FRAGMENTATION OF HABITATS USED BY NEOTROPICAL MIGRATORY BIRDS IN SOUTHERN APPALACHIANS AND THE NEOTROPICS[1]

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ABSTRACT: Recent declines in North American breeding bird populations have sparked great concern over the effects of habitat fragmentation. Neotropical migrant birds use and are influenced by two biomes during a single life span. Yet assessment of the relative importance of changes in tropical wintering areas versus temperate breeding areas is complicated by regional variation in rates and extent of habitat change. Landscape-level measurements of forest fragmentation derived from remotely-sensed data provide a means to compare the patterns of habitat modification on the wintering and breeding grounds of migrant birds. This study quantifies patterns of forest fragmentation in the Southern Appalachian Mountains and tropical Amazon and relates these patterns to the resource needs of neotropical migrant birds. Study sites were selected from remotely-sensed images to represent a range of forest fragmentation (highly fragmented landscape to continuous forest).

INTRODUCTION

The abundance and spatial arrangement of habitats affects the diversity and population sizes of animal species. For example, ant populations are affected by the abundance and age distribution of forests (Punttila et al. 1991). The number and sizes of forest patches also determines the composition of breeding and wintering bird communities (van Dorp and Opdam 1987, Pearson 1993) as well as the persistence of mammal populations (Dueser et al. 1988). Therefore, changes in the broad-scale pattern of habitats will likely affect animal populations in altered landscapes.

Recent declines in North American breeding bird populations (e.g., Robbins et al. 1989, Hagan and Johnson 1992) have sparked great concern over the effects of habitat fragmentation. While a reduction in the area of habitat has obvious consequences, the fragmentation of remaining habitat can also have negative impacts (Freemark and Merriam 1986, Quinn and Hastings 1987, Newmark 1991, Pearson et al. In press), especially since many of the declining bird species are sensitive to edge and the area of remaining habitat.

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DISCLAIMER

Analyses of Breeding Bird Survey (BBS) data suggest that neotropical migrant birds have experienced serious declines in the Southern Appalachians[4]. We use remotely-sensed data to quantify the spatial extent and pattern of forest loss in the Southern Appalachians and portions of the tropical wintering areas used by these bird species. In this paper, we will provide some examples of our work that describe the spatial pattern of deforestation in eastern Tennessee.

QUANTIFYING SPATIAL PATTERN OF DEFORESTATION

The pattern of deforestation varies with physiographic province in the Southern Appalachians. While examining satellite imagery, we noticed that the rugged Blue Ridge physiographic province has experienced much less forest loss than the Ridge-and-Valley province. To quantify these differences in forest loss between the two provinces, we selected three study areas from a land cover map provided by the Tennessee Department of Conservation (Fig. 1). These study areas include a site in Blue Ridge, in the transition zone between the Blue Ridge and Ridge-and-Valley provinces, and a site in the Ridge-and-Valley province. These three sites are located between Chattanooga and Knoxville, TN. Each of these study areas is 1600 km^2 in extent. Deciduous and mixed pine-deciduous forest were classified as suitable habitat for this analysis (shaded areas in Fig. 1). Other land cover types were classified as non-suitable habitat (white areas in Fig 1).

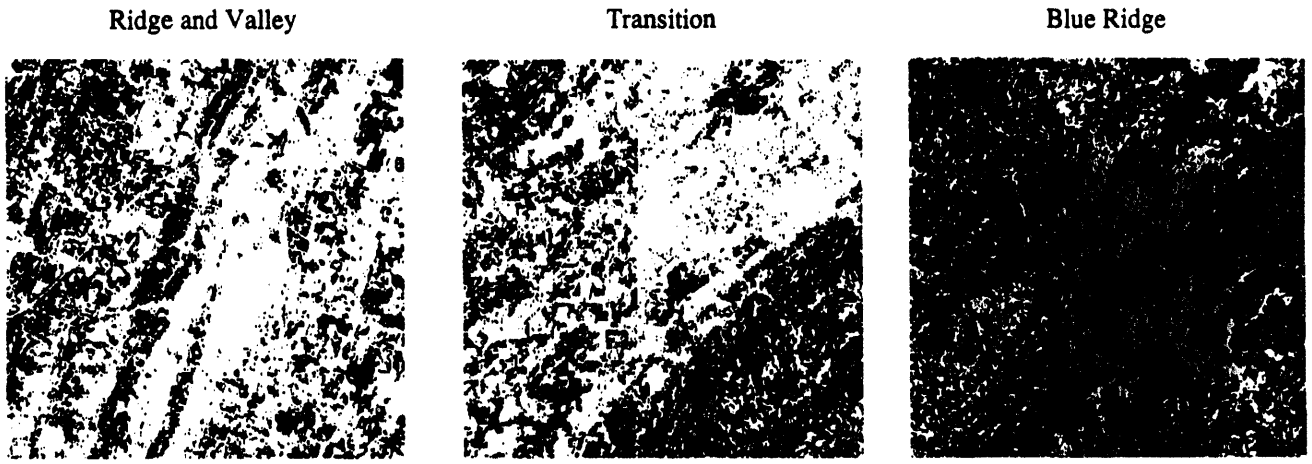

Figure 1. Forested areas (black) and non-forested areas (white) in southeastern Tennessee.

The first step is to tally the area of suitable habitat and identify distinct patches of habitat in each study area. The proportion of suitable habitat and statistics that describe the size distribution of individual patches can be used to describe the spatial pattern of habitat in the three study areas (Table 1). The area of the largest patch divided by the total area of habitat in the map (LC/LC_{max}) provides an

[4]Unpublished data from B. Peterjohn and J. Sauer, USFWS, Patuxent, MD.

index of habitat fragmentation (Pearson et al. In Press). This index varies between 0.0 and 1.0. Habitat in a landscape is highly fragmented when LC/LC_{max} is close to 0 and well connected when LC/LC_{max} is close to 1.0. A measure of patch shape would also be useful, but no such measure has been included in this analysis.

Table 1. Spatial pattern of forest in three study sites in southeastern Tennessee.

Site	LC/LC_{max}	Prop. in Forest	Number of Patches	Average Patch Size
Ridge & Valley	0.174	0.408	1664	6345 ha
Transition	0.614	0.355	1395	21702 ha
Blue Ridge	0.990	0.802	352	125777 ha

Mixed and deciduous forests in the Blue Ridge province account for a high proportion of the map. Those forests exist in small number of very large patches (Table 1). In the Ridge-and-Valley, mixed and deciduous forests cover about 40 percent of the map and are broken up into a large number of small patches. Similarly, the fragmentation index indicates that suitable habitat in the Ridge-and-Valley is fragmented while habitat in the Blue Ridge is highly connected. The transition zone map has less forest, but the forest is better connected because this map is dominated by a few large patches (Table 1, Fig. 1).

The size distribution of patches can also be used for assessing the potential of landscapes to support populations of a particular species. For example, suppose managers are considering the protection status of a species that requires forest patches of at least 100 ha in order to persist. In the Ridge-and-Valley province, 30 percent of the remaining forest habitat is unusable for this species because many of the patches are less than 100 ha in area. In the Blue Ridge province, practically all of the forest is suitable because more than 99 percent of the habitat occurs in patches greater than 100 ha in area (Fig 2.).

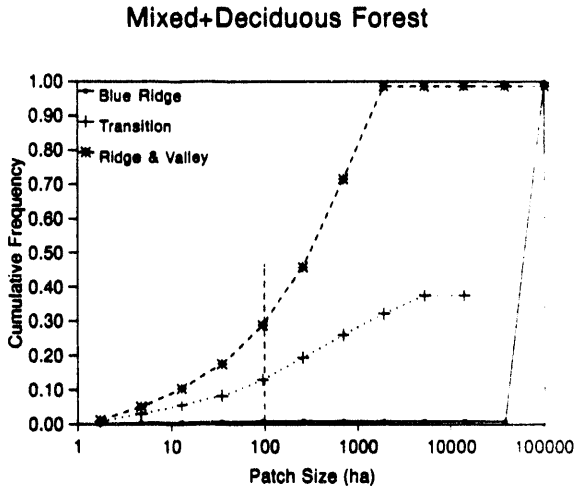

Figure 2. Frequency distribution of forest patch sizes in southeastern Tennessee.

EFFECT OF HABITAT FRAGMENTATION ON ABUNDANCE OF SUITABLE HABITAT

Habitat fragmentation occurs when natural patterns of connectivity are modified to the extent that normal ecological processes are disrupted and/or new processes are initiated. An example of a normal process that could be disrupted is a metapopulation that depends on the exchange of individuals between local breeding populations. Habitat fragmentation could reduce the ability of dispersers to find other breeding groups. Examples of new processes that could be initiated from fragmentation are increased light levels in forests due to an increase in edge, the invasion of exotic plants, and increased predator densities in forest fragments with high edge to area ratios.

Many species of neotropical migratory birds that appear to be declining are sensitive to the size of habitat patches and may avoid forest edges[5]. Forest habitat near patch edges is not suitable for edge/area-sensitive species. If distance of the edge effect is known, then the amount of remaining forest-interior habitat can be measured. Forest-edge habitat was demarcated on the maps of the Ridge-and-Valley and Blue Ridge province study areas by identifying cells of habitat within a given distance of patch edges (Fig. 3). These edge buffers were 80, 160, and 240 m wide. Edge effects on forest birds may extend up to 200 m into forest patches (DellaSala and Rabe 1987, Andren and Angelstam 1988).

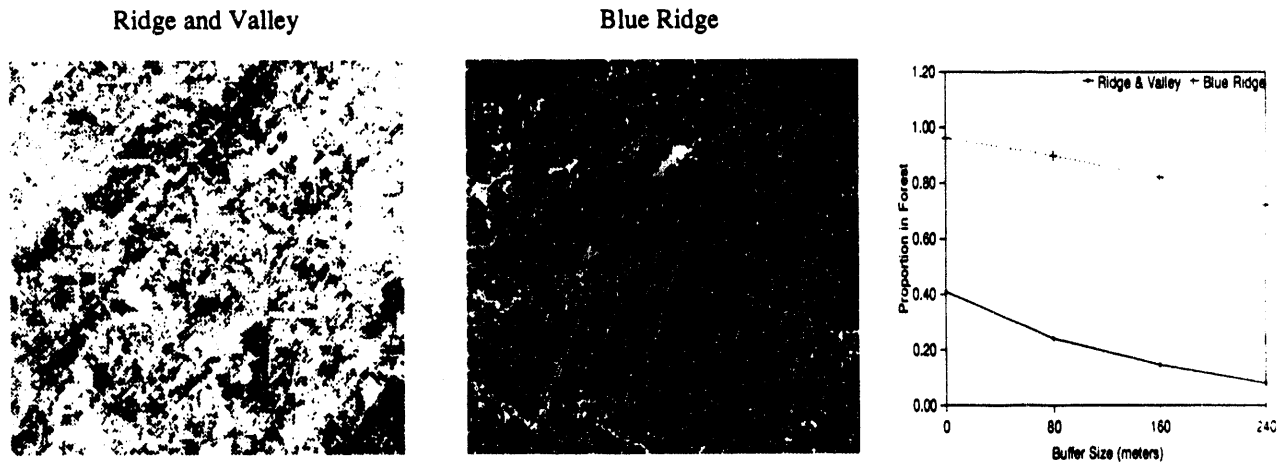

Figure 3. Deleting edge habitat. Forest within a given distance of non-forest habitats (white) was classified as edge habitat (grey). The remaining forest interior (black) declines as required edge buffer increases.

When forest habitat within the edge buffers are deleted, estimates of available habitat decline in both physiographic provinces (Fig. 3). When edge habitat are deleted, proportion of the Ridge-and-Valley study area covered by forest declines from 40% to about 10%.

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[5]Edge is related to patch area and shape.

REFINING HABITAT DEFINITIONS

The coarse habitat classes, such as deciduous or coniferous forest, are useful for studying the geographic patterns of deforestation, but more specific habitat classes are needed to study rates of habitat loss for specific species. It is not always possible to distinguish between different habitat types in a remotely-sensed image if different habitats are covered by the same forest type. Spatial information from other maps can help refine coarse habitat types.

In the Southern Appalachians, the spatial distribution of the major plant communities is strongly influenced by interactions between elevation and site moisture (Whittaker 1956). We are using topographic information derived from digital elevation models, such as elevation, slope, and aspect, to refine our analyses of forest loss for individual and groups of species. For example, forested cover at middle and high elevations (>610 m) is similar in southeastern Tennessee and western North Carolina. At low elevations (<700 m), forest cover is lower in southeastern Tennessee. Therefore, bird species using middle to high elevation sites are similarly unaffected by deforestation in both areas, but low-elevation species are more affected in Tennessee.

DEFORESTATION ON TROPICAL WINTERING GROUNDS

Neotropical migrant birds use and are influenced by two biomes during a single life span. To explore probable causes of population declines, the status of habitats in tropical wintering areas must also be considered. We are applying these same techniques to quantify spatial pattern of forest loss in the Brazilian Amazon Basin.

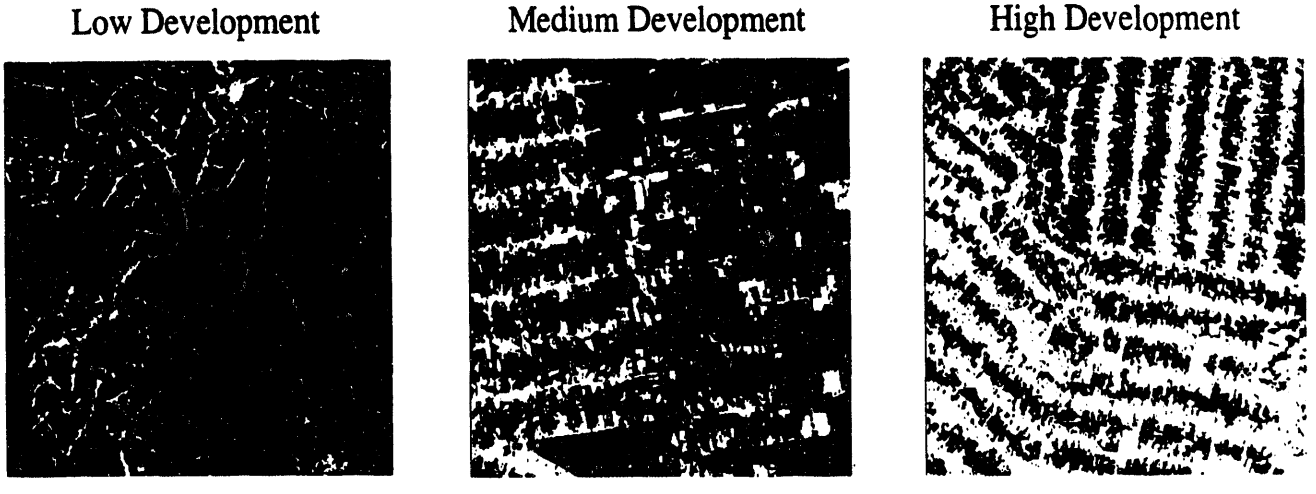

Figure 4. Study sites in the Brazilian Amazon. Three 1600-km2 study area were selected from a map of deforestation covering the state of Rondonia, Brazil. These sites represent three levels of economic development.

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