Land Cover Changes and Pine Patch Response:

Scenario Planning for Biodiversity and Ecosystem Services in Greenville County, SC

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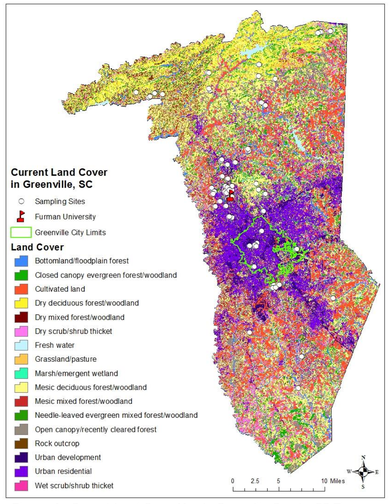

Figure 1. *Current Land Cover Map in Greenville County, SC.* The locations of pine patch sample locations are also displayed. Furman University and the City of Greenville city limits are included for reference.

Introduction / Literature Review

The complexities within decisions about land use and land cover changes require new conservation approaches on local and regional scales. Maps of land cover type become important when demonstrating the value of ecosystem services, often through creating scenarios of land cover change (Swetnam et al., 2010). Greenville County, South Carolina, was ranked as the seventh most sprawling metropolitan area in the United States in 2010, with land use and land cover change driven by urbanization, timber harvest, and agriculture (Hamidi and Ewing, 2014). This rapid transition by specific drivers creates a case study for how drivers can affect local biodiversity and ecosystem services on a county scale. By measuring the ecosystem services and species richness of a specific location and connecting that data to its land cover type, we can assess how land cover changes would affect the measures of biodiversity and ecosystem services in Greenville County. Furthermore, we can compare how different scenarios would affect the evergreen forest land cover type, which is the natural habitat for the birds we observed (Iglecia et al., 2012). By visualizing and analyzing land cover change scenarios in Greenville County, we can observe where conservation efforts should be applied in the area.

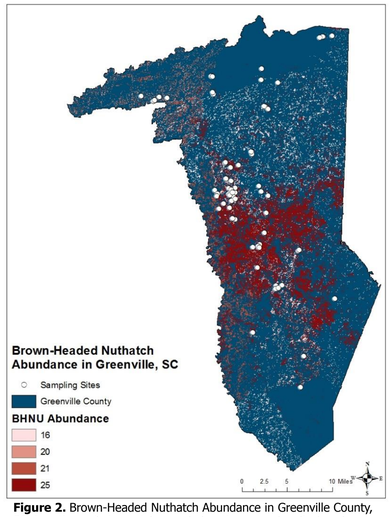

Figure 2. Brown-Headed Nuthatch Abundance in Greenville County, SC. Locations of pine patch sample locations are also displayed.

Methodology

Over the field seasons of 2013 and 2014, our team collected data on ecosystem services and bird biodiversity at 75 pine patch locations in Greenville County.

Biodiversity:

At each patch, we performed four 10-minute point-count surveys to observe the birds there between May and July in both 2013 and 2014. Using birds as the measure for biodiversity allowed for a species richness measurement at each pine patch location. We chose the brown-headed nuthatch (BHNU) as our indicator species because of its conservation priority in the Southeastern United States (Iglecia et al., 2012).

Ecosystem Services:

Taking samples of trees in each patch, I assessed the ecosystem services at each patch using the Davey National Tree Benefit calculator. Then, I connected each patch to a land cover type and averaged the ecosystem service values of storm water drainage, property value, and carbon sequestration for each land cover type.

Landscape Scenarios:

Using ArcGIS software, I created maps of the land cover in Greenville County. I used the land cover drivers to create scenarios about land cover change for urbanization, agricultural growth, pine loss, and pine growth. Modeling growth of agriculture and urbanization, I created a random raster for Greenville County that gave each cell a value 1-20. Then I converted a random 5% of the evergreen forest into either agriculture or urban area to model that land cover change using the raster calculator. This demonstrated a likely degree of urban and agricultural growth for the county. For overall pine growth and loss scenarios, I made a random raster for Greenville County that gave each cell a value 1-5 to demonstrate 20% growth or loss of pine forests. For pine loss, I converted a random 20% of the evergreen forest into deciduous forest using the raster calculator. Modeling pine growth, I converted a random 20% of the deciduous forest into evergreen forest again using the raster calculator.

Ecosystem Services by Land Cover

Land Cover Type	Dollar Value ($)	Property Value ($)	Carbon Sequestration	Stormwater Drainage (gal)	Biodiversity (Species Richness)
Floodplain Forest	171.15	27.26	492.22	72.94	12.5
Evergreen Mixed	153.65	24.53	431.96	65.69	18.16
Cultivated Land	152.4	12.78	271.02	79.43	18.5
Urban Residence	150.27	16.31	290.28	72.63	21
Cleared Forest	140.78	21.76	318.36	63.93	21
Mixed Forest	139.2	17.77	319.95	63.7	19.5
Shrub	133.5	11.98	234.54	66.48	19.25
Urban Development	124.63	19.95	294.86	55.05	16.3
Evergreen Closed Canopy	113.59	19.31	225.435	49.91	18.5
Deciduous Forest	111.29	18.81	271.57	46.15	17.75

Table 1. Ecosystem Services by Land Cover. Land cover types in Greenville County, SC, and their resultant ecosystem service values.

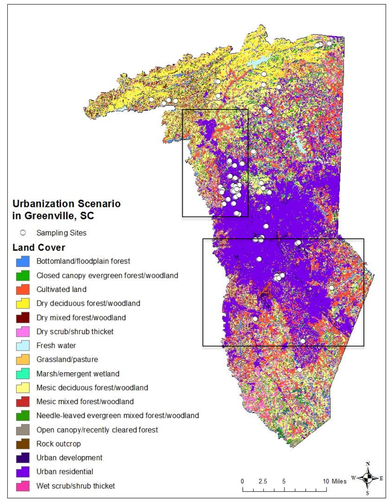

Figure 3. *Urbanization Scenario.* Land cover change under potentially increasing urbanization in Greenville County, SC. Boxes show new areas of conservation concern in this scenario.

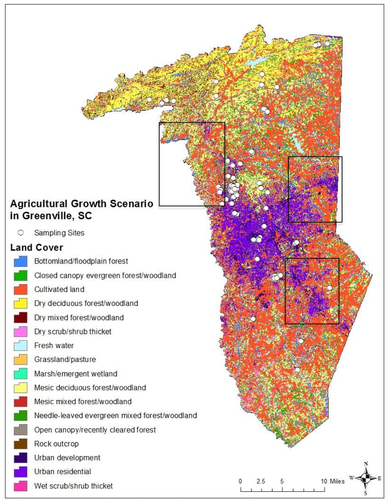

Figure 4. *Agricultural Growth Scenario.* Land cover change under the potential growth of cultivated land in Greenville County, SC. Boxes show new areas of conservation concern in this scenario.

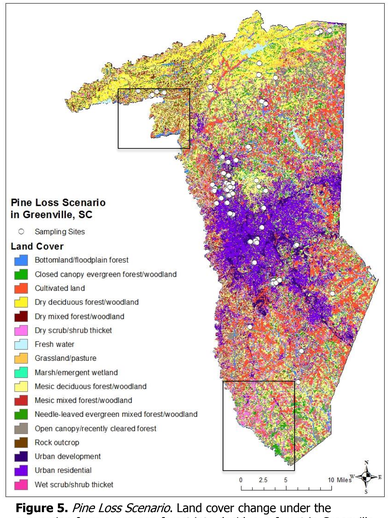

Figure 5. *Pine Loss Scenario.* Land cover change under the conversion from evergreen forest into deciduous forest in Greenville County, SC. Boxes show new areas of conservation concern in this scenario.

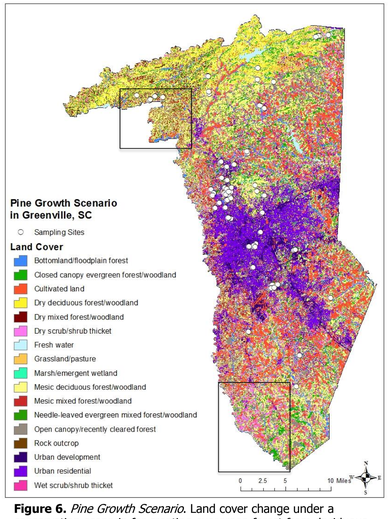

Figure 6. *Pine Growth Scenario.* Land cover change under a conservation scenario for creating evergreen forest from deciduous forest in Greenville County, SC. Boxes show new areas of conservation concern in this scenario.

Results and Discussion

Land Cover and Biodiversity/Ecosystem Services:

Mapping out the land cover in Greenville County allowed the measured ecosystem services to represent the particular land cover type in which it is located (Figure 1). The highest monetarily-valued land cover types are floodplain forest, evergreen mixed forest, and cultivated land (Table 1). In comparing our pine patch samples to the state data about brown-headed nuthatches, we see similar trends in terms of the location and land cover type (Figure 2). The highest BHNU abundance occurs in urban residential areas, mixed forests, and evergreen forests. Overall areas of concern in Greenville County for biodiversity include the urbanized area in the middle of the county, the northwest corner of the county, and the western border. All of these areas have the highest species richness of BHNU (Figure 2). For ecosystem services, the northern half and the southernmost tip of Greenville County are of concern due to their habitat land cover types with high ecosystem service values (Figure 1). Since the cultivated land cover type is high in its ecosystem service value, the area just south of urban Greenville is important, as is the eastern border to the north of urban Greenville (Figure 1).

Scenarios:

The Urbanization Scenario reduces evergreen forest area by 28% (Figure 3). Increased urban residential areas could have benefits for biodiversity, especially for certain species like BHNU. In Figure 3, the boxed area to the north of urban Greenville could reduce the ecosystem services there. The boxed area to the south could see increased biodiversity and BHNU richness. The Agricultural Growth Scenario reduces evergreen forest area by 22% (Figure 4). In Figure 4, the increased cultivated land could benefit ecosystem service values in all boxed areas. However, biodiversity and BHNU richness would decrease in all of these areas. The Pine Loss Scenario reduced evergreen forest area by just under 20% (Figure 5). The Pine Growth Scenario increased evergreen forest area by 11% (Figure 6). The differences between Figures 5 and 6 are important for biodiversity and BHNU richness in the northern boxed area and in the southern boxed area for ecosystem service values.

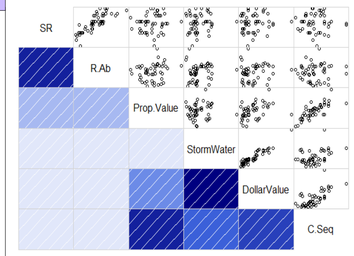

Figure 7. Correlations of measured biodiversity and ecosystem services from pine patch sampling locations. The box's hue demonstrates the strength of the correlation between the two intersecting ecosystem services, as demonstrated through the scatter plot.

Acknowledgements

This project was successful only because of the help of many colleagues. The Furman Advantage provided me with the ability to complete my research. Thanks to Jesse Wood and Jenny Warnken for being wonderful fieldwork partners. Thanks to Mike Winiski for the countless assistance on spatial analyst tools and land cover scenarios in ArcMap. Finally, thanks to Dr. John Quinn for the research opportunity, continual guidance, and constant feedback.

Conclusion

The scenarios indicate that evergreen forests are likely to lose area in the coming years due to the drivers of land cover change in Greenville County. Evergreen forests are the natural habitat for many bird species of conservation, which makes these results concerning (Iglecia et al., 2012). Furthermore, the occupancy of these birds correlates positively with the quality of habitat. However, the data suggest that urbanization is not necessarily a harmful thing for all wild species, as demonstrated through the high species richness and occupancy of brown-headed nuthatches in urban areas (Figure 2). In terms of ecosystem services, the most productive land cover types depend on which services we analyze (Figure 2, Figure 7). The analysis of ecosystem services demonstrates the complexity within conservation decisions, even on a county-scale. Overall, the scenarios indicate that there are opportunities for novel conservation opportunities in Greenville County. To prepare for likely urban growth, I would first suggest increasing public awareness about the importance of urban areas in conservation, which would further increase the value urban and suburban residents place on wildlife conservation (McKinney, 2002). For all of these scenarios, I would suggest prioritizing specific areas, as mentioned above, to ensure that the most important areas in terms of species richness and ecosystem service values are preserved (Ricketts and Imhoff, 2003). Analysis of socio-economic values and tradeoffs will further indicate which areas to prioritize for conservation.

Future Research

In the future, I would like to increase the scale of my scenarios by analyzing more land cover change than that in evergreen forests. This would better encompass the total land cover change in Greenville County. I also plan to extend my measures of biodiversity and ecosystem services to be more indicative of the land cover samples. Furthermore, I plan to use social and economic data for future scenario planning that will fit in the Greenville environment and allow for analysis of tradeoffs in social, economic, and ecological areas.

References/ Data Sources

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Figure 1, 3, 4, 5, 6 Data Sources: land cover and scenario maps created by the author using South Carolina Department of Natural Resources land cover data from http://www.dnr.sc.gov/GIS/gap/mapping.html.

Figure 2 Data Sources: Abundance map created by the author using South Carolina Department of Natural Resources brown-headed nuthatch species richness data from http://www.dnr.sc.gov/GIS/gap/mapping.html.

All other referenced data from personal research.