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Habitat Suitability Analysis for the Frosted Flatwoods Salamander in Florida

Abstract

Species conservation and habitat protection are significant ecological issues that the internationally community has been addressing for decades, yet are challenging to incorporate into city and regional planning. The value of a species is difficult to quantify and measure against the potential for economic development and expansion of housing and industry. GIS offers a way to analyze land area according to multiple values and potential uses. Raster analysis is particularly useful in determining suitability of land uses as well as prioritizing development and preservation of land based on a set of weighted inputs. This project seeks to model a way that GIS can be used to determine suitability of areas in a defined region to provide habitat for a threatened or endangered species and prioritize areas for conservation to inform policy decisions.

The focus of this study is on the spatial relationships between habitat factors that can support a specific species. In this case, the habitat factors include vegetative cover, proximity to freshwater wetlands, and distance from developed areas (which are completely unsuitable). The species of concern is a threatened salamander native to the southeastern United States, the frosted flatwoods salamander (Ambystoma cingulatum). The study area is the entire state of Florida.

The results indicate that only 3% of the land area in the state is completely suitable to the species, while 68% is potentially suitable. Policy should focus on the landuse in that 68% and design a plan that will include conservation measures for the salamander and its habitat. When compared to the range and distribution of this salamander from IUCN and USGS datasets, the results showed a different optimal land area than where the frosted flatwoods salamander

populations have been observed. The validity of the results are questionable due to the minimal inputs and simplistic analytical design, however, they serve as a start for comparison studies. It is recommended that the study procedure be repeated for another species under another set of conditions to test its accuracy against range data.

Purpose

The purpose of this study is to determine habitat suitability for Frosted Flatwoods Salamanders in Florida using raster analysis in ArcGIS 10.3.3 software. This analysis is necessary to assist in conservation planning for the State. The results will be compared with current development trends in the state of Florida. This scope of this study is limited to habitat suitability analysis. It does not conduct the prioritization nor recommend policy alternatives. Herein, the tenets of conservation planning are presented, followed by a brief overview of the chosen species and habitat to evaluate, followed by a review of the literature, the methodology for this study, the results of the study, and suggestions for continued research.

Conservation Planning

Conservation planning is the assessment of natural resources – species and habitat – and the design of landuse strategies to maintain conditions conducive for the preservation or proliferation of a species or environment. Many species, including the subject of this study are protected by the "Endangered Species Act of 1973 (Act), recognizing that endangered and threatened species of wildlife and plants 'are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people (U.S. Fish and Wildlife Service,

2011)." In addition to the intrinsic value of biodiversity, amphibians play and especially functional role in an ecosystem: due their low tolerance of changing conditions, they are considered indicator species'. The populations of indicator species (in advancement, stabilization, or decline) tells scientists if a particular ecosystem is healthy and able to support many different indigenous species. Declining populations, as in the case of the Frosted Flatwoods Salamander, indicate a decline in an overall ecosystem and alerts conservationists and scientists to a potentially larger problem.

Complex biodiverse ecosystems are necessary for human health and well-being. As the U.S. Fish and Wildlife Service impart in the above quotation, Congress has recognized several valuable reasons for conserving species. In addition, native vegetation supports soil stability, filters air, and controls temperature both below the canopy and by virtue of counteracting the heat island effects of impervious surface in urbanized areas. Although this study focuses on an amphibious species, as an indicator species, its decline gives us clues about the potential loss of other valuable aspects of its ecosystem. As part of a intricate food web, the loss of any indigenous species to a potentially fragile ecosystem is alarming. While I did not find any evidence that the disappearance of frosted flatwoods salamanders would cause an ecosystem collapse, it is notable that they contribute to earthworm and spider control.

Frosted Flatwoods Salamander

The frosted flatwoods salamander (Ambystoma cingulatum) has been identified as a vulnerable, threatened species in the United States according to provisions under the federal Endangered Species Act in 1999. The species is also considered a threatened species in the State of Florida (Florida Fish and Wildlife Conservation Commission). Even the international

community recognizes the concern for the declining population of this salamander. In 1996 (and renewed in 2004 and 2008), the International Union for the Conservation of Nature (IUCN) included the frosted flatwoods salamander in its Red List of Threatened Species (Palis & Hammerson, 2008). I chose to focus this project on the frosted flatwoods salamander because of this level of concern in the United States and abroad. In addition, a lot of additional research is needed on amphibious species' given their significance in the ecosystem, indicator species status, and alarming worldwide decline. I selected a species (the frosted flatwoods salamander) specifically in the southeastern United States to demonstrate how GIS technology can be used in gathering quantitative information to direct conservation strategies.

The frosted flatwoods salamander exists in Georgia, Florida, South Carolina, and Alabama. Only thirty-seven known populations have been observed, thirty-three of which are in Florida (Florida Fish and Wildlife Conservation Commission). This species lives in longleaf pine habitats with access to freshwater shallow wetlands for breeding. Due to urban encroachment, agricultural activities, silviculture, and the lack of controlled burns, destruction of this habitat has fragmented populations and decreased breeding opportunities. Thus, the decline of these salamanders due to suitable land for adult habitation is compounded by reproductive obstruction.

Habitat

Longleaf pine land cover is mostly threatened by silviculture and the encroachment of other competing tree species, such as slash pine. The outward sprawl of urban areas and agricultural areas has also destroyed many tracts of longleaf pine forest. The longleaf pine tree species is also listed as a threatened species by the IUCN and is the subject of a special

conservation effort directed by the Florida Forest Service (FFS) and the Florida Natural Areas Inventory (FNAI). The longleaf pine ecosystems supports many "herbs and grasses rare animal species, such as red-cockaded woodpeckers and gopher tortoises (Florida Natural Areas Inventory)". Due to the ecological value of the frosted flatwoods salamander and the longleaf pine, the State of Florida, Florida Fish and Wildlife Conservation Commission, and the Florida Natural Resources Inventory have instituted conservation activities directed specifically to these two species. In addition 1000 Friend of Florida, the University of Florida, and the State have developed general conservation plans that will help slow or strategize urban sprawl into areas sensitive to these species'.

Methodology

I found several model studies to guide my study design. There are also several tools/software packages that have been developed to conduct conservation planning analyses. Among these, a few rely on ESRI's ArcGIS software products (which is the software used to conduct this analysis). For example, the World Wildlife Fund developed a Python script with accompanying graphic user interface to automate the prioritization of conservation areas in ArcGIS (World Wildlife Fund, 2012). In addition, What If? 2.0 software is a standalone package for planning that can accommodate conservation planning and easily integrate with ArcGIS (Klosterman, 2016). The United States Geological Survey has suite of GIS tools called "Decision Support Systems" (United States Geological Survey, 2004). One of these, LINK: ARC GIS Tools for Conservation Planning may be appropriate for this type of study. Some land use conflict studies have already been conducted in other areas in Florida using a model developed by Carr and Zwick called Land Use Conflict Identification Strategy (Carr & Zwick,

Using GIS suitability analysis to identify potential future land use conflicts in North Central Florida, 2005). There is an entire book printed by ESRI Press to instruct how to conduct and interpret the model ((Carr & Zwick, Smart Land-Use Analysis: The LUCIS Model. Land Use Conflict Identification Strategy, 2007). Due to the need for expert input and a lengthy design process, this model was not suited to my needs. I most closely modeled my study design, albeit much simplified, after that described in Heartland Ecological Assessment Report (The Nature Conservancy, 2010).

Other studies on the topic of conservation planning in Florida that include a GIS component are the Wildlife 2060 document based on the Florida 2060: A Population Distribution Scenario for the State of Florida, Florida Natural Areas Inventory conservation planning initiatives, and the Florida Fish and Wildlife Conservation Commission's habitat plans. In addition, the Atlanta Botanical Gardens held a week long workshop called " A New Approach to Flatwoods Salamander Conservation".

Simplified Raster Analysis Approach

I conducted my analysis using a simple raster overlay with three inputs: 1) landcover (tree species), 2) freshwater wetlands/ponds, and 3) areas of urban development. In order to identify the most appropriate areas for frosted flatwoods salamander conservation initiatives, it was necessary to identify the most suitable habitat available in the State. Based on the research on frosted flatwood salamander habitat and the land characteristics of the distribution of this species, I determined that the ideal environment would be in longleaf pine forest within 1.5 miles of shallow freshwater wetlands/ponds to support breeding and as far as possible from developed areas.

First, I ranked the proximity to development into four categories according to the United States Geological Survey's National GAP Analysis[1] ancillary data for levels of human avoidance for frosted flatwoods salamanders. Level 1 represented urbanized areas where human avoidance is impossible. Levels 2 and 3, respectively, represent areas of some human encroachment intermingled with natural areas, such as farms and national parks. Level 4 included land areas that were pristine forested areas by raster cell centroid.

Next, I masked all areas from the landcover raster that did not include longleaf pine. The Florida Comprehensive Statewide Forest Inventory and Analysis Study[2] designates eighteen landcover classes, of which two include longleaf pine. Using the resulting raster, I masked areas of urban development indicated by the 2005 population data from the 1000 Friends of Florida report, "A Time for Leadership: Growth Management and Florida 2060"[3]. From the National Wetlands Inventory, I selected the most appropriate categories – freshwater pond, freshwater forested wetlands, and freshwater emergent wetlands, then created a raster data set from those and performed a Euclidean distance analysis to calculate the relative approximate distances between longleaf pine landcover raster cells and freshwater wetland/pond raster cells. I excluded any cells in which the landcover was not within 1.5 miles of the wetlands by calculating a rasterized buffer of 7920 feet (since all data was saved in a projection that uses feet as a unit of spatial measure) and reclassifying. Last, I used the raster calculator to develop a habitat

[1] USGS GAP Analysis Citation
[2] CSFIAS Citation
[3] FL 2060 Citation

suitability schema with five classes. Since the last two classes were completely unsuitable, I combined them in the display.

I chose the simplest method with the least inputs to conduct this analysis. Hence, the results serve as preliminary findings to the question of what the most suitable land area is for frosted flatwoods salamander habitat conservation. The simplest method often proves to be as accurate or helpful as more complicated methods. Therefore, it is a good start to any analysis. Unfortunately, I believe the methodology led to unreliable results, below, and should be revamped and repeated using more inputs and more thoughtful attention to weighting factors and combining their impacts.

Results

According to this raster analysis, in the State of Florida, 9% of the land area is completely unsuitable for frosted flatwoods salamanders, 19% would not easily support these salamanders, 68% could potentially support these salamanders, and only 3% is completely suitable.

To determine if the results were reliable, I overlaid the current documented range and distribution of the frosted flatwoods salamander with the areas I found to be most suitable. I was perplexed to see that they did not coincide. Either, the existing observed populations are an anomaly, the research about their habitat is insufficient, the observations and analysis conducted by major organizations (the International Union for the Conservation of Nature and the United States Geological Survey) are flawed, or (most likely) my analysis is inaccurate. Since I have

concluded the latter, I am will reevaluate the methodology, continue to explore other tools and methods and redo the analysis.

Conclusion

Since I was not satisfied with the result, I recommend rerunning an analysis modeled after mine using a different species to see if the model itself is terribly flawed. Since the results are not clear, I find this analysis inconclusive. However, it would be accurate to say that the majority of the land in Florida is potentially suitable based on Florida 2060 maps and on studies about conservation planning in Florida. The greater significance in conducting a study such as this one is to create a replicable, dependable, and simple way to evaluate habitat suitability to help guide conservation prioritization on a regional or state-wide scale. The next steps will include attempting some of the aforementioned models and redesigning mine to produce a more reliable result.

Works Cited

Bennett, S. H., Pauly, G. B., Palis, J. G., & Shaffer, H. B. (2012, September 25). Conservation and genetics of the frosted flatwoods salamander (Ambystoma cingulatum) on the Atlantic coastal plain. *Conservation Genetics, 13*, pp. 1-7. doi:10.1007/s10592-011-0274-1

Carr, M. H., & Zwick, P. (2005). Using GIS suitability analysis to identify potential future land use conflicts in North Central Florida. *Journal of Conservation Planning, 1*, pp. 58-73. Retrieved from http://www.journalconsplanning.org/2005/volume1/issue1/carr/manuscript.pdf

Carr, M. H., & Zwick, P. D. (2007). *Smart Land-Use Analysis: The LUCIS Model. Land Use Conflict Identification Strategy.* ESRI Press.

Cerulean, S. (2006). *Wildlife 2060: What's at Stake for Florida?* Florida Fish and Wildlife Conservation Commission.

Contributor, G. (2014, November 18). *How GIS is Being Used in Conservation Biology*. Retrieved from GIS Lounge: https://www.gislounge.com/gis-used-conservation-biology

ESRI. (2007, December). *GIS for Wildlife Conservation.* Retrieved from GIS Best Practices: http://www.esri.com/library/bestpractices/wildlife-management.pdf

ESRI. (2010, October). *Wildlife Managment.* Retrieved from GIS Best Practices: http://www.esri.com/library/bestpractices/wildlife-management.pdf

Farjon, A. (2013). *Pinus Plustris.* Retrieved from TheIUCN Red List of Threatened Species 2013: http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T39068A2886222.en

Flatwoods Salamander. (2001). *Field Guide to the Rare Animals of Florida*. Florida Natural Areas Inventory, 2001. Retrieved from Field Guide to the Rare Animals of Florida: http://www.fnai.org/FieldGuide/pdf/Ambystoma_cingulatum.pdf

Florida Fish and Wildlife Conservation Commission. (n.d.). *Frosted Flatwoods Salamander.* Retrieved from http://myfwc.com/media/2211319/Frosted-Flatwoods-Salamander.pdf

Florida Fish and Wildlife Conservation Commission. (n.d.). *Preliminary Biological Status Report Flatwoods Salamander.* Retrieved from http://myfwc.com/media/1356264/FlatwoodsSalamanderBSR_final.pdf

Florida Natural Areas Inventory. (n.d.). *The Florida Longleaf Pine Ecosystem Database.* Retrieved from http://www.fnai.org/longleafgdb.cfm

Li, Y., & Nigh, T. (2010). GIS-based prioritization of private land parcels for biodiversity conservation: A case study from the Current and Eleven Point Conservation Opportunity Areas, Missouri. *Applied Geography*. doi:10.1016/j.apgeog.2010.02.006

Palis, J., & Hammerson, G. (2008). *Ambystoma Cingulatum.* Retrieved 2016, from The IUCN Red List of Threatened Species 2008: http://dx.doi/10.2305/IUCN.UK.2008.RLTS.T1099A3236962.en

Pfab, M. F., Victor, J. E., & Armstrong, A. J. (2011). Application of the IUCN Red Listing system to setting secies targets for conservation planning purposes. *Biodiversity Conservation, 20*, pp. 1001-1012. doi:10.1007/s10531-011-0009-0

Ross, C. L., Leone de Nie, K., & Barringer, J. (2006). *A Time for Leadership: Growth Management and Florida 2060.* Georgia Institute of Technology, Center for Quality Growth and Regional Development. 1000 Friends of Florida. Retrieved from http://www.1000friendsofflorida.org/connecting-people/florida2060/

Salem, B. B. (2003). Application of GIS to biodiversity monitoring. *Journal of Arid Environments, 54*, 91-114. doi:10.1006.jare.2001.0887

The Nature Conservancy. (2010). *Heartland Ecological Assessment Report.* Babson Park, FL. Retrieved from http://conservation.dcp.ufl.edu/Heartland_2060_Ecological_Report_Final.pdf

U.S. Fish and Wildlife Service. (2011, April). *Habitat Conservation Plans Under the Endangered Species Act.* Retrieved from https://www.fws.gov/endangered/esa-library/pdf/hcp.pdf

United States Geological Survey. (2004). *Geographic Information Science Tools for Conservation Planning.* Upper Midwest Environmental Sciences Center, La Crosse. Retrieved from http://www.umesc.usgs.gov/documents/fact_sheets/gis_conservation.pdf

United States Geological Survey. (2004). *Use of Amphibians as Indicators of Ecosystem Restoration Success.* Retrieved from http://pubs.usgs.gov/fs/2004/3106/#pdf

United States Geological Survey. (n.d.). *Adaptive Habitat Conservation for Flatwoods Salamanders.* Retrieved from https://www.usgs.gov/science/adaptive-habitat-conservation-flatwoods-salamanders?qt-science_center_objects=1#qt-science_center_objects

Zwick, P. D., & Carr, M. H. (2006). *Florida 2060 A Polpulation Distribution Scenario for the State of Florida.* University of Florida, GeoPlan Center. 1000 Friends of Florida. Retrieved from http://www.1000friendsofflorida.org/connecting-people/florida2060/

Data Sources:

Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31, available at http://www.fws.gov/wetlands/data/Data-Download.html.

Florida 2060 Development Projections. 2006. University of Florida GeoPlan Center, available at https://databasin.org/datasets/4a1340791089437dae38593f0ef39439.

Forestland Cover Data. Comprehensive Statewide Forest Inventory Analysis and Study (CSFIAS) – 2014. Florida Department of Agriculture and Consumer Services, available at http://www.freshfromflorida.com/Divisions-Offices/Florida-Forest-Service/Our-Forests/Working-Forest/Comprehensive-Statewide-Forest-Inventory-Analysis-and-Study-CSFIAS-2014.

John Palis, Geoffrey Hammerson. 2008. *Ambystoma cingulatum*. The IUCN Red List of Threatened Species 2008: e.T1099A3236962.http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T1099A3236962.en. downloaded

US 50 States + DC Shapefile. Charlie Fitzpatrick, January 29, 2012, available at https://www.arcgis.com/home/item.html?id=f7f805eb65eb4ab787a0a3e1116ca7e5

U.S. Geological Survey Gap Analysis Program. 2011. National GAP vertebrate species distribution model. http://gapanalysis.usgs.gov/species

Software:

NatureServe. 2015. NatureServe Conservation Status Assessments: Rank Calculator Version 3.185. NatureServe, Arlington, VA. Online at http://connect.natureserve.org/publications/StatusAssess_RankCalculator

Schill, S. and G. Raber (2012) Protected Area Tools (PAT) for ArcGIS software http://www.gispatools.org. The Nature Conservancy, Arlington, VA.

Watts, M.E, I.R. Ball, R.R. Stewart, C.J. Klein, K. Wilson, C. Steinback, R. Lourival, L. Kircher, and H.P. Possingham. 2009. Marxan with Zones: software for optimal conservation based land- and sea-use zoning, Environmental Modelling & Software (2009), doi:10.1016/j.envsoft.2009.06.005

What if?, Inc., Richard E. Klosterman, What if? 2.0, [Computer software]. (2016). Retrieved from http://www.whatifinc.biz/documentation.php

World Wildlife Fund, Smart Infrastructure Planner (beta) [Computer software]. (2012). Retrieved from http://www.worldwildlife.org/publications/smart-infrastructure-planner-beta