MAPPING AND ANALYSIS OF FRAGMENTATION IN SOUTHEASTERN NEW HAMPSHIRE

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ABSTRACT:

As the human population has grown significantly in the last 20 years throughout New England, Southeastern New Hampshire has become increasingly susceptible to issues associated with urban development and sprawl. Urbanization has increased the amount of impervious surface in the area as well as fragmented many of the crucial habitats, especially forests. Mapping and analyzing these fragmented habitats is of critical importance for conserving and protecting critical habitat for water quality, wildlife, and quality of life. Several methods for quantifying fragmented landscapes have recently been developed. These techniques include: FRAGSTATS (University of Massachusetts), the Forest Fragmentation program from the Center for Land Use Education and Research (CLEAR, University of Connecticut), and a number of other image analysis techniques. This project used the National Land Cover Dataset Land Cover Retrofit product of Coastal Watershed, NH to evaluate various fragmentation techniques. In exploring the results from FRAGSTATS and the CLEAR Forest Fragmentation program, we found no significant difference in the land cover fragmentation between 1992 and 2001. These two methods were compared to determine the strengths and shortcomings of each. The CLEAR program provided the advantage of visual results while the FRAGSTATS results were only numeric. We found that each of these methods alone is insufficient to precisely map fragmentation, especially when applied to the National Land Cover Dataset maps. Our continued work will be to develop a tool that combines the best of these techniques together to better map and analyze fragmentation.

1. INTRODUCTION

Habitat loss has been a major concern of the New Hampshire Coastal Watershed in the Seacoast area due to the increasing population and the development pressures that come with that population increase (Andren, 1994; MacLean et al., 2010). Habitat loss and fragmentation has been tied with losses in biodiversity, issues with carbon storage, reduction in water quality, and many other environmental factors (Andren, 1994; Riitters et al., 2002; Fischer and Lindenmayer, 2007; Vogt et al., 2007). Therefore, identifying and quantifying the past landscape change in the Seacoast area of New Hampshire has become a priority for predicting how the landscape with continue to change in the future and what species might be lost due to these changes.

Historically, when habitat, especially forest cover, has been evaluated in this area, only the amount of habitat has been documented and not how the amounts of habitat are spatially distributed. Fragmentation generally deals with not only the amount of a certain habitat type that is available, but also the spatial relationship between pieces of that specific habitat (Riitters et al., 2002). In general, the measure of fragmentation of a landscape can actually provide more information than total habitat areas can. Some habitats may see a very small overall change in area while there is a decline in the average size of the habitat patches. Often this patch size decrease can be observed in the proliferation of roadways into forested habitats. While the overall area of the forest may only decrease minutely, the roadways can impede the dispersion of a species and may cause that species to disappear in a smaller patch created by these roadways (Andren, 1994; Fischer and Lindenmayer, 2007). Therefore, fragmentation, or the spatial relationship between habitats, can be a very important descriptor when assessing habitat change over time.

Several programs have been written to determine the fragmentation of habitats using spatial data such as satellite imagery (McGarigal et al., 2002; Riitters et al., 2002; Parent et al., 2007; Vogt at al., 2007). Two of these programs were explored in this study to quantify the extent of the fragmentation in the Coastal Watershed in southeast New Hampshire. The first program used was FRAGSTATS, developed at the University of Massachusetts, Amherst, which is one of the most popular, strictly statistical, programs used to assess fragmentation of a landscape (McGarigal et al., 2002). This program provides excellent quantitative measures but does not produce any visual results. The second program used was a newer program that does have a visual output. This program is the Forest Fragmentation program from the Center for Land Use Education and Research (CLEAR) out of the University of Connecticut (CLEAR, 2009; Parent et al., 2007) which built upon older work done by Riitters et al. (2002).

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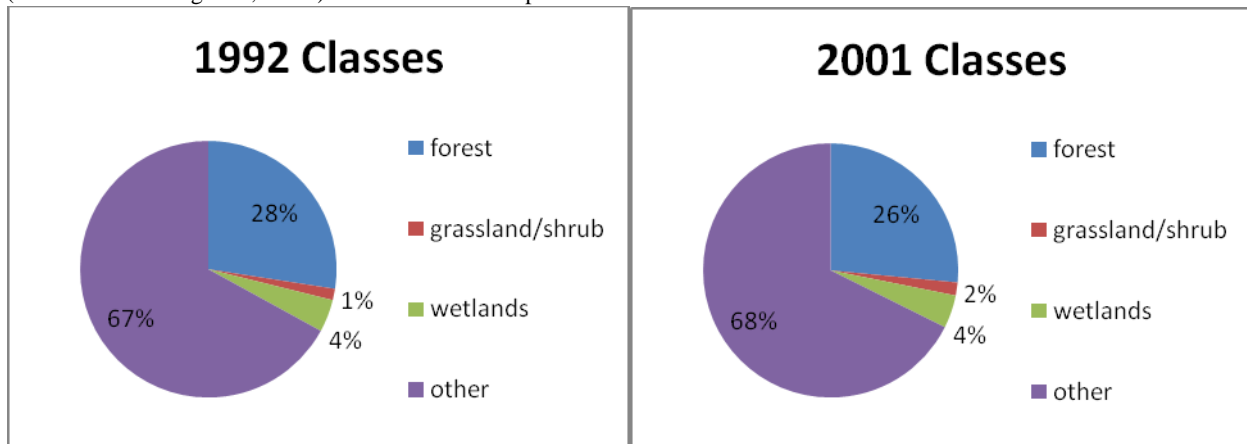November 15-19, 2010 Orlando, Florida

2. METHODS AND RESULTS

FRAGSTATS was chosen as one of the programs used to quantify fragmentation in the Seacoast since it provides detailed statistical information on various landscape levels. FRAGSTATS can provide metrics at the individual patch level. Area, perimeter, and radius of gyration can be computed for each area of homogeneous habitat (McGarigal et al., 2002). Consequently, similar statistics can be computed for each class of habitat (i.e. the compilation of all of the patches for each habitat), with many added metrics such as percentage of landscape or total edge within that class. Lastly, landscape metrics can also be computed for the entire study area. For this study, the class metrics were the most important to determine how different habitats were changing over time. Total edge was a particularly important metric for this study since it is defined as the area along the border between the habitats of interest and the surrounding habitats. Usually the edge areas suffer from some effects from the surrounding habitat. The areas not affected by edge effects are often referred to as "core" habitats and are thought to suffer from fewer effects from the surrounding habitats.

Since FRAGSTATS only runs with raster data (i.e., equal area grids or cells), an initial investigation was performed using the National Land Use Database (NLCD) 1992-2001 Land Cover Change Retrofit Product as the base layer. The Land Cover Change Retrofit (LCCR) Product was chosen as opposed to the original NLCD maps for 1992 and 2001 since the two NLCD maps were created using different classification techniques and cannot be directly compared (Graham and Congalton, 2009). Two distinct maps were created out of the LCCR Product, one for 1992 and one for 2001, each with the same, broad, Anderson Level I classes, so that the two maps can be directly compared (Fry et al., 2009). The Anderson Level I classes include 7 different categories in this area: agriculture, barren, forest, grassland/shrub, open water, urban, and wetland. The land cover maps were then analyzed in FRAGSTATS, setting the forest, grassland/shrub, and wetland categories as the habitats being fragmented. The urban, barren, and agriculture categories were treated as the habitats doing the fragmenting, and open water was treated as a background value. A fixed edge depth was also defined with a width of 300ft.

When the 1992 and 2001 maps were compared using class level metrics in FRAGSTATS, only the statistics for the habitats being fragmented (i.e. forest, grassland/shrub, and wetlands) were outputted, since they are the areas of interest. As displayed in Figure 1, very little changed between the 1992 and 2001on these maps. In fact, there was no significant difference between the class areas and the total edge values for each class (Table 1).

Since no visual output was created by the FRAGSTATS program, a second analysis was performed using the Forest Fragmentation program from CLEAR. The CLEAR program performs similarly to FRAGSTATS, using a raster dataset to calculate areas of habitat, however it only calculates areas of certain habitat types and number of patches and outputs these variables into ArcMAP, rather than numerous statistics that can be viewed in a text file as with FRAGSTATS (CLEAR,

Figure 1. The percent of the total study area covered by each habitat class on the 1992 and 2001 NLCD Land Cover Change Retrofit Product, as described by FRAGSTATS.

Table 1. The comparison of the class areas and total length of edge per class type using FRAGSTATS.

Class Type	1992			2001			χ^2		
	Class Area (ha)	Total Edge (m)	Number of Patches	Class Area (ha)	Total Edge (m)	Number of Patches	Class Area	Total Edge	Number of Patches
forest	148458.06	21171840	3597	143361.81	20515200	3445	9.96E-79	0	8.90E-04
grassland/shrub	7688.7	5015490	8023	8926.56	5397150	8223			
wetlands	22225.77	7791450	6952	22605.93	7759200	6822			

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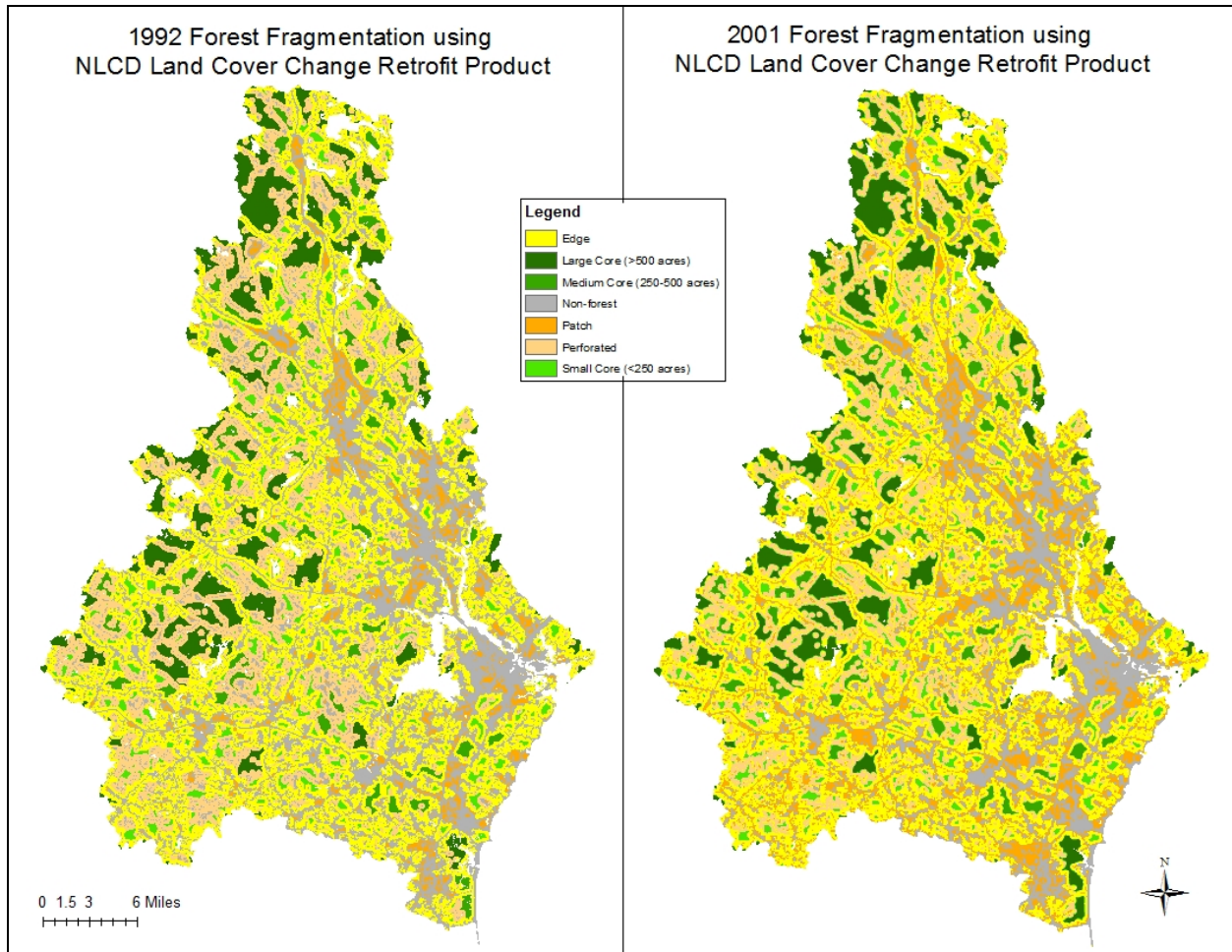November 15-19, 2010 Orlando, Florida

2009). A valuable feature of the CLEAR program is that it can be run directly in ArcMAP and creates an output map with seven different categories of fragmented landscapes. The seven categories are: non-forest, patch, edge, perforated, small core (<250 acres), medium core (250-200 acres), and large core (>500 acres). Since the program was created to monitor the effects of fragmentation on forested landscapes in Connecticut, it is assumed that the areas of interest are forests. Therefore, the default within the program is to clump anything that is not forest into a "non-forest" category. The core habitats are defined as above, areas out of the area affected by surrounding different "non-forest" landscapes. Edge is still the boundary zone between habitats, generally suffering some effects from both habitats. A patch area, in this instance, is an area of a habitat of interest (i.e. forest) that is completely enclosed in what would be "edge" habitat, but does not have any core area, and therefore is considered a patch rather than edge and core habitat. A perforated section is the edge habitat created by a small area of non-forest habitat completely surrounded by core habitat.

For this analysis, anything in the forest NLCD LCCR Product was also considered forest in the CLEAR program. However, both the grassland/shrub and wetland categories were added to the "forest" class in the CLEAR program to match the analysis using FRAGSTATS. Therefore, all three of these categories can contribute to core habitat. The urban, barren, and agriculture were again set as the "non-forest" categories, or the categories impeding on the "forest" categories. Lastly, open water was used as an "other" category and removed from the analysis. Figure 2 illustrates the output maps for both 1992 and 2001. When the two output maps were compared by area covered by each output category, no significant difference was found between the two dates (p<0.05) (Figure 3). This result is the same as when using FRAGSTATS for the same area.
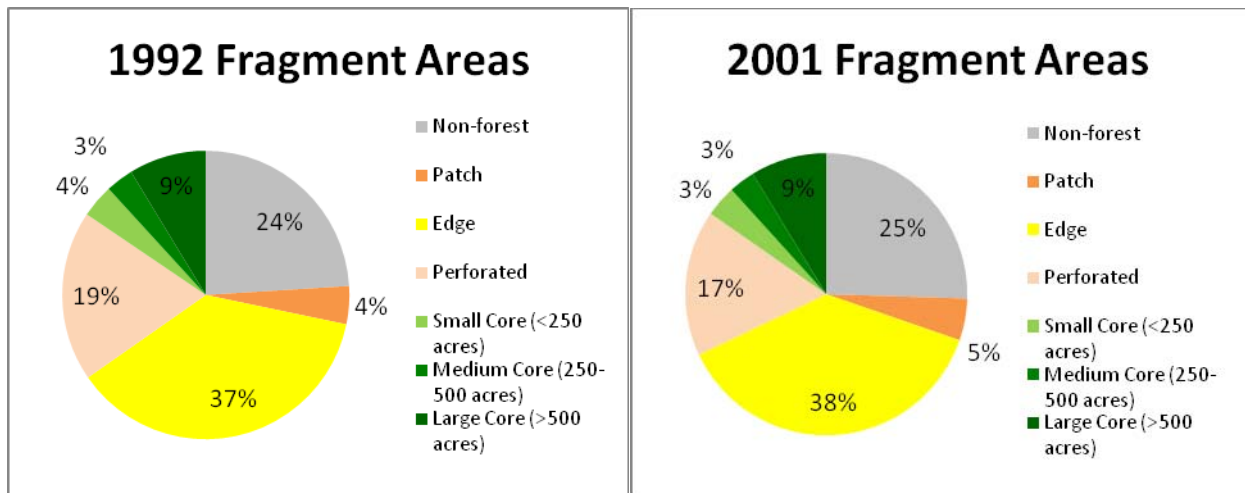
3. CONCLUSIONS AND FUTURE WORK

Both FRAGSTATS and the CLEAR Forest Fragmentation program provided valuable information about the fragmentation of the Coastal Watershed in New Hampshire. However, the visual output created by the CLEAR Forest Fragmentation program was comparatively a much easier output to use when dealing with land cover maps that are often viewed in ArcMAP. Despite not having a visual output, the statistics generated by FRAGSTATS were much more descriptive for the land cover classes of interest and FRAGSTATS, in general, was much more amenable to different situations. A program that is able to output a similar visual representation as the CLEAR program with the information provided by FRAGSTATS would be more useful for quantifying specific fragmentation within such a small area.

Although both programs indicated that there is no significant difference in fragmentation of the landscape from 1992 to 2001, this is more an artifact of the maps used to calculate fragmentation. Although the Land Cover Change Retrofit product has corrected for issues in the original 1992 and 2001 NLCD classifications, the new product has habitat labels that are too broad to identify small changes in land cover (Graham and Congalton, 2009). The broad categories caused the no detection of change in each of the fragmentation programs, even though other sources have noted changed habitat fragmentation within the Coastal Watershed. Therefore, both a new program and new land cover maps will be necessary to better quantify the fragmentation of the Coastal Watershed in New Hampshire.

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Figure 2. The output maps for both 1992 and 2001 using the CLEAR Forest Fragmentation program.

Figure 3. The percent of the total study area covered by each of the output categories.

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