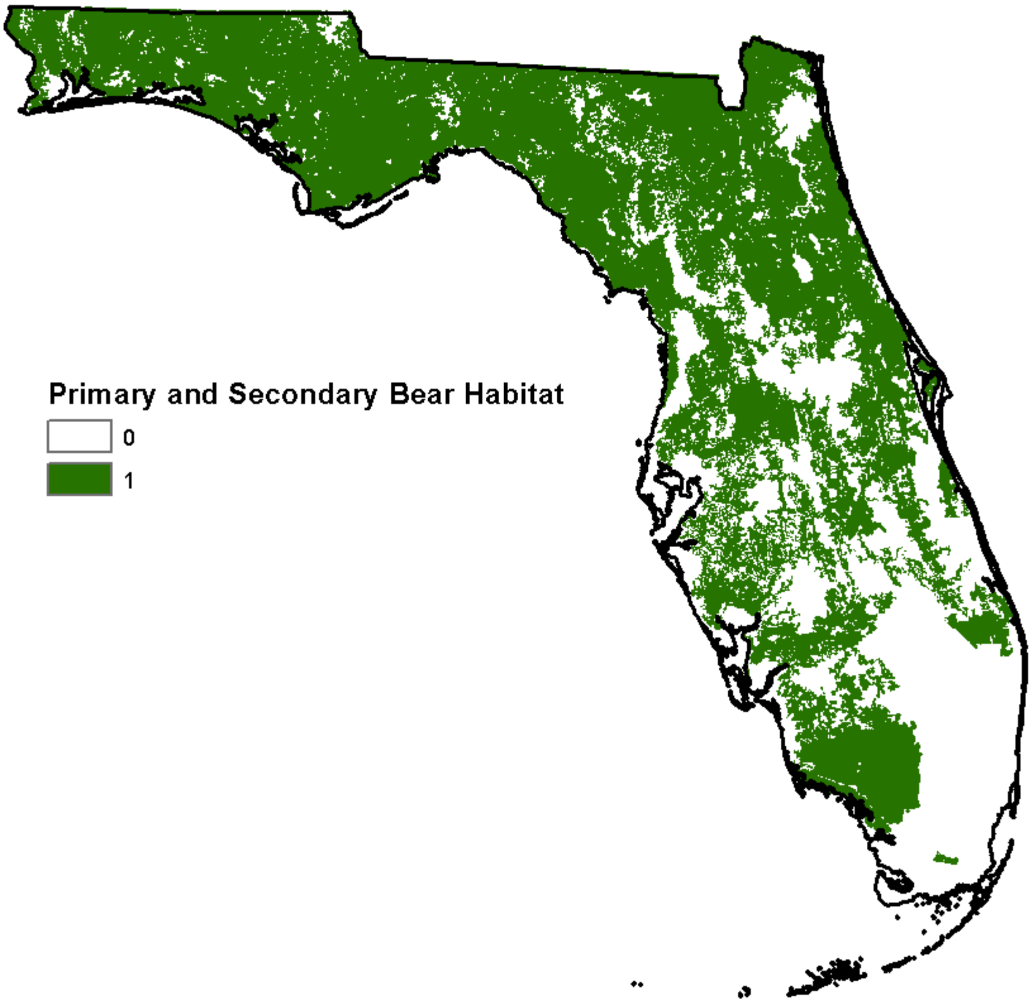

Figure 6. Primary and Secondary Bear Habitat.

- Block Size Primary and Secondary Habitat: This predictor identifies contiguous blocks of primary and secondary habitat bounded by major roads (in this case, major roads are all roads with average daily traffic of 2500 or greater and other road segments within 100m of bear road kills). The value used in the model is patch size (m2) modified using a logarithmic transformation due to the large variation in patch sizes.

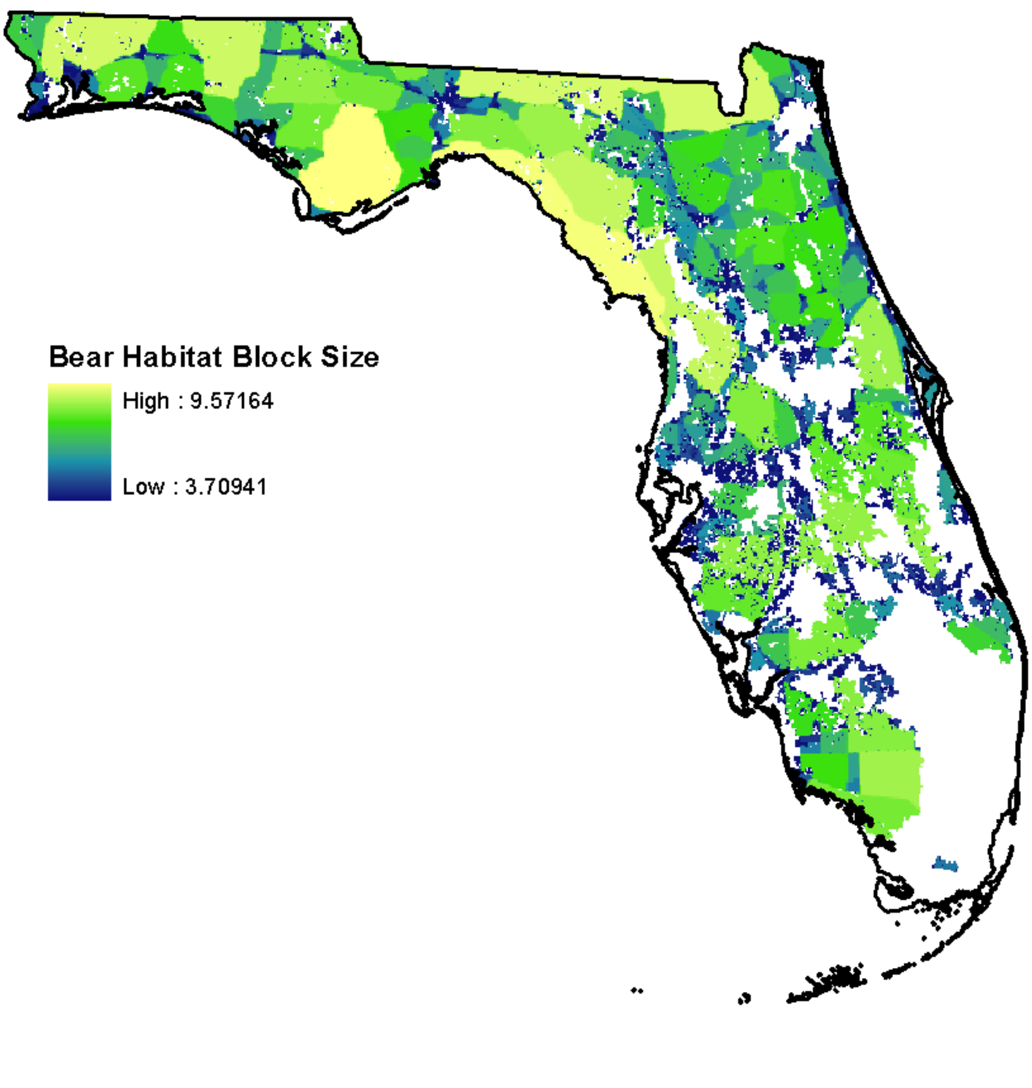

Figure 7. Bear Habitat Block Size.

- Major Roadless Patches: This data set includes interstate highways, turnpikes, parkways, state highways, and some county roads and is derived from the Landscape Context data.

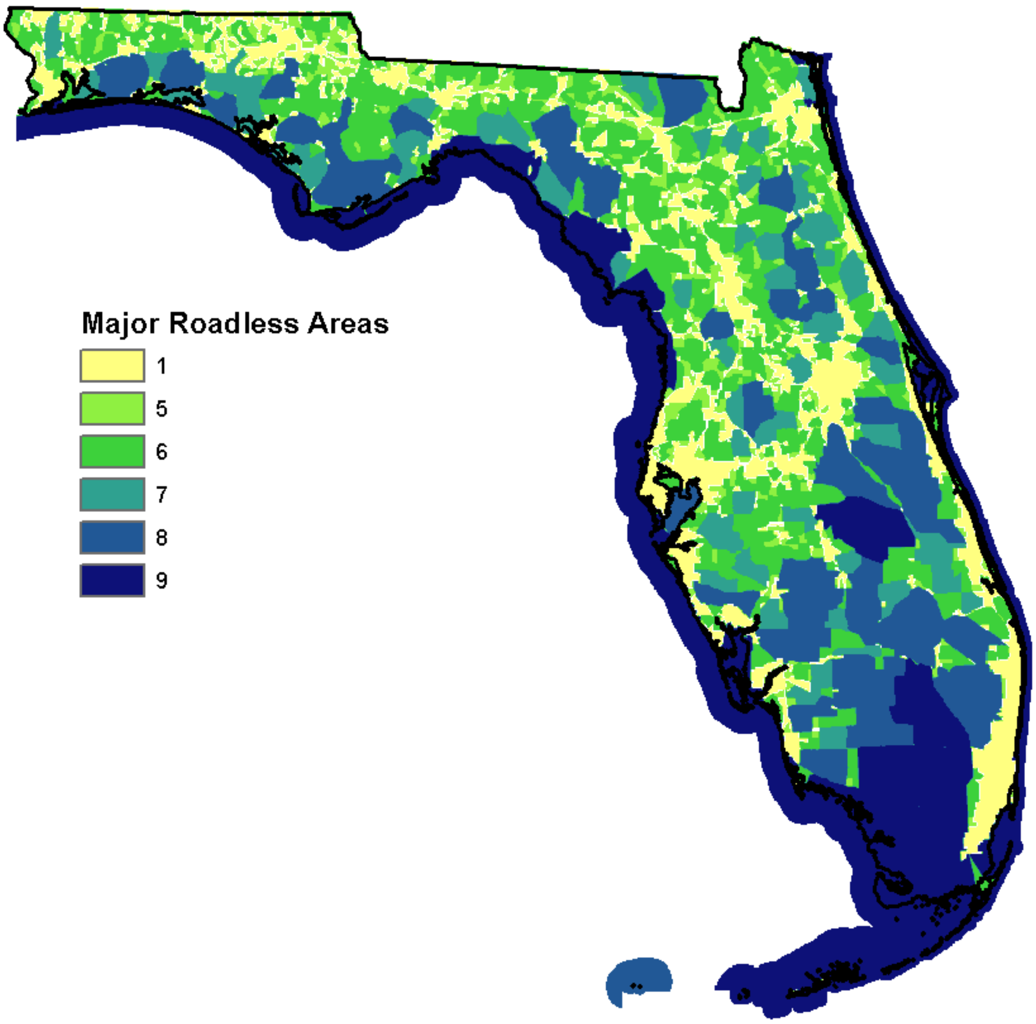

Figure 8. Major Roadless Areas.

- Forest Density: This is a landscape scale variable where the amount of forest was calculated in a 35 x 35 neighborhood using 90 m cells. The values used in the model were the number of cells within the neighborhood that contained forest cover.

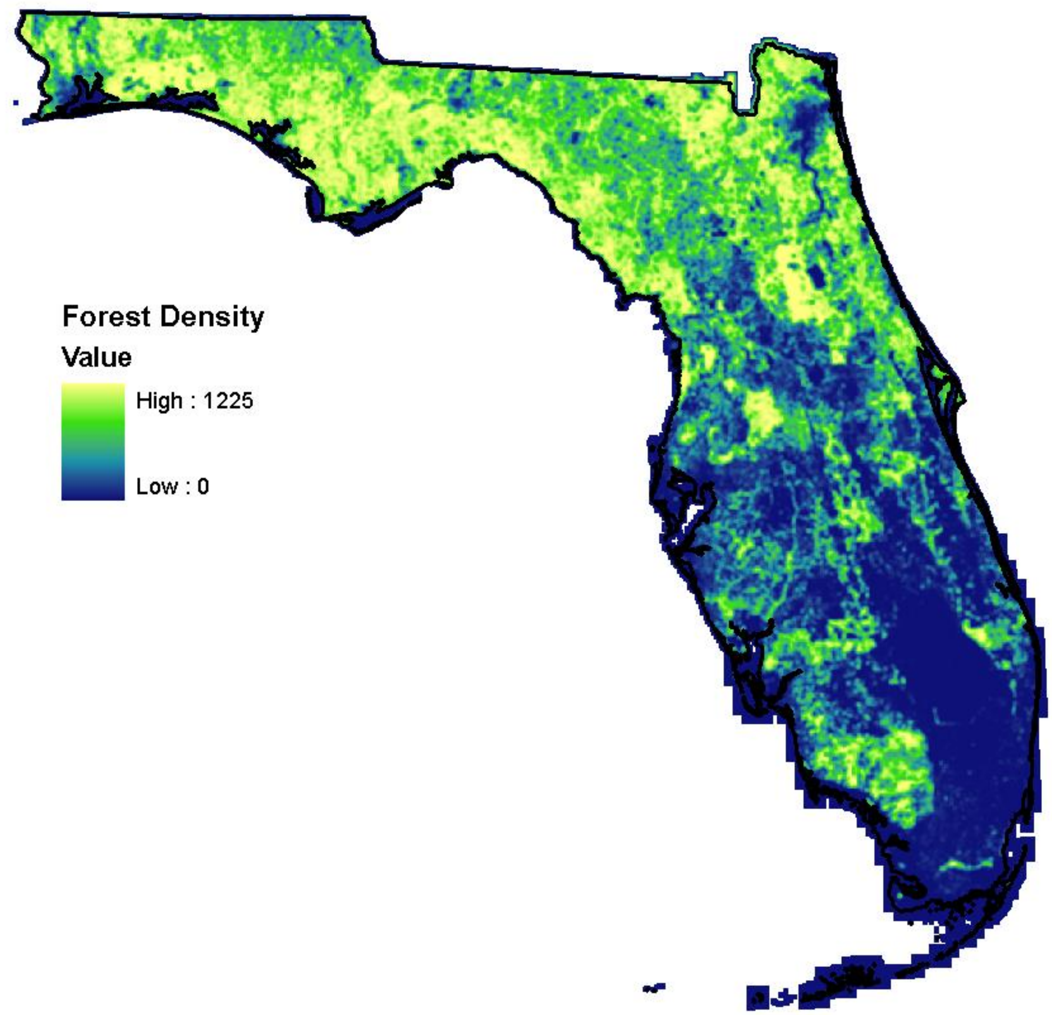

Figure 9. Forest Density.

- Land Use Intensity: This is a landscape scale variable using a neighborhood analysis in a 11 x 11 window with 90 m cells. Land uses were lumped into 4 categories: natural, which was given a value of 0; low intensity and semi-natural, which was given a value of 1; moderate intensity including most agriculture and some mining, which was given a value of 2, and high intensity including residential, commercial, and industrial, which was given a value of 3. These values were then summed for each focal cell of the neighborhood so that the larger the returned value, the more intensive the land use in the surrounding area.

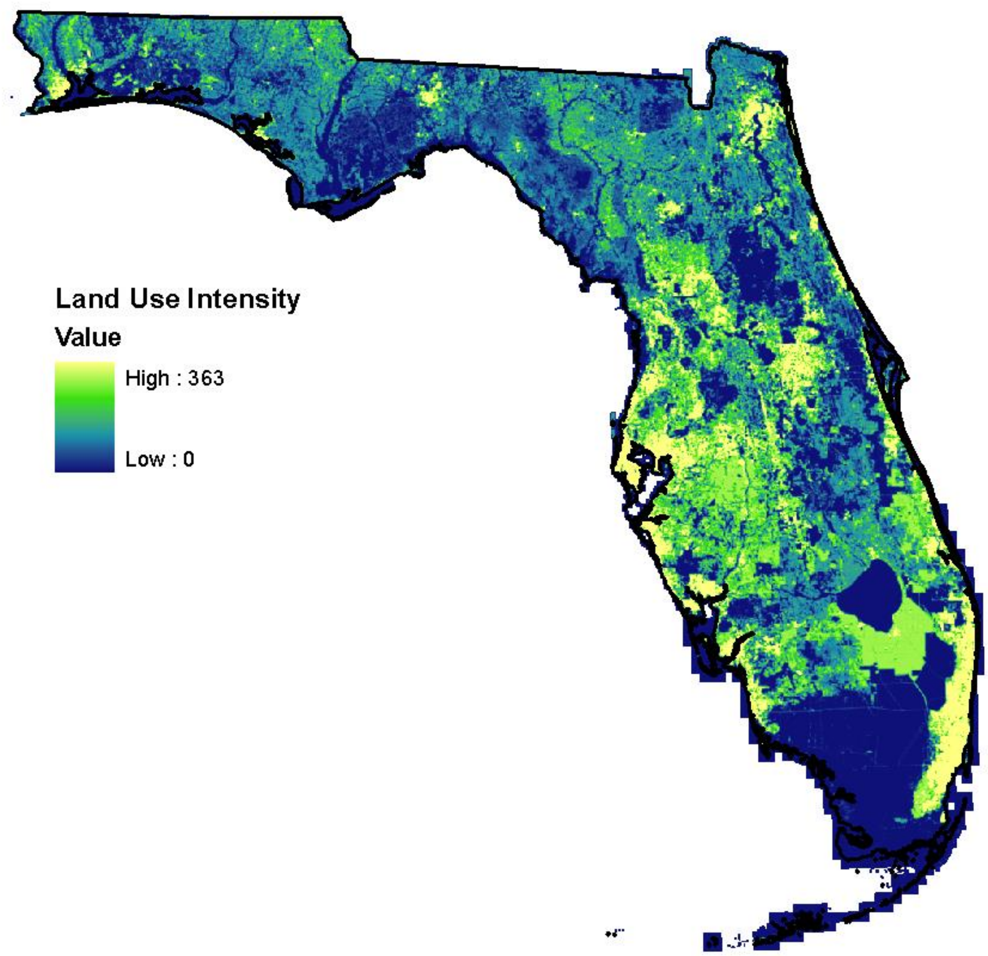

Figure 10. Land Use Intensity.

- Bear Habitat Density: This variable was created by giving primary and secondary habitat the same value: 1, and all other cells a 0, and then a neighborhood analysis was conducted at the scale of 11 x 11 90 m cell area.

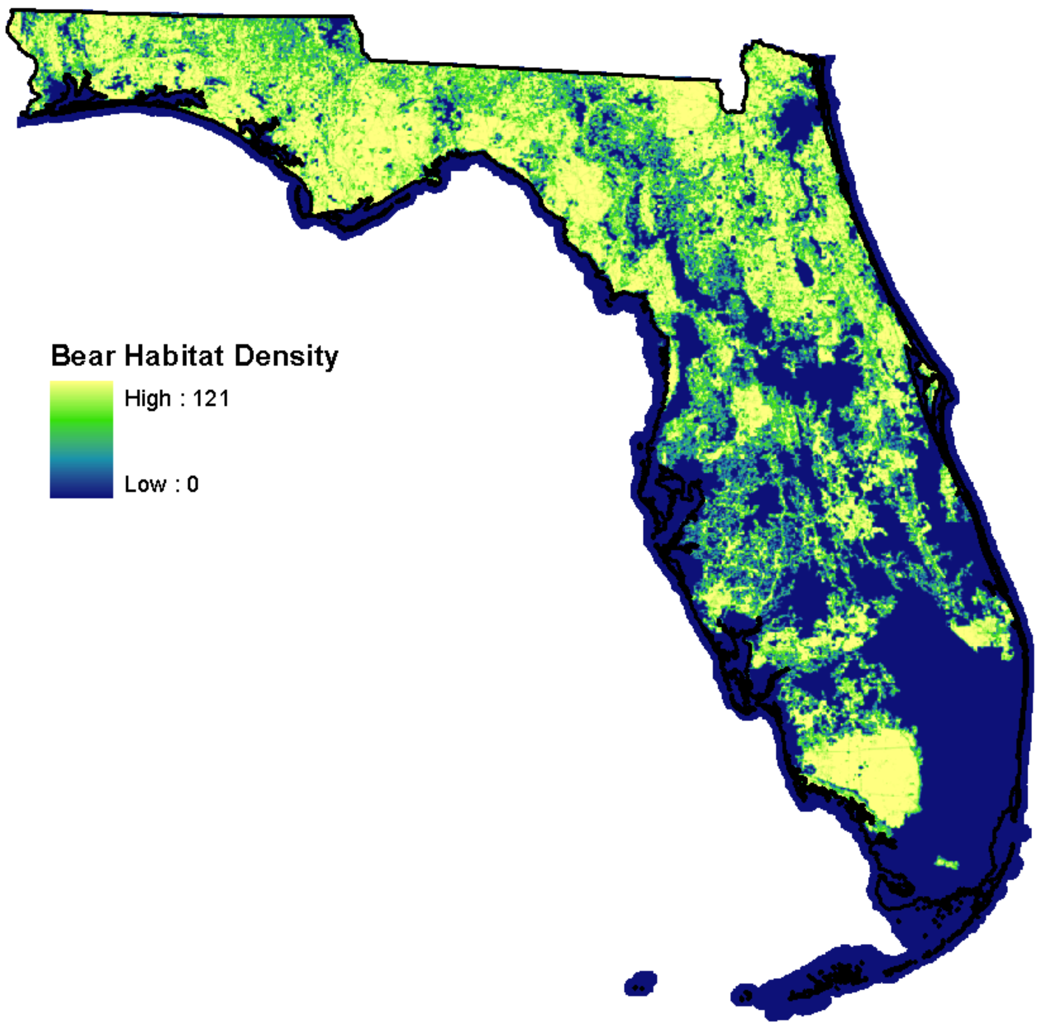

Figure 11. Bear Habitat Density.

Scenarios Modeled.--Five different independent variable scenarios were modeled for each of two different point datasets (Statewide and Highlands/Glades), indicating ten scenarios overall:

- Landscape Context
- Bear Specific Variables
- Bear Specific Variables minus Bear Habitat Block Size
- Bear Specific Variables + Landscape Context
- Bear Specific Variables + Landscape Context minus Bear Habitat Block Size

The resulting models were evaluated for model performance metrics and visual consensus among wildlife experts. Based upon these considerations, the "Bear Specific Variables + Landscape Context minus Bear Habitat Block Size" model was chosen to be used as a basis for future connectivity analyses.

Additional Suitability Model Post-Processing.--Based upon differences between the Highlands Population and the rest of the subpopulations it was decided to integrate a separate instance of the habitat suitability model for the Highlands/Glades region. This model was trained using Highlands/Glades data only. Model runs using the individual subpopulations as test data, and the whole population as training data, also indicate poor model performance using the Highlands/Glades subpopulation as a test example. Results were then integrated with the statewide habitat suitability model by using the Highlands/Glades subpopulation home range (outline shown in green).

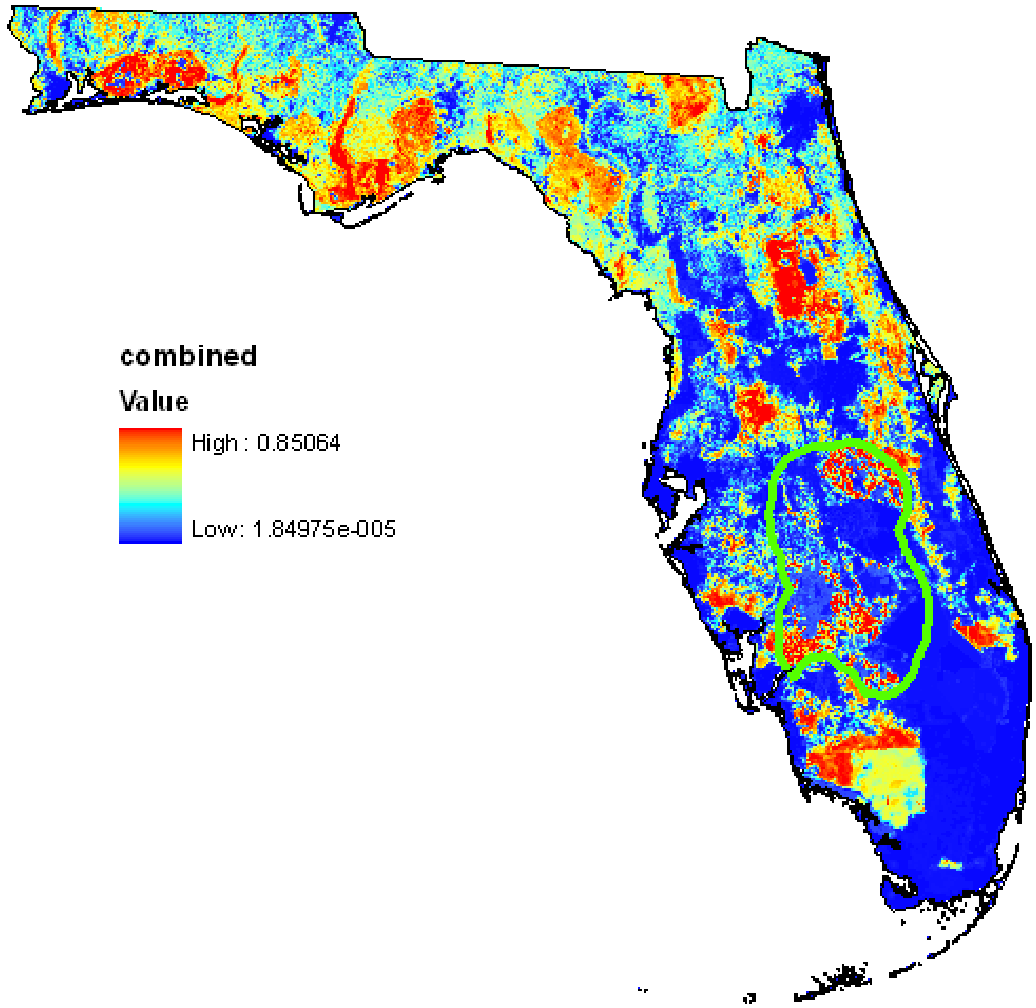

Figure 12. Highlands/Glades bear population integrated suitability model.

Maxent model output used in connectivity analyses includes an additional noData filter for developed lands. Doing this excludes such areas from subsequent connectivity analyses.

Habitat Patch Creation.--Core areas of habitat were created using a combination of the selected Maxent output and existing Bear home ranges. Maxent results were filtered by probability of presence and patch size. A minimum 50% probability or presence threshold with 2,000-acre minimum patch size was used to create core hub areas. Additional areas were added to the hubs layer based on wildlife biologist input. Core habitat patches, or hubs were aggregated using a 3x3 cell neighborhood analysis in ArcGIS. The resulting output was expressed in vector format.

Connectivity Analysis.--Connectivity was assessed in three different ways: least cost path, shortest path and current flow methods. Least cost paths were modeled between specified hubs using the cost distance and cost path tools in ArcGIS. This analysis identifies a single path between the selected hubs using an inverse of the Maxent habitat model as a cost surface.

The shortest path analysis was performed using Connectivity Analysis Toolkit. This methodology identifies a minimum network of linkages between nodes. The Connectivity Analysis Toolkit employs network theory to assess connectivity throughout the landscape. This is a stand-alone tool, which processes an ASCII file created from habitat suitability raster data. A hexagonal network shapefile is created from the habitat suitability model at a user-specified resolution. Points and lines on the graph represent nodes and pathways, where nodes facilitate movement across a graph. The resulting output shows the network of linkages in raster format.

Current flow analysis considers conductance and resistance though a diffuse landscape and produces a more distributed output. The Connectivity Analysis Toolkit also models current flow, but the model Circuitscape was ultimately chosen due to its added features and faster performance. Circuitscape analyses connectivity as if the landscape were an open circuit. Therefore, a habitat suitability model can be used to specify either conductance or resistance throughout the landscape. Each hub area is used as a current source node to assess pairwise connectivity between hubs. The model supplies a current source and results are shown as voltage flow across the landscape.

Results

Maxent Output.--The maps below represent the Maxent model output for Florida Black Bear's probability of presence. Warmer colors show areas with higher probability conditions. Areas of high probability tend to occupy portions on or adjacent to existing natural/conservation areas. This helps to further validate the model. These areas include: Big Cypress, Avon Park, Kissimmee Prairie, Green Swamp, Ocala National Forest, Osceola/Okefenokee, Apalachicola and Eglin AFB.

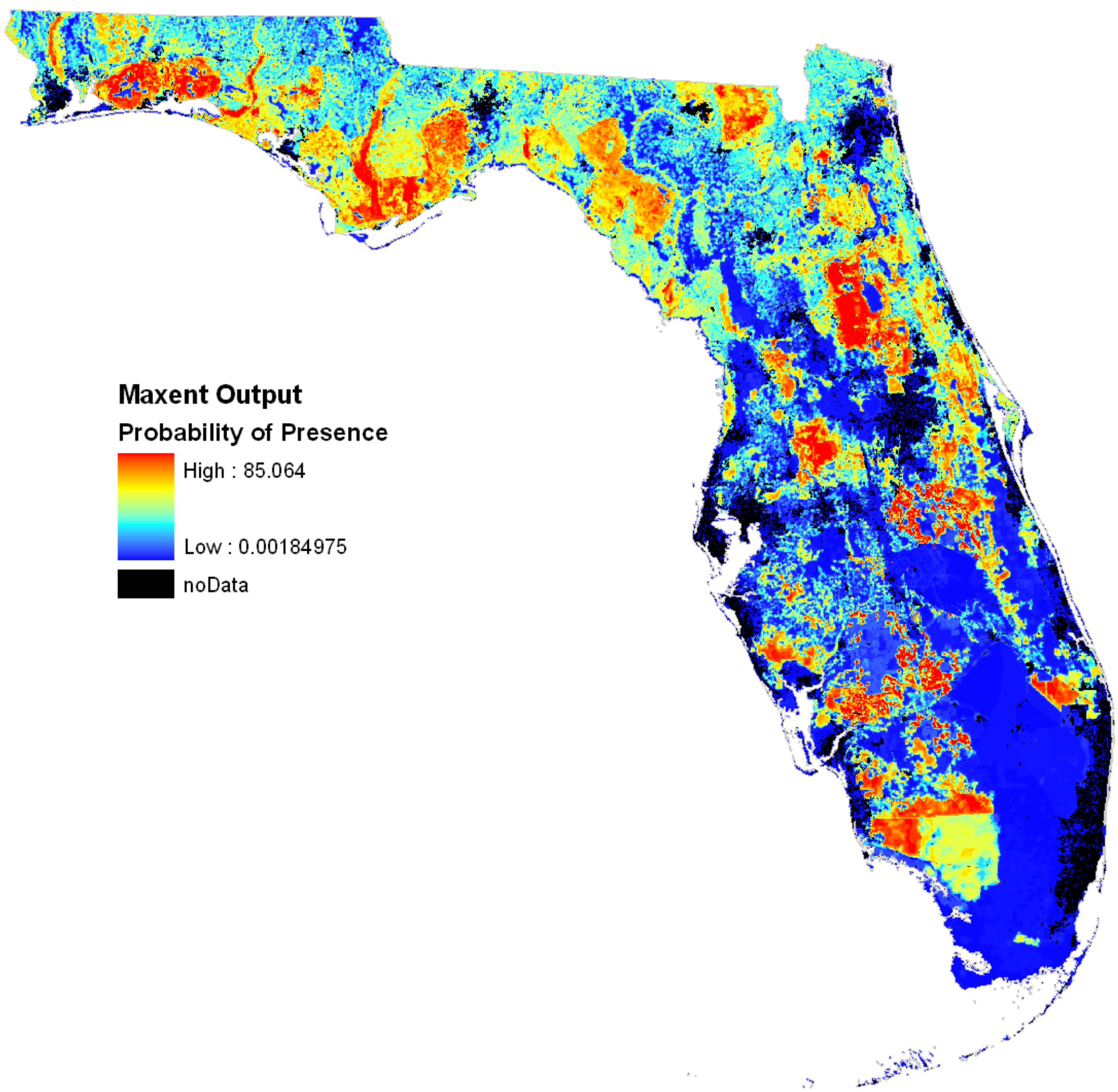

Figure 13. Florida Black Bear Maxent output results

Model Performance.--To assess model performance, the Area Under Curve (AUC) and Gain are observed to determine how well specific scenarios predict the presence of species by using test points. AUC expresses how close the test data performs to the training data, while gain is a representation of how much more likely a prediction will be compared to a random offering. The maximum achievable AUC is less than one. A value of 0.50 means the model's prediction is no better than a random guess. The closer to AUC is to one, the better the model fit. Table 1, below, shows the AUC and Gain for each scenario modeled.

Table 1 - Summary of Model Performance

Scenario	AUC	Gain
Recent Data Points 2000 - 2010		
Landscape Context	0.850	0.998
Bear Specific Layers	0.864	1.007
Bear Specific Layers minus Block Size	0.823	0.748
Bear Specific Layers plus Landscape Context	0.860	0.998
Bear Specific Layers (without Block Size) plus Landscape Context	0.810	0.810

For example, regularized training gain for the "Landscape Context" scenario is 0.998. The gain indicates how well the model is concentrated around the presence samples. Thus, exp(0.998) ~= 2.71, meaning average likelihood our model's presence sample is approximately 2.71 times higher than that of a random background sample.

Final Hubs Delineation.--Habitat patch delineation was based upon a 50% probability threshold and a 2,000-acre minimum patch size. Additional areas were added with the help of wildlife experts. The map below shows an aggregate of the habitat patches that meet these quality and size thresholds and added areas.

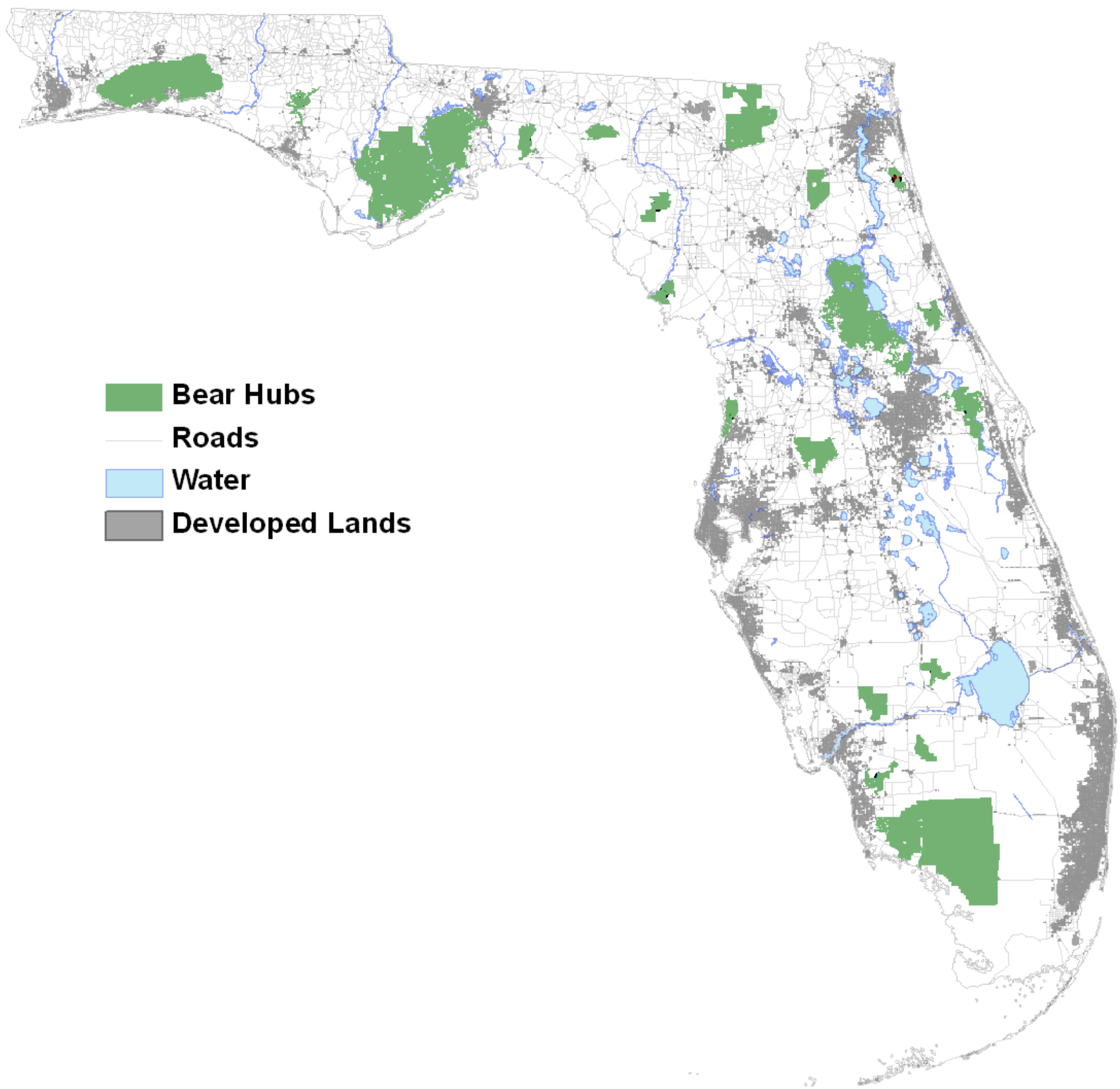

Figure 14. Bear Hubs.

Connectivity Results.-- Both current flow, least cost path and shortest path methodologies show similar pathways and identify critical linkages that should be of high conservation priority. Least cost paths identify a single route between selected nodes while the shortest path analysis may identify alternate paths of lesser suitability. Using current flow, if a wide swath of suitable land exists for a wildlife corridor, values will be less than those of a more restricted corridor. These higher values, identifying restricted flows, can help to better identify stressed or narrow wildlife corridors. Results for current flow, least cost path and shortest path connectivity analyses are shown below.

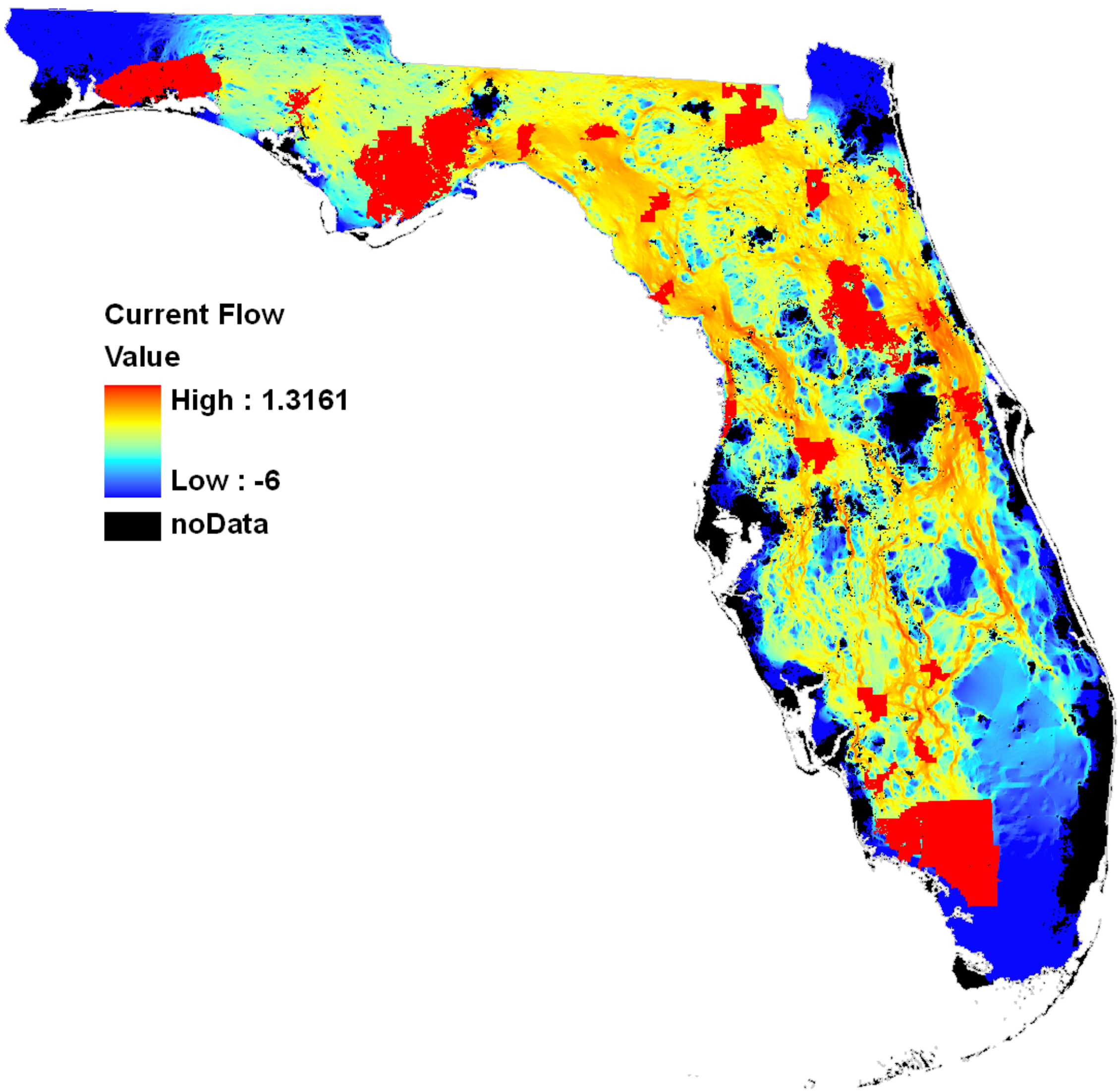

Figure 15. Current Flow Analysis.

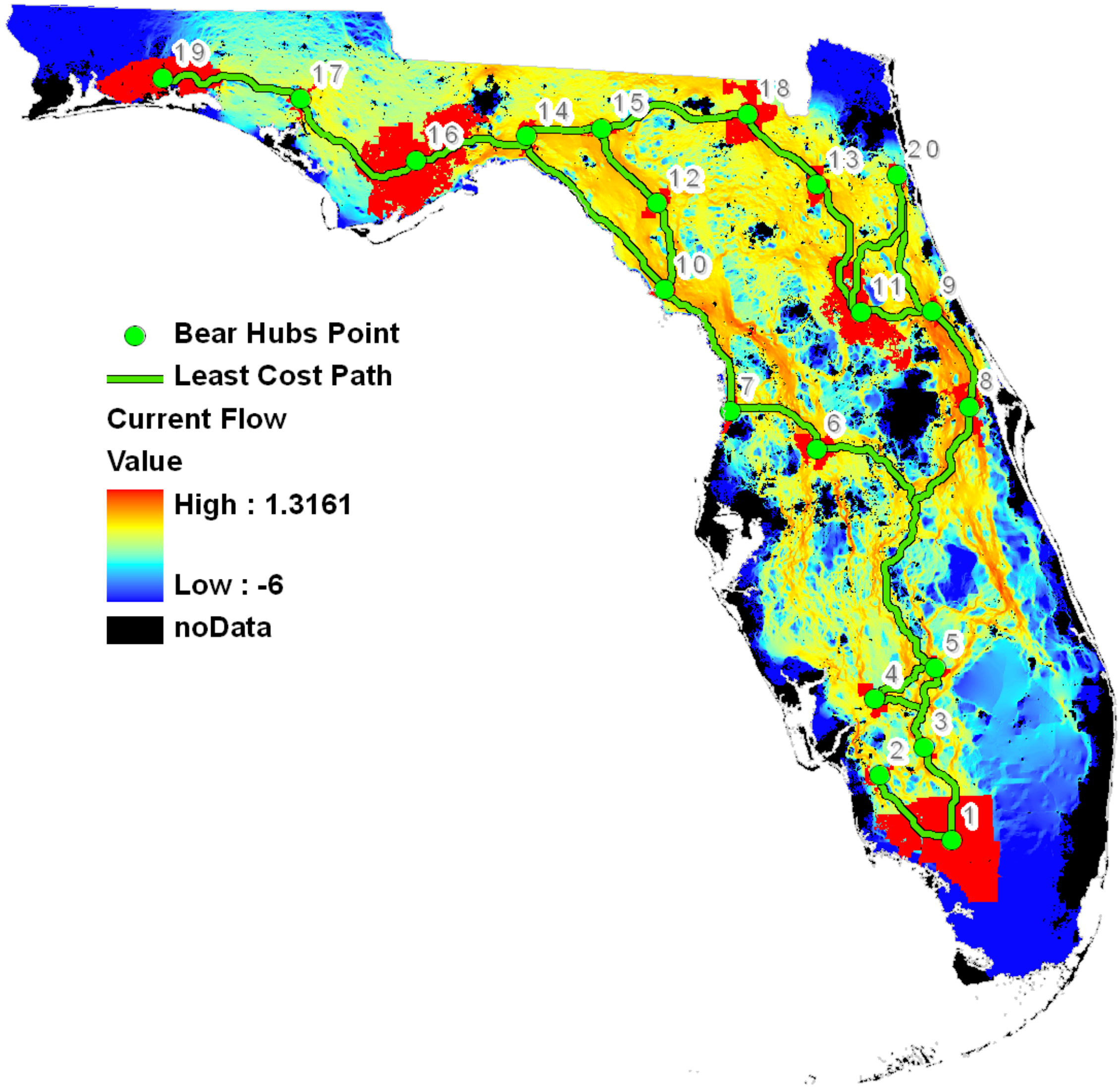

Figure 16. Least Cost Path Analysis.

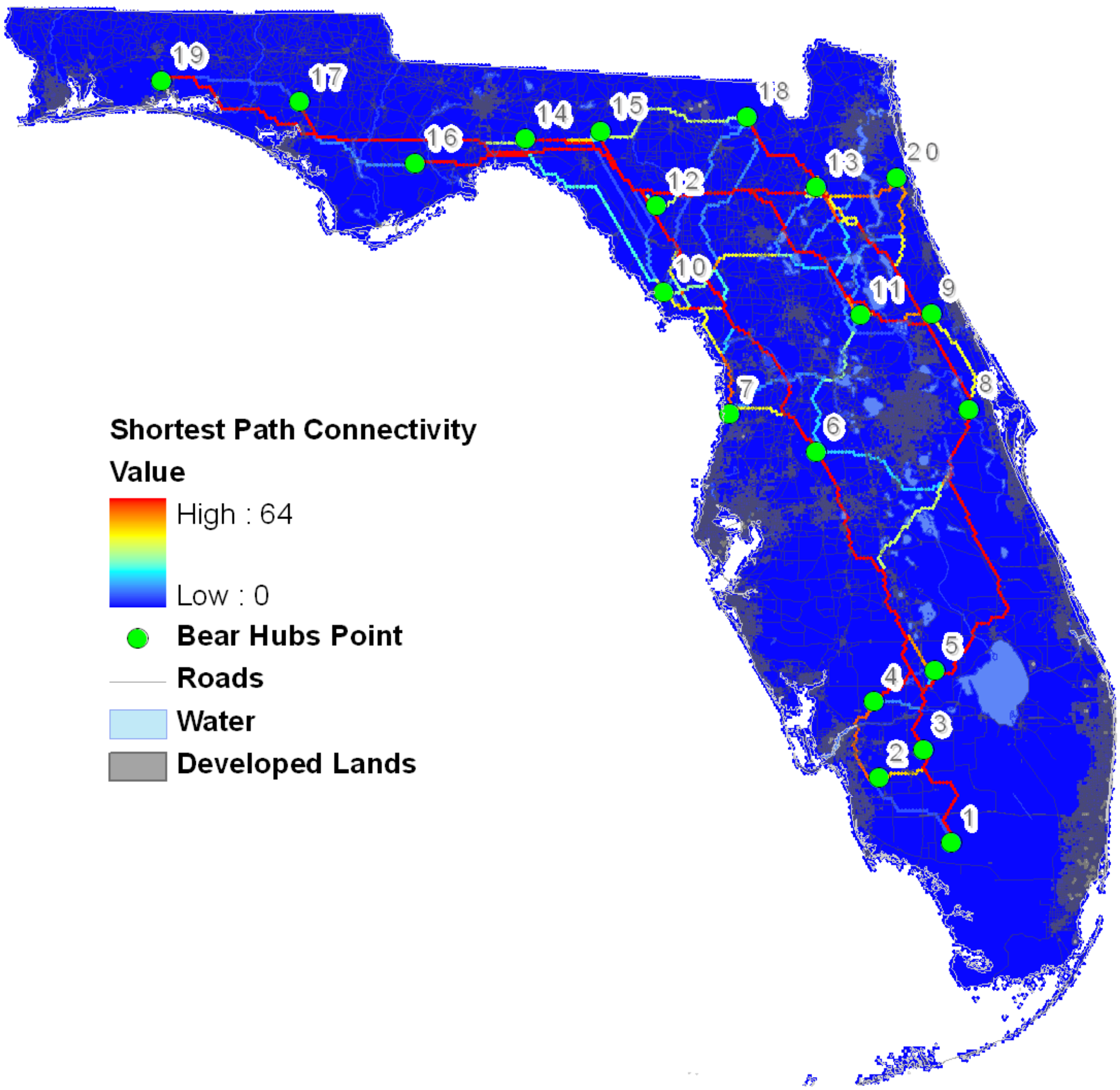

Figure 17. Shortest Path Analysis.

Discussion/Conclusions

In general, the process of determining habitat connectivity for the Florida Black Bear was a three-part process, requiring multiple revisions. Many iterations of the Maxent model were performed to determine the most appropriate selection of telemetry data, which independent variables were significant predictors and which model settings produced the best results. While measures of model performance were considered, once performance surpassed an acceptable threshold, visual cues were strongly considered in final Maxent model selection as well.

Ecological hubs identified by Maxent tend to occupy portions on or adjacent to existing natural areas. These areas include: Big Cypress, Avon Park, Kissimmee Prairie, Green Swamp, Chassahowitzka, Ocala National Forest, Osceola/Okefenokee, Apalachicola and Eglin AFB. These identified hubs were later amended to include additional areas that may not have been included but are important hub areas for the species. These hubs serve as nodes, a critical component for the connectivity analyses.

Connectivity models show the most probable or suitable path(s) based on the Maxent output and ecological hubs. Both current flows, least cost path and shortest path methodologies show similar pathways and identify critical linkages that should be of high conservation priority. Each connectivity analysis has its unique advantages and was completed using different tools but conclude similar pathways. Least cost path identifies a singular, least costly route to travel. While shortest path does a similar operation, it may consider alternate routes and may be able to consider different combinations of routes due to its automated nature. Current flow shows a continuous surface of varying values which can be useful in identifying corridor widths, quality and narrow linkages in ways a singular path is not capable.

Critical linkages from South to North may follow corridors from Big Cypress to Avon Park to the Kissimmee Prairie area. Here, a possible route could either move west through Green Swamp or flank the Orlando area to the east and connect with the Ocala National Forest. Bears from the Ocala National Forest have the option to head north to Osceola National Forest and the surrounding areas, or veer east and follow the Big Bend area to Apalachicola and Eglin AFB along with bears from the Green Swamp area. Identified linkages can serve as blueprint for guiding conservation efforts that ensure healthy wildlife corridors.

While several corridors look relatively healthy, such as the Big Bend/Nature Coast, Connectivity analyses indicate several corridors at risk due to fragmentation. Linkages along the I-4 corridor from Tampa to Orlando and from Orlando to Daytona are at risk. This is a critical issue to conserve North to South connectivity. While this analysis does identify critical linkages, it does not examine the effects of future changes such as development projections or sea level rise. These are a few areas future research could direct its focus to help further planning.

APPENDIX C: FLORIDA PANTHER HABITAT AND CONNECTIVITY MODELING

Introduction

The Florida Panther (Puma concolor coryi) is a species that requires large, intact home ranges and sufficient connectivity to other populations to ensure genetic variability and population viability (Hellgren and Maehr 1992). The Panther population is not large enough yet to ensure genetic diversity long-term (Maehr et al. 2002). There are currently less than 100-tagged individuals and there are thought to be less than 200 total in Florida. Due to habitat reduction, Panthers now occupy 5% of their traditional range (McBride 2003).

To better understand the habitat needs and migratory barriers to the Florida Panther, the use of ecological modeling was employed. Two integrated modeling techniques: habitat suitability modeling and connectivity analyses were used in this study to answer questions of species distribution and connectivity. The habitat suitability analyses performed help to identify areas which focal species are likely to occupy based on presence records (dependent variable) and environmental layers (independent variables). Using spatial statistical tools, habitat patches of sufficient quality can be identified based on the relationship between records of species' presence and the corresponding environmental layers. Once areas of suitable size and quality are identified, connectivity analyses can be performed to assess the ability of the species to migrate throughout the current landscape from one core area (or hub) to the next. This migration/dispersal potential is quantitatively based upon output from habitat suitability modeling. Using different connectivity theories, such as least cost path, network and current flow (using electrical conductance theory) can give scientists and managers a more robust model of species distribution and movements.

Methodology

Habitat Suitability Model.--To predict the extent of a species' distribution, the Maximum Entropy Model (Maxent) was applied. Maxent predicts the probability of a species' occurrence across a landscape based on presence only point data in conjunction with environmental variable layers. Maxent finds the largest spread (maximum entropy) in a geographical dataset of species presences in relation to these environmental layers. The resulting output is expressed as the log likelihood of the data associated with presence data minus a penalty term. Each environmental layer is weighted by how much complexity it adds to the model and the sum of these weightings determine how much the likelihood should be penalized for over-fitting. Maxent runs through an optimization routine where all cells start with equal probability, and the model continually improves "fit" measured by gain (Elith et al. 2010). Gain measures the likelihood of deviance, which maximizes the probability of presences in relation to the background data. The exponent of gain measures the mean probability of presence samples versus random background samples. Area Under Curve (AUC) is another metric of model performance; the maximum achievable AUC is less than one. A value of 0.50 means the model's prediction is no better than a random guess. The closer to AUC is to one, the better the model predicts species occurrence.

Data Sources and Processing.--Data required for habitat analyses are presence locations (X/Y data) and environmental layers, expressed in ASCII format. Several processes were required to convert data to the appropriate format and continuity, for use within the model. To ensure uniformity, all data required post-processing. All layers were clipped to the Florida state boundary, projected in NAD 83 HARN Albers and header information checked for uniformity to prepare for model input.

Presence Data.--Presence data was taken from either GPS or radio telemetry of tagged individuals. At a minimum, each record provided indicates species, latitude, longitude, date, time and sex. Age was not included with the data, and individuals were not assumed to be tagged from birth. Therefore juvenile Panthers may or may not be included in the analysis.

Panther presence locations used in the model were derived from data supplied by the Florida Fish and Wildlife Conservation Commission. Supplied data spans from 1981 – 2012. Multiple model scenarios were tested, and the most recent ten years of data was found to be most statistically significant. To ensure uniformity and reduce bias, presence data were filtered using the following criteria:

- Most recent 10-year period data available (2002 – 2012)
- Both male and female cats were used
- Individuals with less than 50 records were removed
- A random subset of 50 records was selected per individual to eliminate bias of an individual with more than 50 data points.

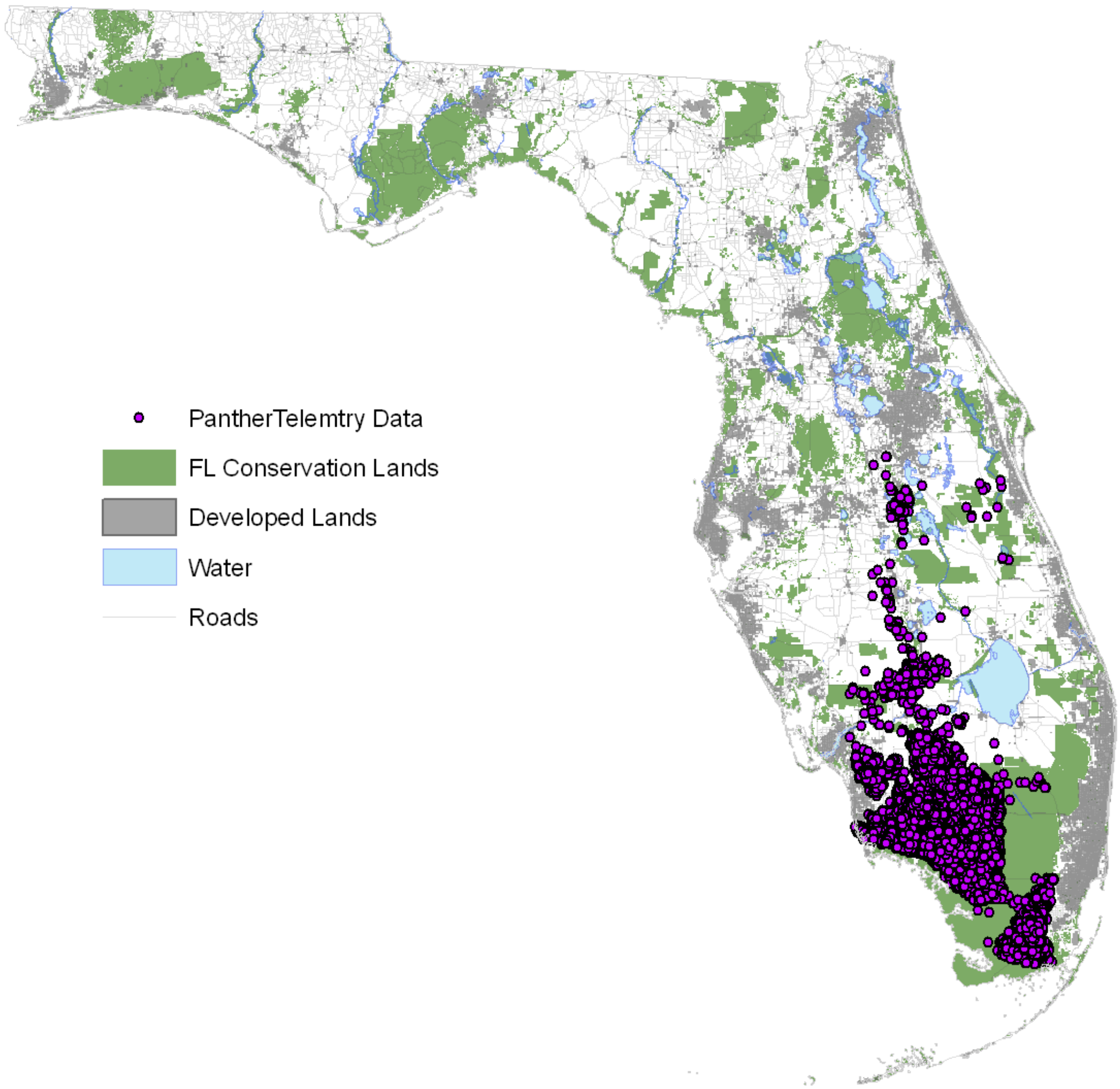

Figure 1. Panther Telemetry Data.

Training and Testing.--Maxent uses a percentage of input data to test model performance while the remaining data is used as training data to determine model parameters. Different percentage values were tested, but the general consensus in the machine learning community recommends using approximately 30% of the data for testing purposes (Witten et al. 2011). This is what was eventually decided upon. The performance of different combinations of variables was evaluated to achieve the best results for successive connectivity analyses.

Independent Variables.--Environmental variables used in Panther analysis were:

- Landscape context layers from the CLIP 2.0 report (Oetting et al. 2012):
    - Landscape Integrity: This layer is comprised of two related landscape indices assessing ecological integrity based on land use intensity and patch size of natural communities and semi-natural land uses. The landscape integrity layer was developed as part of the CLIP TAG process after discussion about the need for an additional landscape layer that identified areas of high ecological integrity based on land use intensity and patch size, where areas dominated by large patches of natural and semi-natural land use are assigned the highest significance.

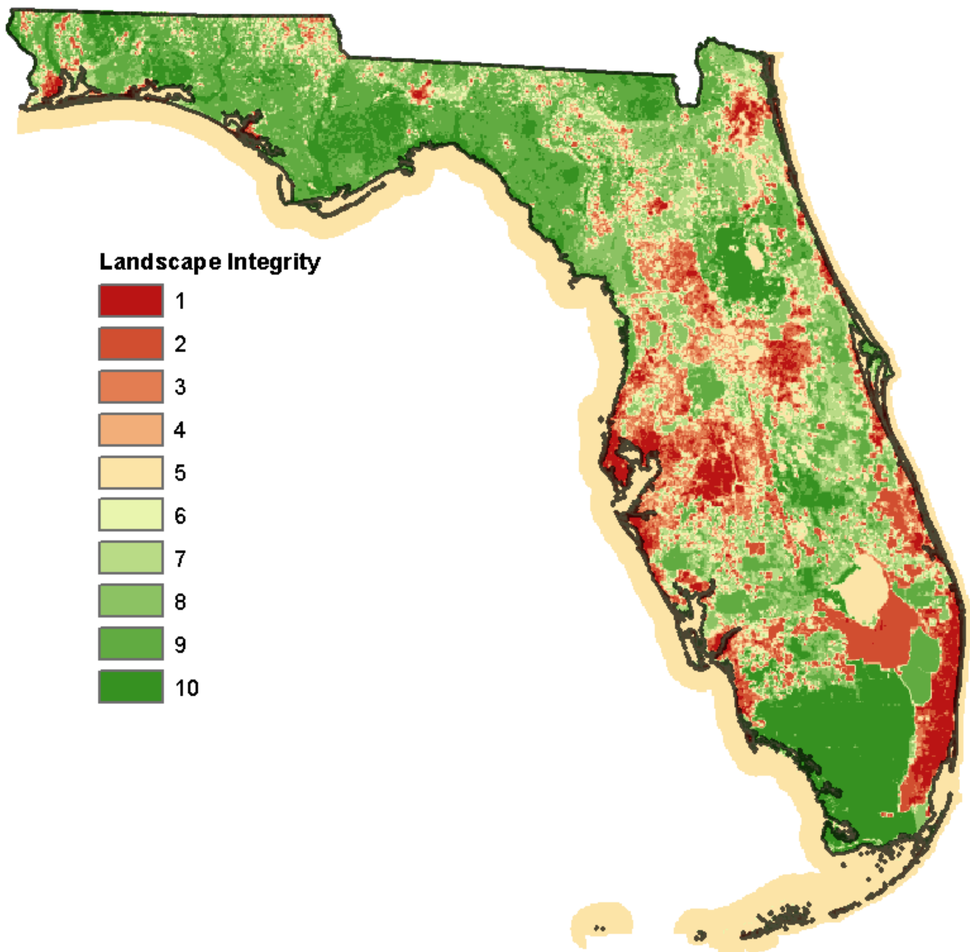

Figure 2. CLIP 2.0 Landscape Integrity.

- Intactness/Fragmentation: This is a multi-scale model of landscape intactness (in this sense, the opposite of fragmentation) where all natural and semi-natural land uses is treated as "intact" and all other land uses are treated as "not intact" (improved pasture in the south-central and southwest Florida prairie region is included as intact in this model in the same fashion as the Patch Size model in the landscape context analysis and the Landscape Integrity core data layer described above). The land use data used is from the 2009 Cooperative Land Cover Data. Then a focal sum neighborhood analysis is done at three scales (approximately 10 acres; approximately 100 acres; and approximately 1000 acres), then ranked into 9 priority classes based on percent intact, and then all three scale results are combined with equal weighting to identify the areas in the state with the most and least intact land cover.

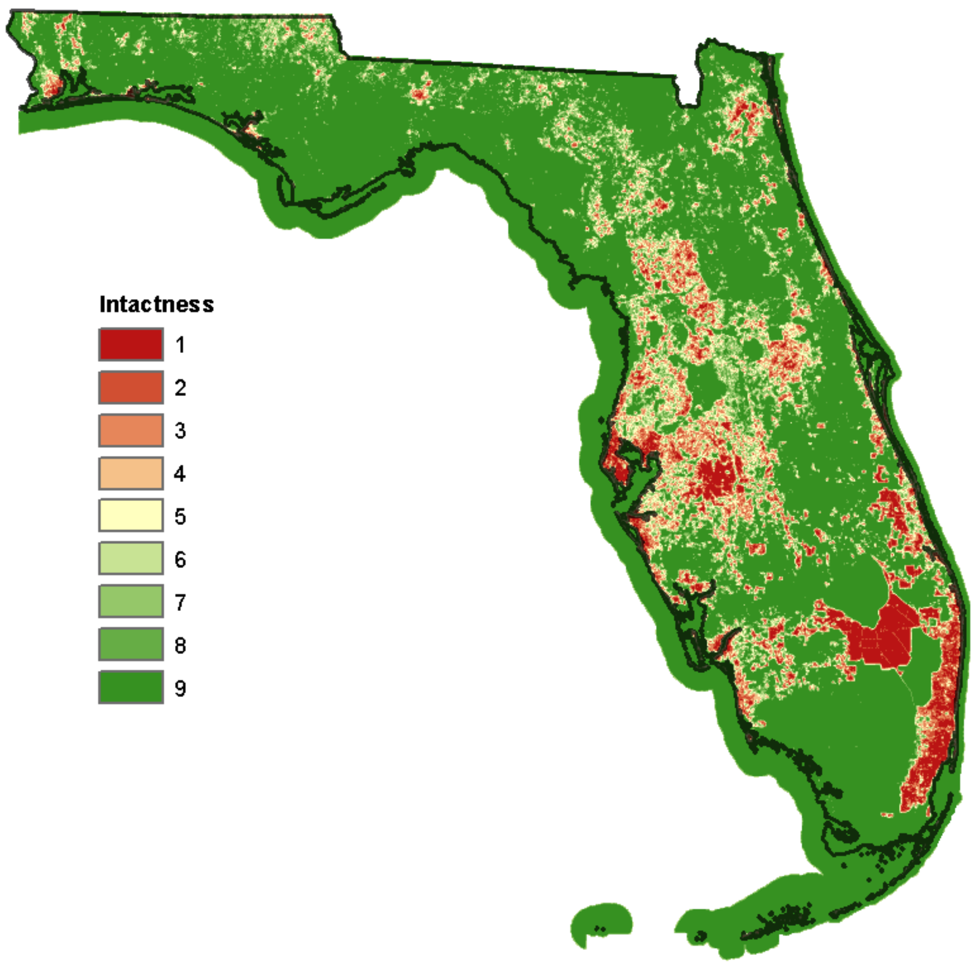

Figure 2. CLIP 2.0 Landscape Intactness/Fragmentation.

- Distance from Intensive Land Uses: Intensive development was defined as all higher density residential, commercial, and industrial land uses (including active mining operations) in patches 100 acres or larger. The land use data used is from the 2009 Cooperative Land Cover Data within Florida and Southeastern GAP land cover data.

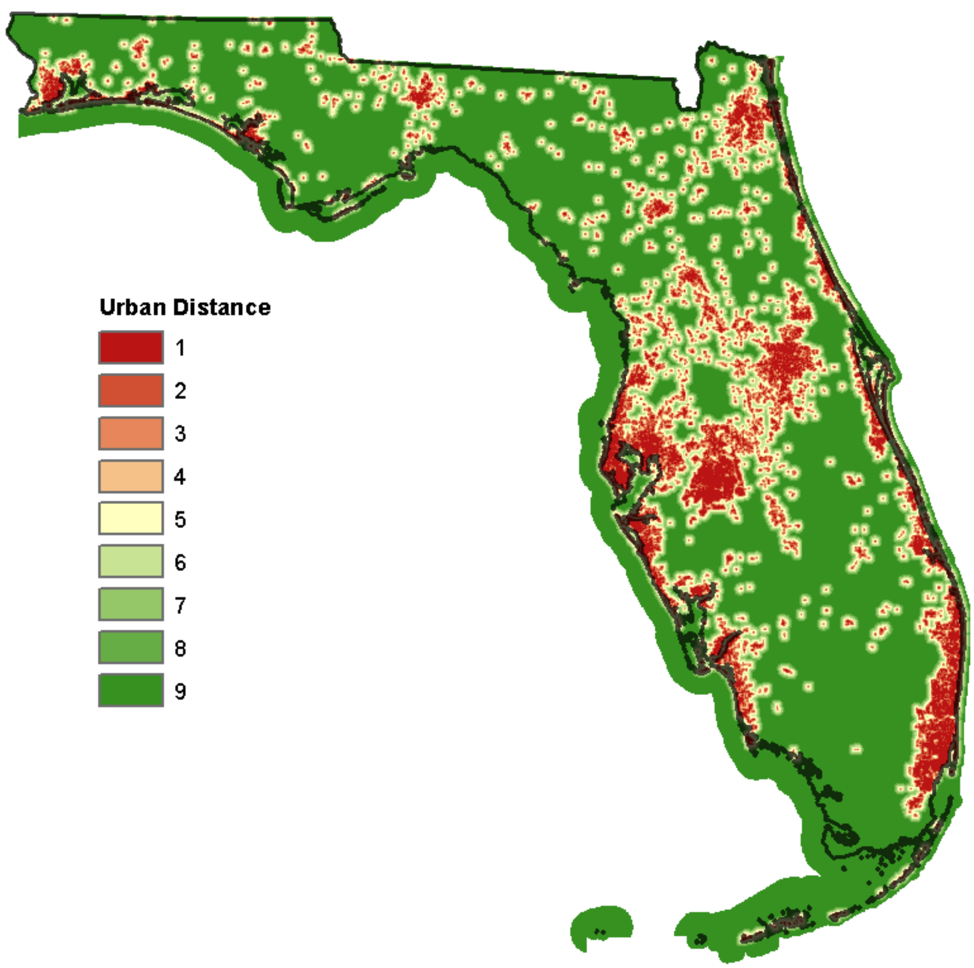

Figure 3. CLIP 2.0 Distance from Intensive Land Uses.

- Roads Context: Three road-based models (all roadless, major roadless, and road density) were combined into a Roads Context layer using equal weighting.
  - All Roadless: Used all roads within the U.S. Geological Survey 1:24,000 digital line graph roads. Only narrow areas of water (less than 90 meters wide) were included within roadless areas. Open water was not included in roadless areas because this analysis is intended to focus on terrestrial ecosystems and large water bodies tend to bias roadless analyses.
  - Major Roads Roadless: Used only the roads within the Florida Department of Transportation's Major Roads data layers. This layer only includes major highways and arterial roads including interstates, toll roads, U.S. Highways, state roads, and at least most county roads. This layer does not include residential or other smaller paved roads, improved dirt or gravel roads, or jeep trails.
  - Road Density: We calculated road density using the U.S. Geological Survey 1:240,000 digital line graph roads. This index represents straight road density in miles/mile2 using a 1-mile search radius.

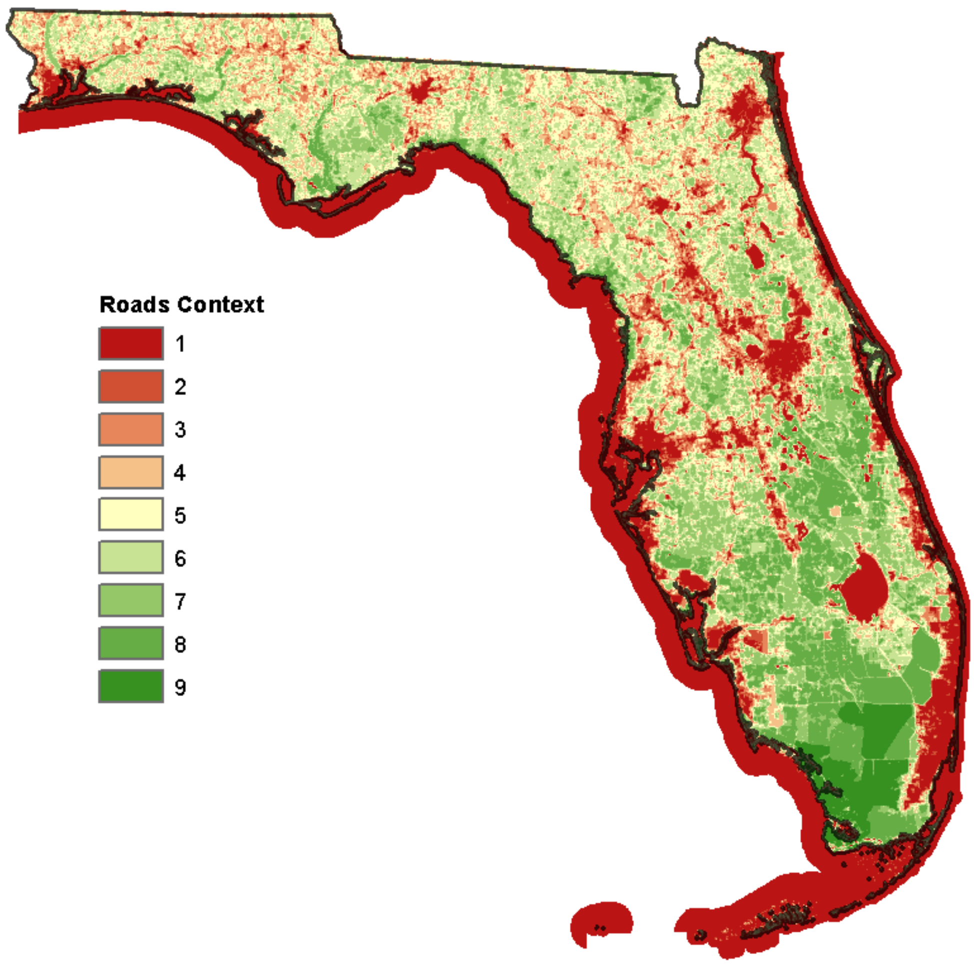

Figure 4. CLIP 2.0 Roads Context.

- Panther Specific criteria based on an USFWS study (Frakes et al. 2011):
    - Land cover: Generalized land cover data (Cooperative Land Cover Map 2010)

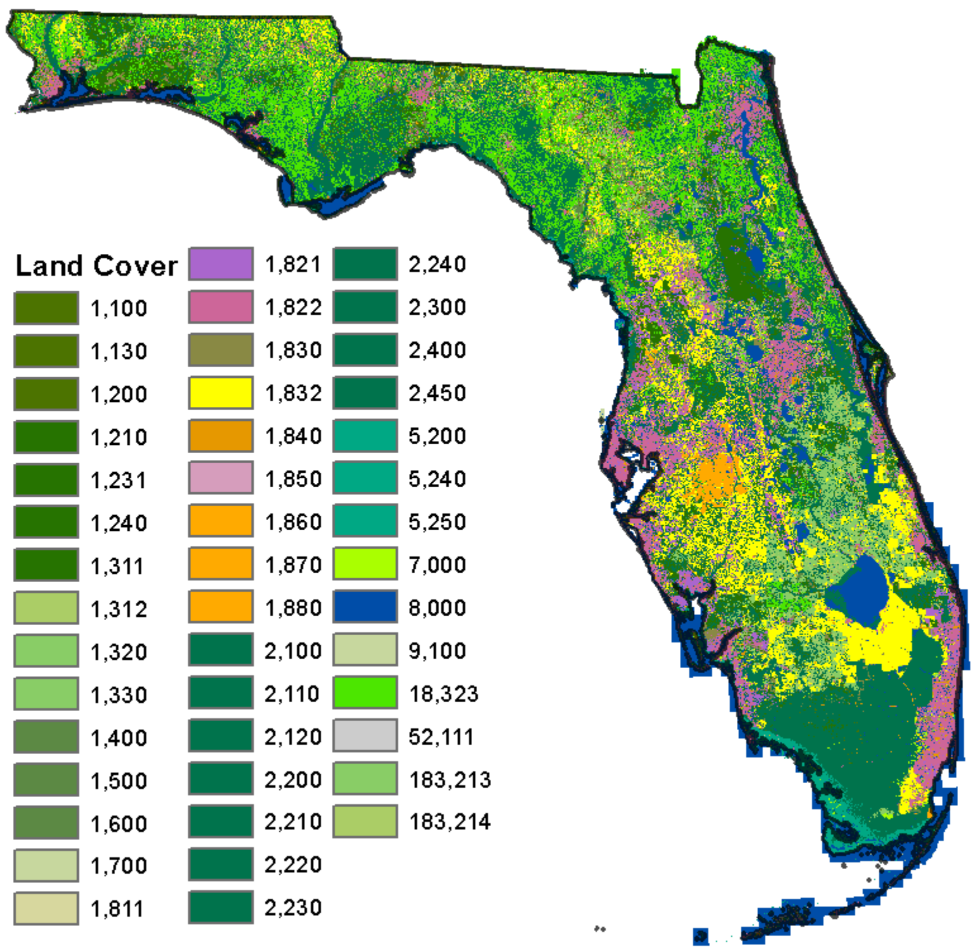

Figure 5. Cooperative Land Cover Map.

- Forest edge: This layer is used as a surrogate for prey abundance/availability. Created using a line density function at the intersection of forested and any other natural landcover, and between upland forest and wetland forest.

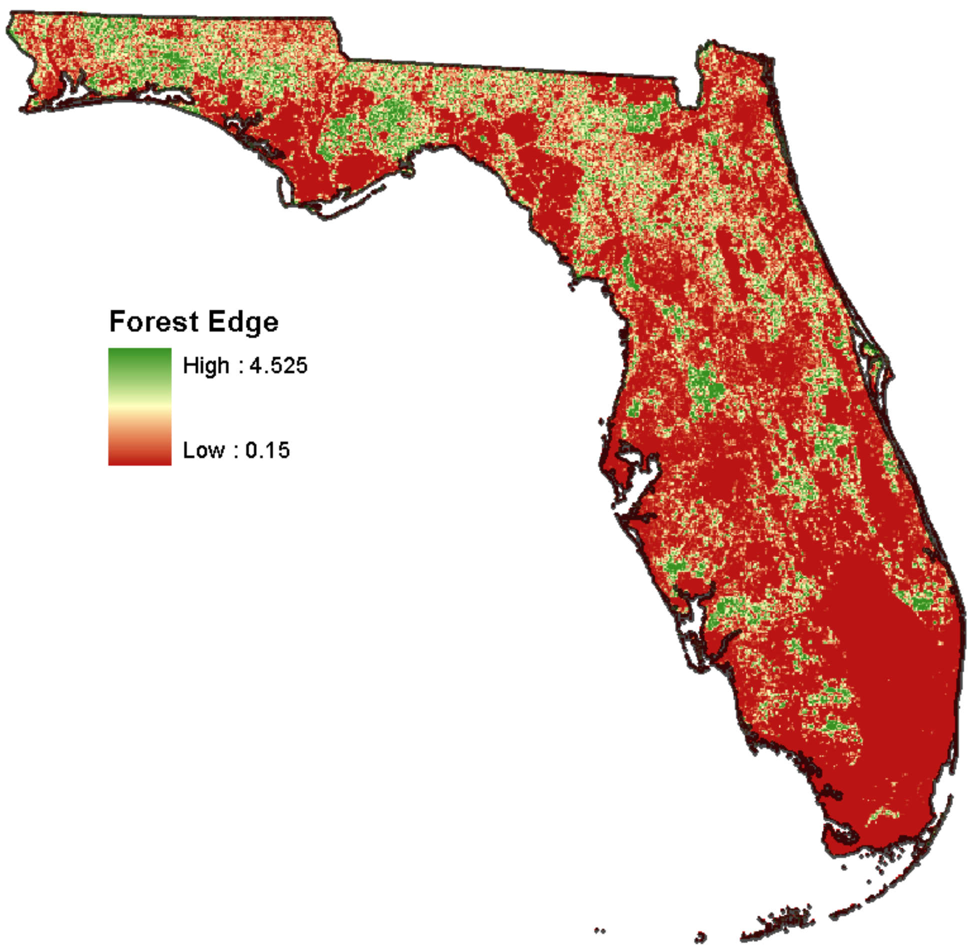

Figure 6. Forest Edge.

- Population density: Rasterized 2010 US Census Block data in Florida, at 300m resolution.

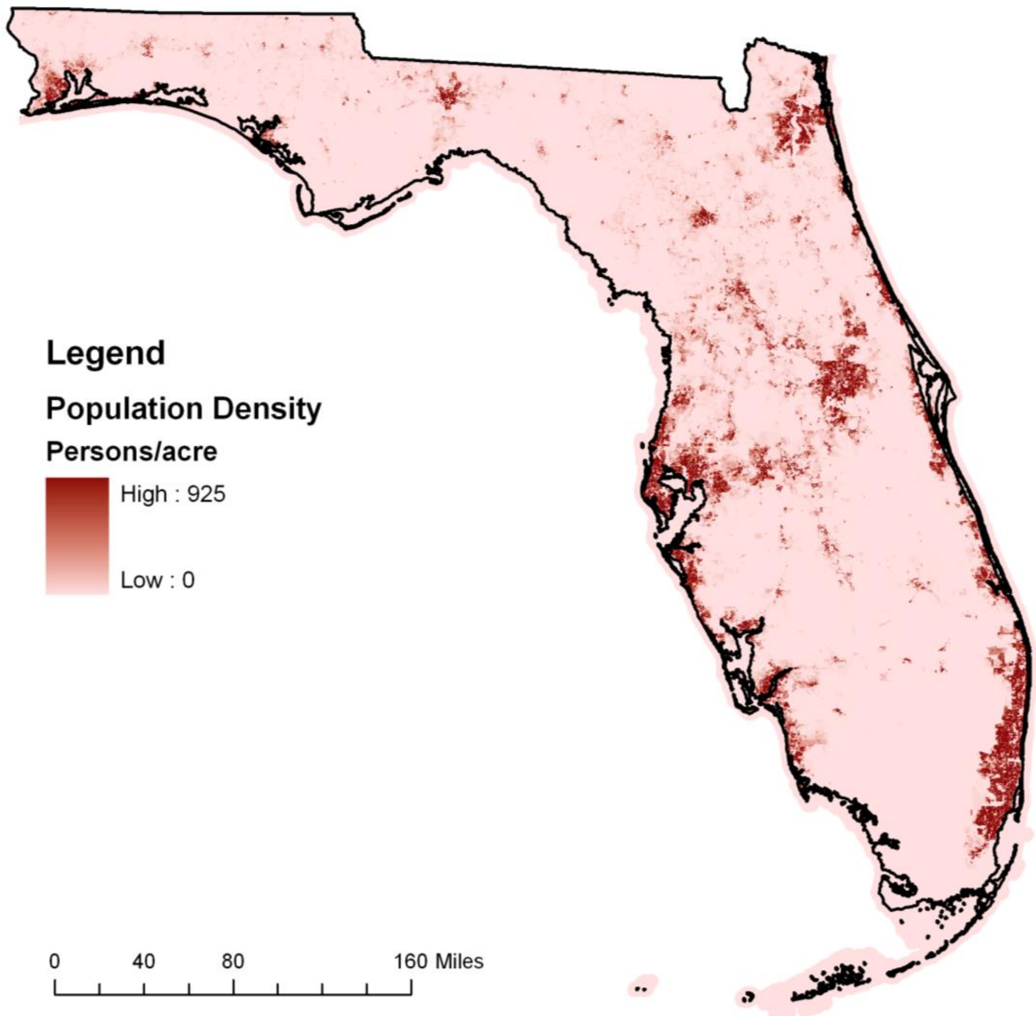

Figure 7. Population Density.

- Road Density: Calculation of road density based on a 3x3 cell focal neighborhood analysis of major roadways.

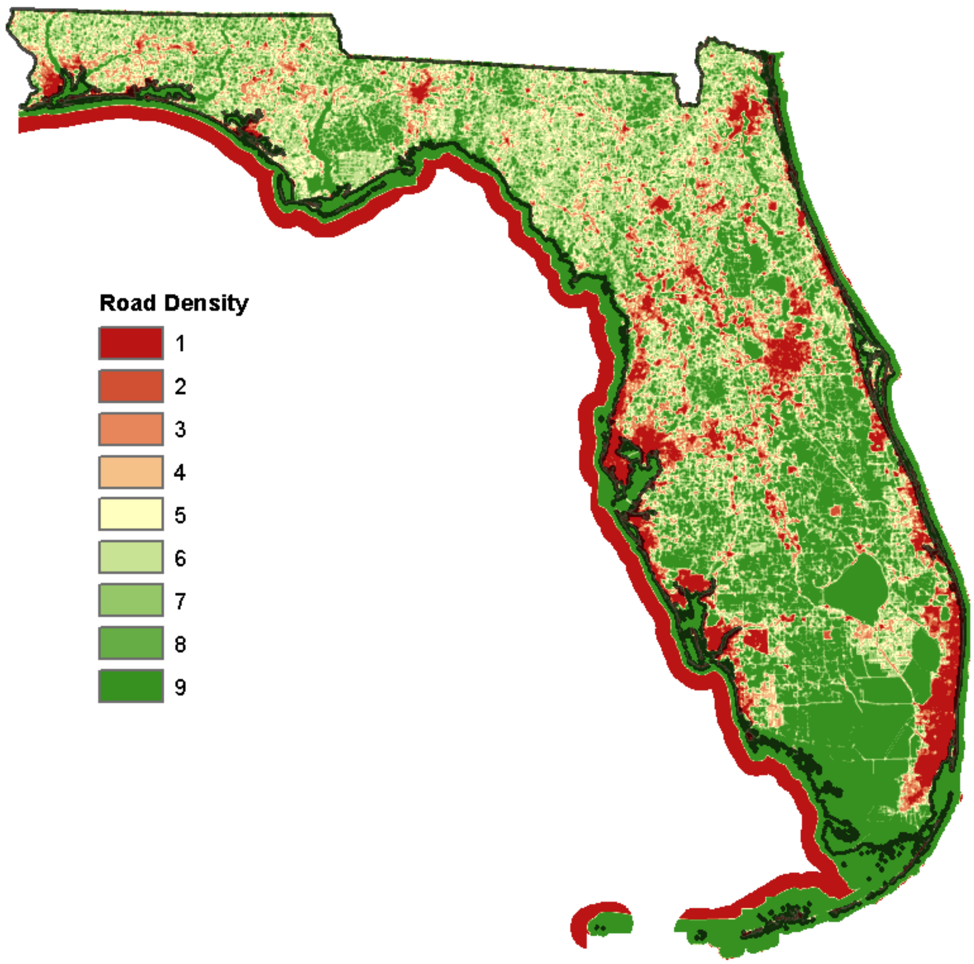

Figure 8. Road Density.

Scenarios Modeled.--Three different independent variable scenarios were modeled in conjunction with the point dataset. The environmental layer scenarios used were:

- Landscape context layers (Intactness, landscape integrity, roads context, urban distances)

- Panther Specific Variables: USFWS study-related layers (population density, forest edge, land cover, road density)
- Landscape context + Panther Specific variables combined

The resulting models were evaluated for model performance metrics and visual consensus among wildlife experts. Based upon these considerations, the "Landscape context + Panther Specific variables combined" model was chosen to be used as a basis for future connectivity analyses. Additionally, the Maxent model output used in connectivity analyses includes an additional noData filter for developed lands. Doing this excludes such areas from subsequent connectivity analyses.

Habitat Patch Creation.--Core areas of habitat were created using a combination of the selected Maxent output and existing Panther home ranges and suitable core habitat areas. Maxent results were filtered by probability of presence and patch size. A minimum 50% probability or presence threshold with 5,000-acre minimum patch size was used to create core hub areas. Additional areas were added to the hubs layer based on wildlife biologist input. Habitat patches, or hubs were created using a 3x3 cell neighborhood analysis in ArcGIS. The resulting output was expressed in vector format.

Connectivity Analysis.--Connectivity was assessed in three different ways: least cost path, shortest path and current flow methods. Least cost paths were modeled between specified hubs using the cost distance and cost path tools in ArcGIS. This analysis identifies a single path between the selected hubs using an inverse of the Maxent habitat model as a cost surface.

The shortest path analysis was performed using Connectivity Analysis Toolkit. This methodology identifies a minimum network of linkages between nodes. The Connectivity

Analysis Toolkit employs network theory to assess connectivity throughout the landscape. This is a stand-alone tool, which processes an ASCII file created from habitat suitability raster data. A hexagonal network shapefile is created from the habitat suitability model at a user-specified resolution. Points and lines on the graph represent nodes and pathways, where nodes facilitate movement across a graph. The resulting output shows the network of linkages in raster format.

Current flow analysis considers conductance and resistance though a diffuse landscape and produces a more distributed output. The Connectivity Analysis Toolkit also models current flow, but the model Circuitscape was ultimately chosen due to its added features and faster performance. Circuitscape analyses connectivity as if the landscape were an open circuit. Therefore, a habitat suitability model can be used to specify either conductance or resistance throughout the landscape. Each hub area is used as a current source node to assess pairwise connectivity between hubs. The model supplies a current source and results are shown as voltage flow across the landscape.

Results

Maxent Output.--The map below represent the Maxent model output for Florida Panther's probability of presence. Warmer colors show areas with higher probability conditions. Areas of high probability tend to occupy portions on or adjacent to existing natural/conservation areas. This helps to further validate the model. These areas include: Big Cypress/Everglades, Avon Park, Kissimmee Prairie, Green Swamp, Ocala National Forest, Osceola/Okefenokee, Apalachicola and Eglin AFB.

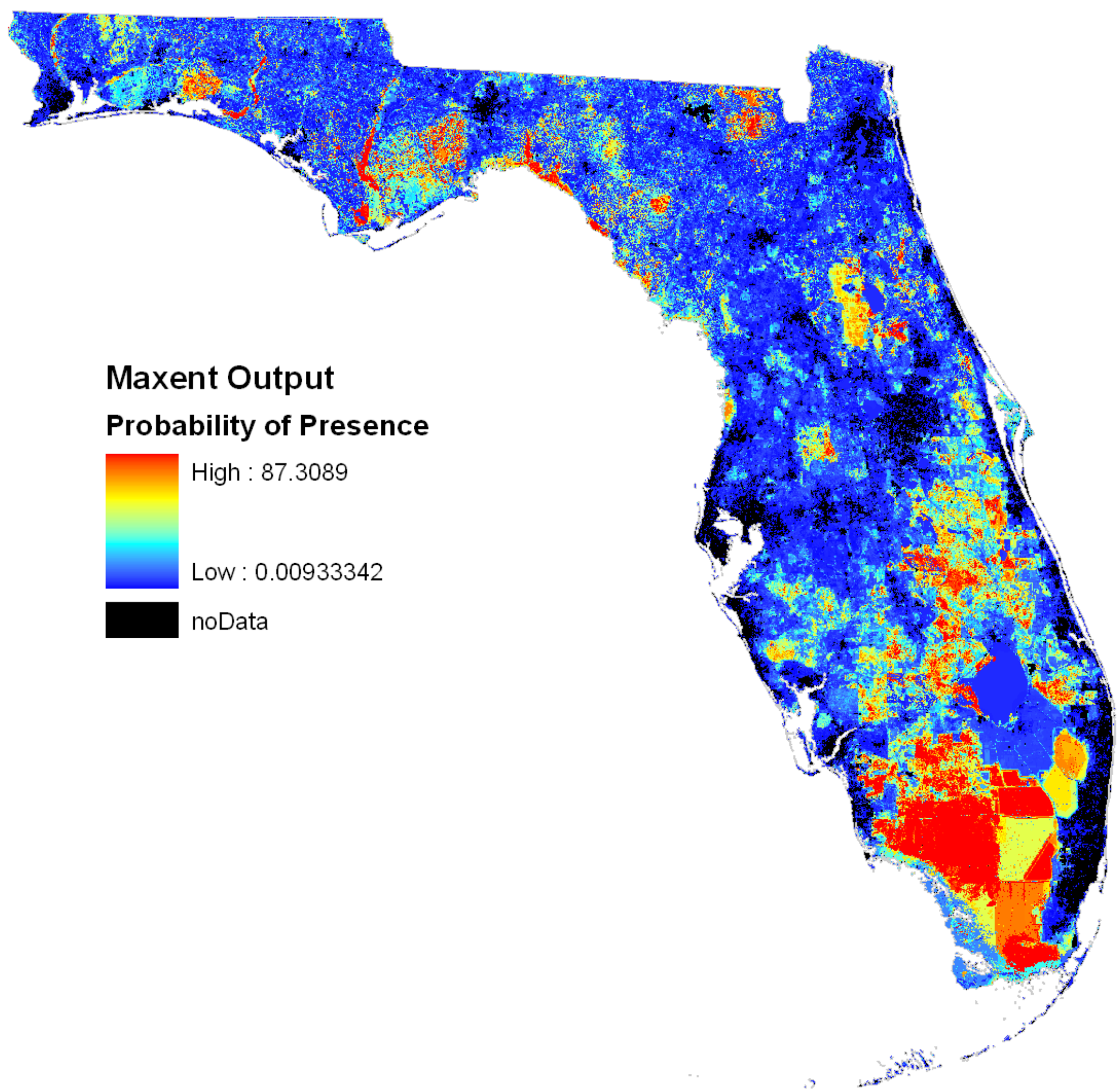

Figure 9. Florida Panther final Maxent output

Model Performance.--To assess model performance, the Area Under Curve (AUC) and Gain are observed to determine how well specific scenarios predict the presence of species by using test points. AUC expresses how close the test data performs to the training data, while gain is a representation of how much more likely a prediction will be compared to a random offering. The maximum achievable AUC is less than one. A value of 0.50 means the model's prediction is no better than a random guess. The closer to

AUC is to one, the better the model fit. Table 1, below, shows the AUC and Gain for each scenario modeled.

Table 2 - Summary of Model Performance

Scenario	AUC	Gain
Recent Data Points 2002 - 2012		
Landscape Context	0.896	1.252
Panther Specific (USFWS)	0.872	1.056
Landscape Context + Panther Specific	0.862	0.922

For example, regularized training gain for the “Landscape Context” scenario is 1.252. The gain indicates how well the model is concentrated around the presence samples. Thus, exp(1.252) ~= 3.50, meaning average likelihood our model’s presence sample is approximately 3.494 times higher than that of a random background sample.

Finals Hubs Delineation.--Habitat patch delineation was based upon a 50% probability threshold and a 5,000-acre minimum patch size. Additional areas were added with the help of wildlife experts. The map below shows an aggregate of habitat patches that meet these quality and size thresholds and added areas.

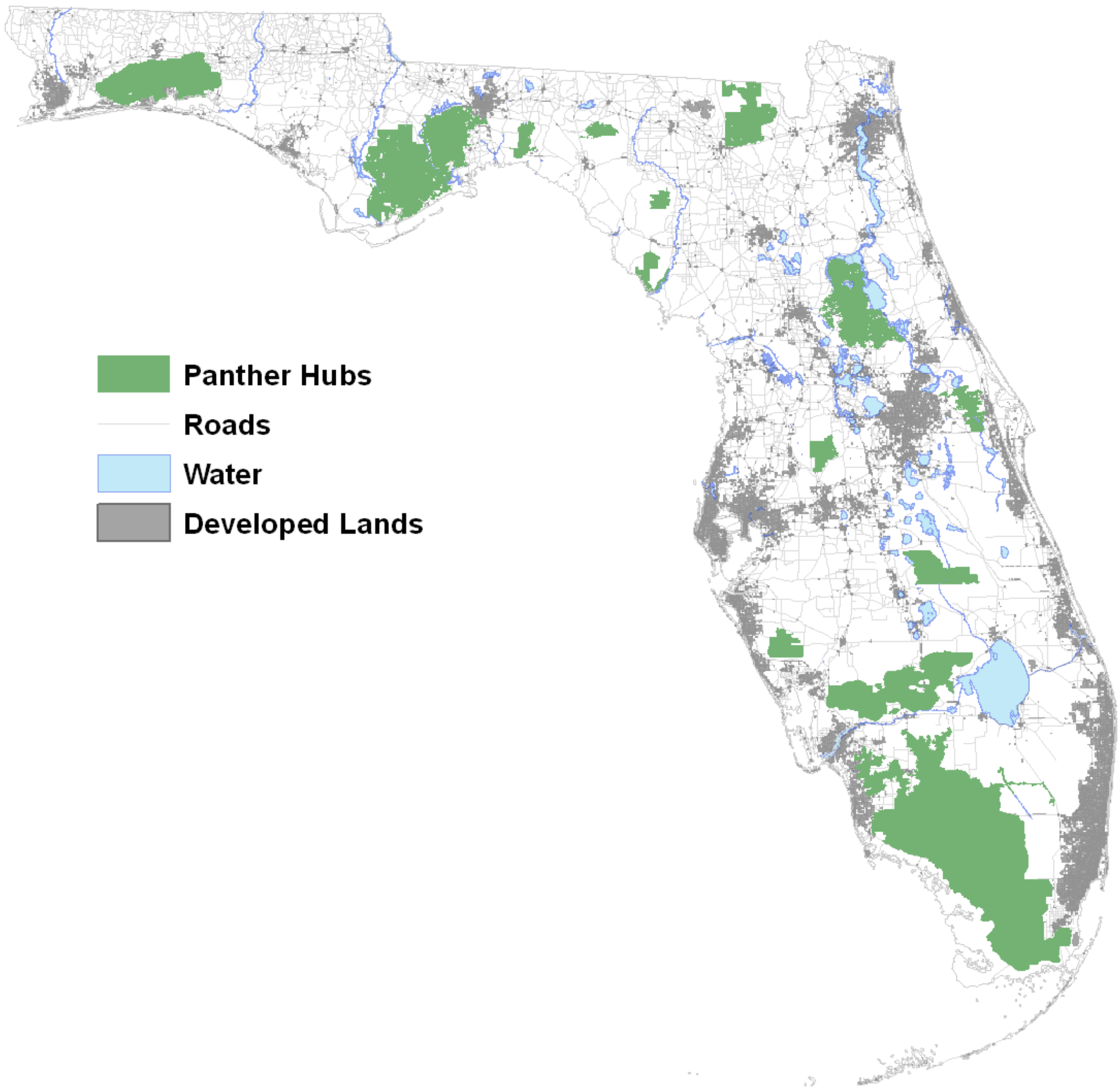

Figure 10. Panther Hubs.

Connectivity Analysis.--Both current flow, least cost path and shortest path methodologies show similar pathways and identify critical linkages that should be of high conservation priority. Least cost paths identify a single route between selected nodes while the shortest path analysis may identify alternate paths of lesser suitability. Using current flow, if a wide swath of suitable land exists for a wildlife corridor, values will be less than those of a more restricted corridor. These higher values, identifying restricted flows, can help to better identify stressed or narrow wildlife corridors. Results for current flow, least cost path and shortest path connectivity analyses are shown below.

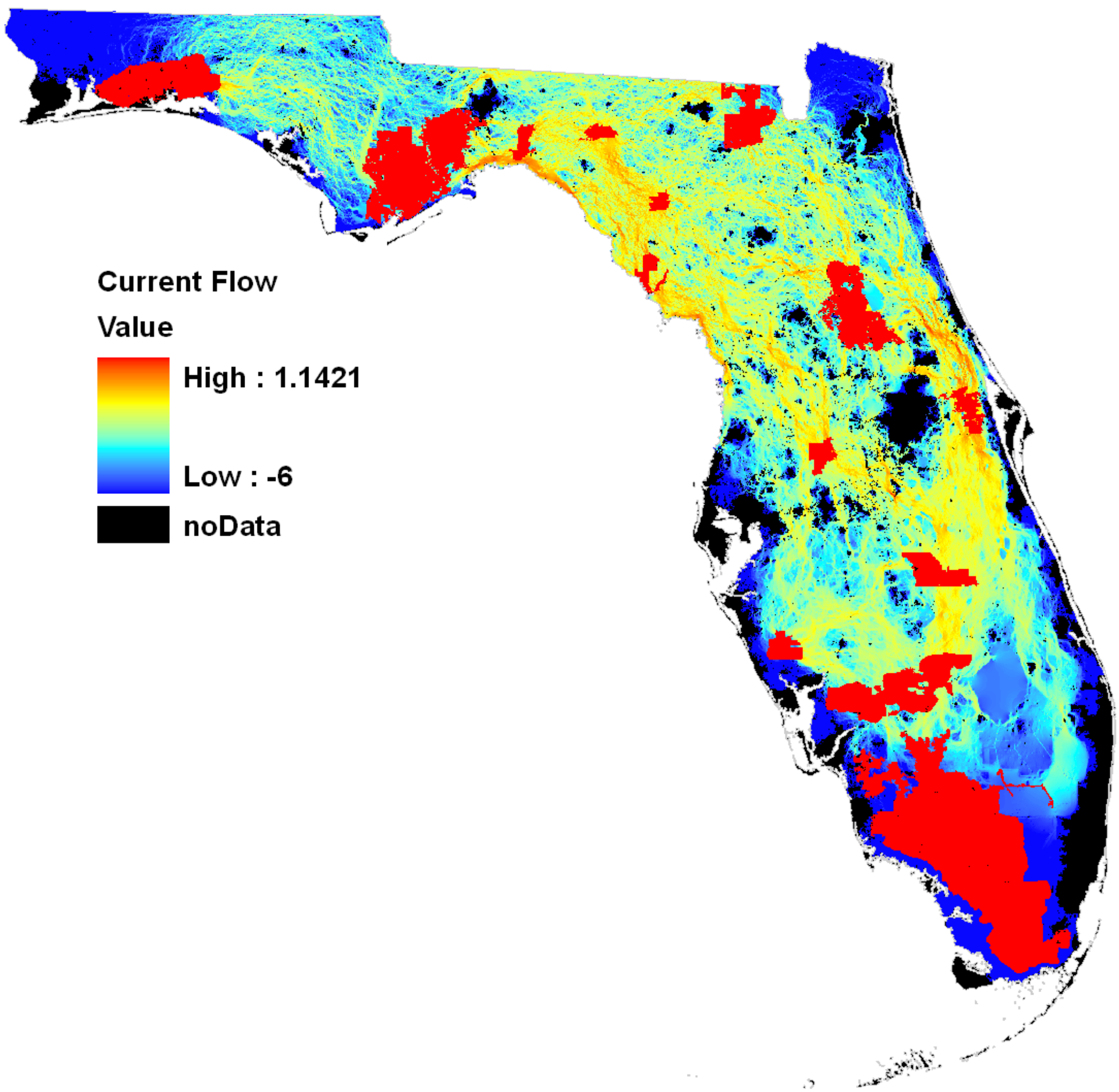

Figure 11. Current Flow Analysis.

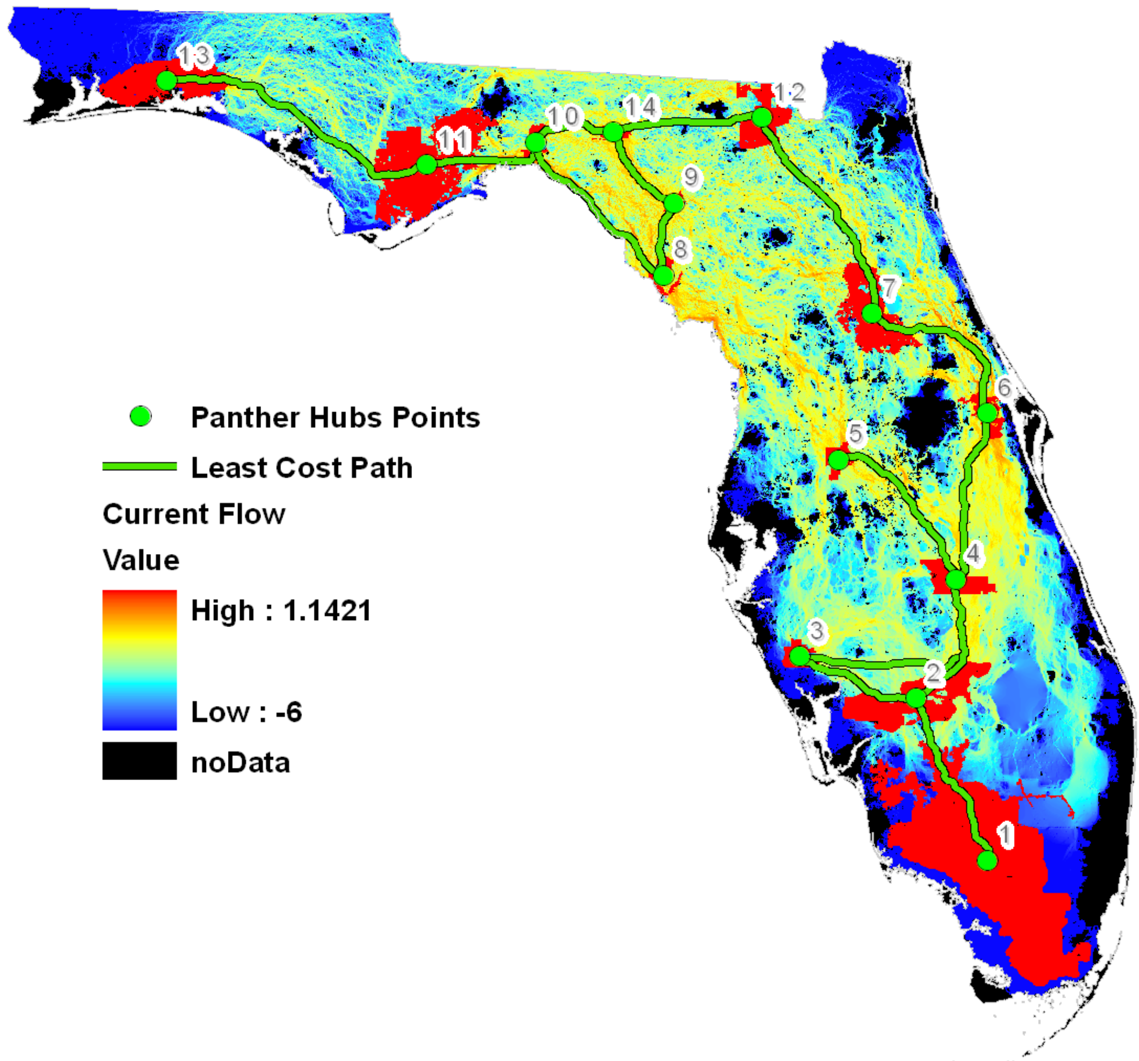

Figure 12. Least Cost Path Analysis.

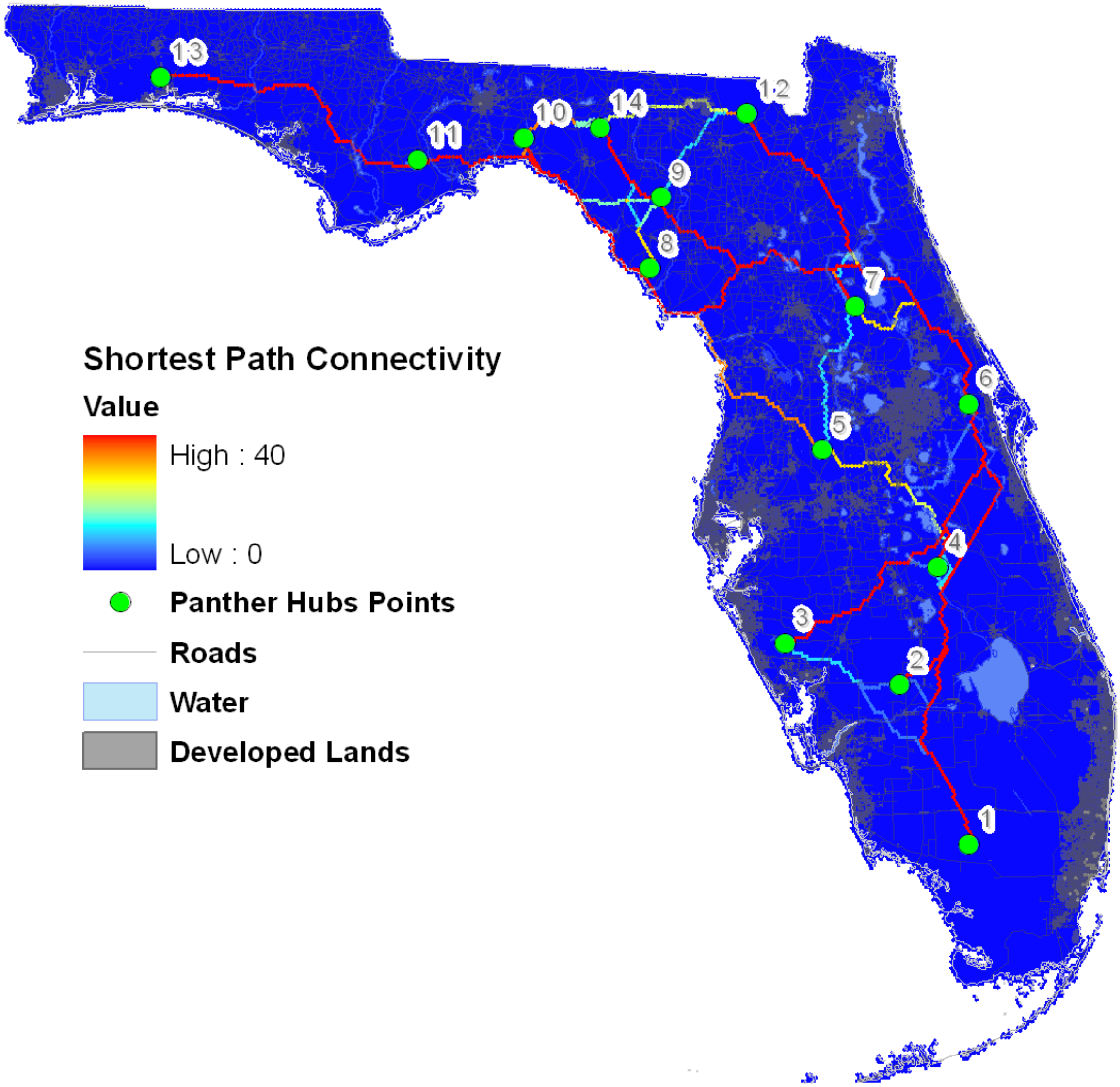

Figure 13. Shortest Path Analysis.

Discussion/Conclusions

In general, the process of determining habitat connectivity for the Florida Panther was a three-part process, requiring multiple revisions. Many iterations of the Maxent model were performed to determine the most appropriate selection of telemetry data, which independent variables were significant predictors and which model settings produced the best results. While measures of model performance were considered, once performance surpassed an acceptable threshold, visual cues were strongly considered in final Maxent model selection as well.

Based upon the Maxent results, it is interesting that certain areas, such as Ocala National Forest, Okeefenokee and the Panhandle, are represented less much than that of the Black Bear model output. This could be due to all the telemetry locations being based in Southwest Florida, and associated bias to Southwest Florida landcover (although landcover was generalized) and population density. Conversely the model may be more telling as to the ability for the current Panther population to inhabit broader ranges. Inclusion of Landscape Context data into Maxent modeling shows a higher probability of presence beyond South Florida, whether combined with the “Panther Specific” variables or not.

Ecological hubs identified by Maxent still tend to occupy portions on or adjacent to existing natural areas. These areas include: Big Cypress, Avon Park, Kissimmee Prairie, Green Swamp, Ocala National Forest, Osceola/Okefenokee, Apalachicola and Eglin AFB. These identified hubs were later optimized and amended to include additional areas that may not have been included but are important hub areas for the species. These hubs serve as nodes, a critical component for the connectivity analyses.

Connectivity models show the most probable or suitable path(s) based on the Maxent output and ecological hubs. Both current flows, least cost path and shortest path methodologies show similar pathways and identify critical linkages that should be of high conservation priority. Each connectivity analysis has its unique advantages and was completed using different tools but conclude similar pathways. Least cost path identifies a singular, least costly route to travel. While shortest path does a similar operation, it may consider alternate routes and may be able to consider different combinations of routes due to its automated nature. Current flow shows a continuous surface of varying values which can be useful in identifying corridor widths, quality and narrow linkages in ways a singular path is not capable.

Critical linkages from South to North may follow corridors from Big Cypress to Avon Park to the Kissimmee Prairie area. Here, a possible route could either move west through Green Swamp and on to the Big Bend, or flank the Orlando area to the east and connect with the Ocala National Forest. Panthers from the Ocala National Forest have the option to head north to Osceola National Forest and the surrounding areas, or veer east and follow the Big Bend area to Apalachicola and Eglin AFB along with panthers from the Green Swamp area. Identified linkages can serve as blueprint for guiding conservation efforts that ensure healthy wildlife corridors.

Connectivity analyses indicate several corridors at risk due to fragmentation. Linkages along the I-4 corridor from Tampa to Orlando and from Orlando to Daytona are at risk. This is a critical issue likely fragmenting important habitat and limiting migration northward. While this analysis does identify important critical linkages, it does not examine the effects of future changes such as development projections or sea level rise. These are a few areas future research could direct its focus to help further planning.