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EFFECT OF LAND COVER CHANGE ON RED-HEADED WOODPECKER POPULATIONS AT HIGH VS LOW ABUNDANCE RANGE LOCATIONS

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Laura A. Lukomski

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Major professor

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EFFECT OF LAND COVER CHANGE ON RED-HEADED WOODPECKER POPULATIONS AT HIGH VS. LOW ABUNDANCE RANGE LOCATIONS

By

Laura A. Lukomski

A THESIS

Submitted to
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ABSTRACT

EFFECT OF LAND COVER CHANGE ON RED-HEADED WOODPECKER POPULATIONS AT HIGH VS. LOW ABUNDANCE RANGE LOCATIONS

By

Laura A. Lukomski

Range collapse studies of endangered species have revealed that location within a species' geographic range is not a critical factor for survival. However, wildlife mangers have documented a higher translocation success rate if transplant populations are relocated within the center of the species geographic range. The inconsistencies between translocation success and patterns of range collapse lead to management confusion. The purpose of this study is to help clarify this confusion by evaluating a case species, that of the red-headed woodpecker (*Melanerpes erythrocephalus*), from 1978 to 1993 and 1.) Isolate land cover changes significantly related to population change; and 2.) Determine if the red-headed woodpecker is more sensitive to these changes at low versus high- abundance regions of its range.

The multi-temporal GIS and statistical analysis revealed the red-headed woodpecker to be statistically sensitive to changes in agricultural mean patch dimension, agricultural edge density, and urban area; and abundance change was not significantly different between low versus high-abundance routes. Therefore, the red-headed woodpecker was not sensitive to range location in this study, and, as a result, optimal habitat located in the periphery of the species' range should not be disregarded for management activities.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my advisory committee, Dr. David Lusch, Dr. Brian Maurer, and Dr. Catherine Lindell, for their knowledge and guidance. Thank you.

Thanks to my sister, Kara Lukomski, who will always be my best friend. Finally, I would like to thank my parents, Andy and Marsha Lukomski, for their unwavering support and encouragement.

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CHAPTER 1. INTRODUCTION

1.1 Background

The structure of land cover on our planet has changed dramatically over the past century. The human population has increased at an extraordinary rate and changed the landscape as it continues to grow. Forests have been converted to agriculture, agricultural lands engulfed by suburban development, and productive wetlands paved over for shopping centers (Whitney 1994, Rome 2001). As more people demand resources, non-human species are forced to adapt or compete for diminishing resources (Campbell 1996).

The challenge of our generation is to ensure that these species will have a place on our planet for the enjoyment of future generations and to preserve Earth's biological diversity. The more we can learn about the distribution, habitat requirements, and biology of an animal, the better prepared we will be to manage for the species in the future. Current biogeographic research suggests that if we can understand the dynamics of species' distributions, then endangered species' management, translocations, and other conservation management activities would benefit considerably (Brown 1984, Lomolino and Channell 1995, Wolf et al. 1996). My thesis research attempts to clarify the distribution enigma of species response to range location by quantifying the effect of land cover change at the core and periphery of a species' range.

My research question was developed in response to contradicting literature about the patterns of species decline in biogeography and ecology journals (Griffith et al. 1989, Lomolino and Channell 1995, Wolf et al. 1996, Lomolino and Channell 1997). A species occupies an area or region referred to as its geographic range, and some general patterns have been observed (Brown and Lomolino 1998). Species tend to have highest abundance near the center of their geographic range, and abundance usually decreases gradually toward the periphery (Hengeveld and Haeck 1982, Brown 1984). The area of high density, which is theoretically located in the center of a species' geographic range, is referred to as the core. The outer limit of a species range, where population density is the lowest, is called the periphery. For the purpose of my study, the core is defined as the geographic region with the highest density (i.e., the upper quartile of my sample routes). The terms high-abundance and core will be used interchangeably. The periphery in this study is the geographic region with the lowest density (i.e., the bottom quartile of my sample routes). The terms low-abundance and periphery will be used interchangeably.

Based on general theories of species distribution, species decline should be initiated in the outer extent of its range where populations are low and suitable habitat is minimal (Lomolino and Channell 1995). Yet, this pattern is not routinely exhibited.

Many species have a present-day range found in the peripheral extent of their historic range (i.e., the geographical range exhibited by a species in the past; Lomolino and Channell 1995). On the other hand, translocations and re-introduction sites of species are found to be more successful if they are located in the core of the species' historic range (Griffith et al. 1989, Wolf et al. 1996). The inconsistencies between translocation success and patterns of range collapse could lead to management confusion, which would be reduced if we could identify areas where species are more susceptible to decline. Research conducted at the landscape-scale has demonstrated that land cover change and degradation of habitat are influential in promoting species decline (Wilcox and Murphy 1985, Flather and Sauer 1996, Bohning-Gaese 1997). However, the effect of land cover change on populations at the periphery versus the core of their range has not, to my knowledge, been studied.

1.2 Statement of Problem

I will evaluate the effect of land cover change on the abundance of the red-headed woodpecker (*Melanerpes erythrocephalus*) at the periphery and core of its range. The red-headed woodpecker was selected for my study because its population has been declining, population data are readily available, multi-temporal land cover data are available throughout its range, and its range boundaries remain relatively constant year round (Short 1982, Page 1996, Sauer et al. 2001).

My study attempts to answer the following two questions:

1) What land cover changes are significantly related to red-headed woodpecker population change?

2) Are red-headed woodpecker populations more sensitive to land cover changes in low-abundance regions of their range than in high abundance regions?

Based on the central patterns of species distribution, I hypothesize that peripheral red-headed woodpecker populations will be more sensitive to land cover change than core populations. Therefore, for routes that experience similar land cover changes, I expect that the mean population change in the periphery will be significantly different than the mean change in the core. The null hypothesis (H_O) that will be tested states:

H_O: (mean change along low-abundance routes) = (mean change along high-abundance routes)

The alternative hypothesis (H_a) that will be tested states:

H_a: (mean change along low-abundance routes) <> (mean change along high-abundance routes)

If a species is more vulnerable to extinction at the furthest extent of its range, then habitat disturbances, competition, or human activity may cause anomalous patterns of species decline, and restoration efforts should be concentrated in the core of a species range. However, if species decline is not related to geographic range location, then managers should consider all areas of the range when selecting restoration sites.

1.3 Overview of the Thesis

Chapter two gives a detailed account of the relevant literature in this topic area. The discussion will begin broadly, focusing on current paradigms relating to species distribution and the relationship of these paradigms to species reintroduction. Next, I will discuss patterns of species decline, as they relate to range collapse and reintroduction strategies. Chapter two will conclude with a discussion of a key data source used in this study, the Breeding Bird Survey and the study species, the red-headed woodpecker.

Chapter three presents the methods used to answer the research question. The chapter is organized around the bird data, land cover data, and statistical analysis. The bird data section describes population change determination and route selection. The land cover data subchapter includes details about data processing, land cover classification, the geographic information system layers used, processes that yield the final land cover output, and calculating the change in landscape. The statistical analysis section provides details about statistical methods used to determine which land cover changes were significantly related to bird population change, determination of similar routes in the core and periphery, and analysis of core/peripheral population response to land cover change.

Chapter four presents the results of the analyses. A detailed discussion and interpretation of the results follows in chapter five, which concludes with a summary of significant findings and implications of this study as well as some suggestions for future research.

CHAPTER 2. LITERATURE REVIEW

2.1 Spatial Distribution of Species

Species exhibit unique geographic distributions, which are dynamic over space and time. The spatial distributions of species demonstrate some general patterns. First, most species are not evenly distributed throughout their range. Hengeveld and Haeck (1982) examined the spatial distribution of abundance within the geographic ranges of selected species in northwest Europe. Their goal was to determine whether species density was homogenous or heterogeneous across a range. Through the use of grid sampling, data were collected throughout the selected species' ranges and processed in an indirect interpolation model. All populations were found to be heterogeneous across their range, and a tendency for the highest population densities to be located in the center and the lowest densities to be at the limits of the geographic range was revealed (Hengeveld and Haeck 1982).

Brown's (1984) research findings paralleled those of Hengeveld and Haeck (1982): density was greatest near the center of the range, and population abundance decreased gradually toward the peripheral edge. Brown synthesized studies conducted on the relationship between abundance and distribution, and developed a theory to explain the general patterns consistent with the research.

In addition to the general patterns of distribution within a species' geographic range, it was found that the spatial distribution of species is positively correlated with abundance (Brown 1984). Thus, species with high average abundance will have a larger geographic range compared to those with low average abundance. These patterns of distribution have some exceptions: anomalous distributions occur at sharp environmental contrasts and sporadic distributions are caused by environmental patchiness (Brown 1984). However, in landscapes with little environmental patchiness or abrupt environmental obstacles, species abundance should be greatest at the core and gradually decline to the outer limits of the geographic range.

Environmental limiting factors affect geographic range boundaries and population density. In locales with good habitat, so-called source populations occur (i.e., populations in which the birth rate exceeds the death rate; Brown and Lomolino 1998). The habitat at the outer limits of a species' range is of marginal quality. Thus, it would seem that sink populations (i.e., the death rate exceeds the birth rate) would be more common at the peripheral limits of a geographic range.

Hengeveld and Haeck (1982) expected the amount of favorable habitat to decrease at the margins of the range, but anticipated that the density of species would remain the same at optimal habitat locations in the margin and central range locations. This outcome was not upheld; independent of scale and habitat quality, species became more rare as they approached the range margins (Hengeveld and Haeck 1982). Thus, species responded differently to habitat conditions throughout their range.

Based on the central patterns within a single species' distribution, population decline should first appear at the edge of the range, where sink populations are prevalent, population density is low, and habitat is marginal (Lomolino and Channell 1995). However, this pattern of range collapse is not exhibited in relic species.

2.2 Species Reintroduction

Lomolino and Channell (1995) reviewed terrestrial mammals whose present distributions were reduced to less than 25 percent of their historic range. They argued that if patterns of range collapse are related to the occurrences of sink populations, then populations of endangered species should be located in the center of their historic range. They used a geographic information system to divide the historic range into core and peripheral regions. Peripheral regions were determined by buffering the edges of the range until the interior area equaled that of the outer. Analysis was completed through the use of an index to compare present range locations to their historic locations. The authors found that 23 of the 31 species analyzed were located in the periphery of their historic range (Lomolino and Channell 1995).

Based on this discovery, the consideration of peripheral sites as potential reintroduction locations was recommended (Lomolino and Channell 1995). Yet, analyses of successful wildlife translocations have revealed the opposite.

Griffith et al. (1989) surveyed professionals involved in wildlife translocations to uncover patterns of success within these programs. Seven variables were correlated with translocation success, one of which was the location of the release site in relation to the historic range of the species.

Translocations are considered successful if they result in self-sustaining populations (Griffith et al. 1989). Releases in the core of the species' historic range were 76 percent successful. Conversely, releases in peripheral historic range locations were only 48 percent successful. Stepwise regression of the survey variables revealed that location of release was statistically significant in predicting translocation success (Griffith et al. 1989).

This study was revisited in 1996 to verify the variables that Griffith et al. (1989) attributed to translocation success (Wolf et al. 1996). A series of questionnaires were issued to people involved with translocation programs, and multiple regression analysis was used to determine the variables that were significant predictors of translocation success. The results revealed that both mammals and birds were sensitive to release location within the range. Animals relocated in the core of their historic range had a significantly higher success rate. Wolf et al. (1996) claimed that their findings contradict the conclusions of Lomolino and Channell (1995), i.e., relocating a species in the periphery of their historic range is significantly related to translocation failure. They also pointed out that patterns of decline are more complex than a simple distinction between core and periphery.

2.3 Spatial Patterns of Decline

Complex patterns of decline were revealed in a study of two species of warblers that are declining over their breeding range, and temporal and spatial abundance maps were created to explore patterns of population change (Villard and Maurer 1996). Areas of decline were scattered throughout the geographic range and were inconsistent in temporal analyses. The inconsistencies in the patterns of decline demonstrate the extreme difficulty in applying general patterns to spatially and temporally dynamic processes. Species abundance fluctuates in response to external environmental stimuli. Perhaps looking at within-habitat interactions between abundance and environmental conditions can clarify the conflicting observations of species decline. While many researchers have looked at general patterns of species decline, very few have linked these patterns to the underlying processes causing decline.

In landscape-level studies, environmental conditions such as temperature, vegetation, forest size, and habitat heterogeneity are often described as factors limiting species abundance (Smith 1974, Williams 1975, Bohning-Gaese 1997). For example, temperature was isolated as a limiting factor for pika abundance (Smith 1974). High-altitude pikas are more likely to have a greater home range and abundance than low-altitude populations because average daily temperatures were not limiting activity and mobility (Smith 1974).

Most species, however, have more than one environmental variable affecting their abundance (Hutchinson 1957). For example, a study evaluated habitat utilization of woodpeckers in central Illinois, and each species of woodpecker was found to occupy a specific niche (Williams 1975). Foraging techniques, nesting strategies, and utilization of certain height classes of vegetation were some of the many strategies used to reduce competition and permit co-existence between species. Thus, the woodpeckers utilized these strategies to fulfill their multiple life requirements.

If one of the variables significantly related to a species' survival is no longer available, then the species must adapt, move, or go extinct (Brown and Lomolino 1998). Therefore, a decline in species abundance is a direct result of one or many changing environmental conditions. Our understanding of the general patterns of decline would be enhanced if we could pinpoint the underlying reasons for the decline. General patterns of decline should be linked back to their causes whenever possible.

For example, ecologists have linked habitat loss to the decline in Neotropical migratory bird abundance. Flather and Sauer (1996) analyzed the relationship between land use and Neotropical bird abundance at a small-scale and found Neotropical migrant abundance was correlated with many aspects of landscape structure. Birds were more abundant in areas of forests and wetlands, especially areas with larger forest patch size and fewer edges and where forests were dispersed throughout the environment (Flather and Saurer 1996). However, the land cover data were for one time period; two time periods of land cover are necessary for a true temporal change analysis. Nevertheless, this study attempted to connect patterns of decline to the processes underlying the pattern.

2.4 Breeding Bird Survey

Since 1966, bird populations have been monitored annually nation wide through the Breeding Bird Survey (Fallon et al. 2000). The Breeding Bird Survey (BBS) has unveiled that the population of many species of birds, including the red-headed woodpecker, have declined since the start of the survey (Cunningham and Saigo 1995, Sauer et al. 2001). The survey is conducted in early June during the peak breeding season throughout North America (Fallon et al. 2000). Birds call more often during the breeding season, thus there is more likelihood of observing (hearing) a bird during this time period. BBS routes contain 50 stop locations at approximately half-mile (800 m) intervals; the same route and corresponding stop locations are often surveyed yearly. The exception to the half-mile stop interval occurs if there are hazards or excessive noise at a location (Adams 2000). Birds within a quarter-mile radius of the stop location are recorded (Fallon et al. 2000). Birds are recorded by sight and sound, with each individual bird recorded only once. Volunteers follow BBS procedures consistently every year.

Breeding Bird Survey data are collected by experienced, volunteer birders. Volunteers are required to know the song, calls, and visual identification of all avian species that may be encountered (Sauer et al. 2001). The observers submit to BBS headquarters their annual roadside counts and document the weather conditions, number of vehicles encountered, wind speeds, and excessive noise sources (Sauer et al. 2001).

Some concerns were initially raised regarding data obtained from the BBS including the appropriateness of conducting a survey along a road, excessive noise impeding an observers' surveying, and the skill differences among observers. The rationale of conducting bird surveys along roads, as opposed to off road, has been explored (Keller and Scallan 1999). Traditionally, human-induced changes in habitat occur near roadways. The worry is that these habitat changes are not representative of what is occurring away from transportation networks. However, the study discovered that habitat changes along roadsides matched changes occurring in the landscape within 1600 meters of BBS routes, but changes in urbanized areas were more likely near the road (Keller and Scallan 1999). BBS route locations avoid urban areas, and road surveys are easier to collect than off-road surveys, thus the use of roadside surveys seems appropriate.

Noises associated with traffic, weather, and residential living can hinder an observer's ability to hear and accurately record birds. Vehicles that pass during each three-minute stop are recorded on BBS data sheets, and the survey is conducted under specific weather guidelines (Fallon et al. 2000). Counts are conducted on days with little wind, no precipitation, and good visibility, with weather conditions recorded on the field sheets. Since factors impacting bird observations are recorded, survey sites with excessive noise can be eliminated from subsequent analyses.

Changes in observers on BBS routes can greatly influence the perception of bird populations (Link et al. 1994). BBS routes are sampled by thousands of volunteers across North America. The observers may vary in skills and abilities, thus resulting in inaccurate and inconsistent counts between routes and survey years. It was found that changes in bird counts were significantly greater when observers differed between years (Link et al. 1994). The impacts of this change can result in inaccurate interpretations of changes in individual species along a route. To combat this problem, the BBS includes unique observer numbers associated with each route and year. A change in observer can be accounted for in an analysis. For example, the year immediately following an observer change may not be included in the calculation of BBS trends on the BBS web site (Sauer et al. 2001). So, researchers are made aware of changes in observers and can make adjustments if they think it is necessary. Even with all the associated and potential problems, the BBS is still one of the most comprehensive species monitoring programs in North America (Sauer et al. 2001).

2.5 Red-headed Woodpecker

The red-headed woodpecker was selected for this study because populations have been declining, population data are readily available, its range is located in North America where land cover data are available, and its range limits remain relatively stable year round (Short 1982, Page 1996, Sauer et al. 2001).

The red-headed woodpecker is an eastern North America species. It's range limits (Figure 1) extend from southeast Canada to Florida, and the Atlantic coast to Colorado (Brown et al. 1999). The woodpecker is most abundant in the central mid-west states of Iowa, Missouri, and Illinois (Sauer et al. 2001).

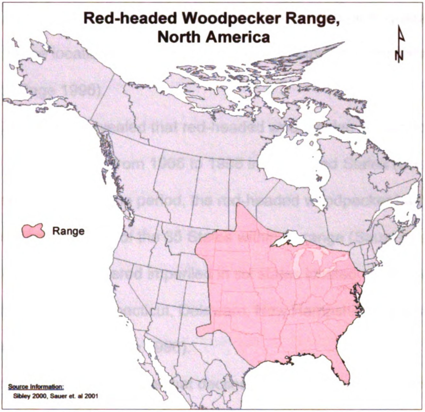


Figure 1. Red-Headed Woodpecker Range.

Throughout its range, the red-headed woodpecker inhabits open deciduous woodlots, wooded field edges, riparian forests, and urban parks (Short 1982, Robert 1989, Winkler et al. 1995, Page 1996, Brown et al. 1999). It resides in habitats containing dead trees for nesting and open areas for foraging insects. The red-headed woodpecker is an omnivorous species, eating insects, berries, nuts, corn, sap, seeds, and other bird's eggs (Short 1982, Winkler et al. 1995, Page 1996). It occupies a home range size of 0.04 to 2.0 hectares

(Winkler et al. 1995). The woodpecker is monogamous and generally has a clutch size of four to seven eggs and produces up to two broods per year; both male and female excavate the cavity and tend to the young (Short 1982, Ehrlich et al. 1992, Page 1996). The red-headed woodpecker can be migratory, mostly in northern range locations, but range limits remain fairly constant year round (Short 1982, Page 1996).

BBS data have revealed that red-headed woodpecker populations have declined at a rate of 2.4% from 1966 to 1998 in the United States (Sauer et al. 2001). During the same time period, the red-headed woodpecker has experienced declines in 23 of the 35 States within its range (Sauer et al. 2001). The woodpecker is considered imperiled in six states located on the outer limits of its breeding range: Connecticut, Delaware, New Hampshire, New Mexico, Rhode Island, and Utah (Page 1996).

Current literature suggests that declines in red-headed woodpecker populations may be attributed to a loss in nesting habitat due to clear cutting, removal of dead trees in urban and residential areas, and cleaner agricultural practices such as monoculture fields and removal of hedgerows (Kilham 1958, Page 1966, Robert 1989, Brown et al. 1999). In addition, competition for nest cavities with the exotic European starling (*Sturnus vulgaris*), which often overtakes newly excavated nest cavities for their own broods, has contributed to the woodpecker's decline (Ingold 1989, Page 1996, Brown et al. 1999).

CHAPTER 3. METHODS

3.1 Overview

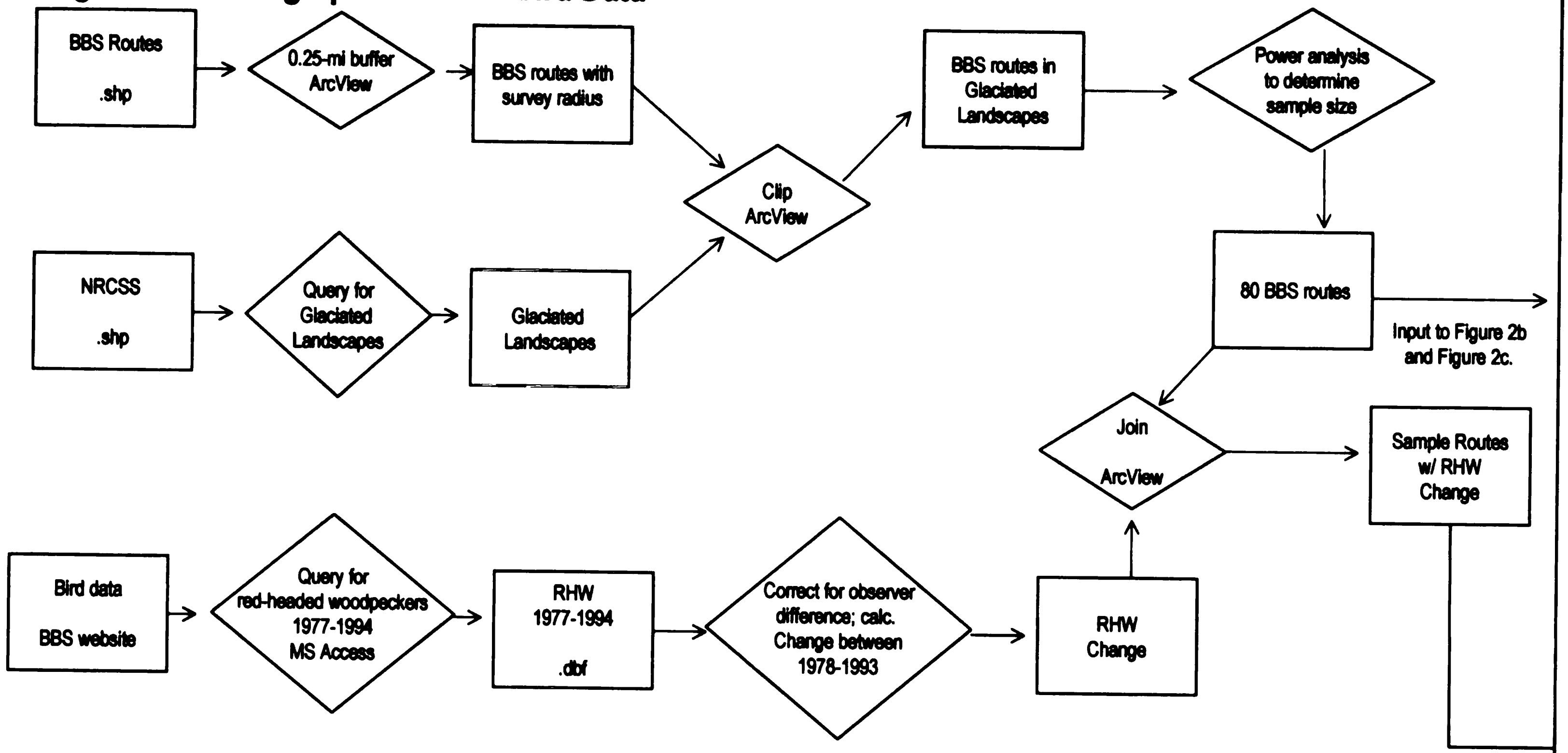
Based on the habitat requirements and suggested factors leading to red-headed woodpecker decline, I calculated land cover characteristics that might impact woodpecker abundance in order to determine the land cover variables that are statistically significant to red-headed woodpecker abundance.

Red-headed woodpecker data were obtained from the Breeding Bird Survey, and land cover data were obtained from the United States Geological Survey. Figure 2 is a cartographic model of the methods used in my research (Figures in this thesis, with the exception of figure 2 and 3, are presented in color). Figure 2a shows the steps used to analyze red-headed woodpecker data obtained from the BBS. The number of sample routes was determined through a power analysis, and a random number table was used to select individual routes. Core and peripheral routes were distinguished by ranking routes based on average populations. Routes were ranked into quartiles: definite core (i.e., with largest numbers of red-headed woodpeckers detected), intermediate core, intermediate periphery, and definite periphery (i.e., with the fewest red-headed woodpeckers detected).

Land cover data (Figure 2b and Figure 2c) were resampled to obtain the same resolution and land cover attributes (based on red-headed woodpecker biological requirements) and were analyzed in a geographic information system (GIS). Trends in red-headed woodpecker populations from 1978-1993 were calculated, and a multiple regression analysis was used to determine which land cover attributes were significantly related to red-headed woodpecker population change. Figure 2d shows the steps used to analyze the data. A hierarchical clustering analysis was used to isolate routes that were similar in the land cover attributes related to woodpecker abundance. Finally, an analysis of variance test was used on clustered routes to demonstrate whether or not the red-headed woodpecker is more sensitive to land cover change at high-abundance locations or low-abundance range locations.

Figure 2. Cartographic Model.

Figure 2a. Cartographic Model: Bird Data



Continued in Figure 2d.

Figure 2 (cont'd).

Figure 2b. Cartographic Model: 1978 Land Cover Data

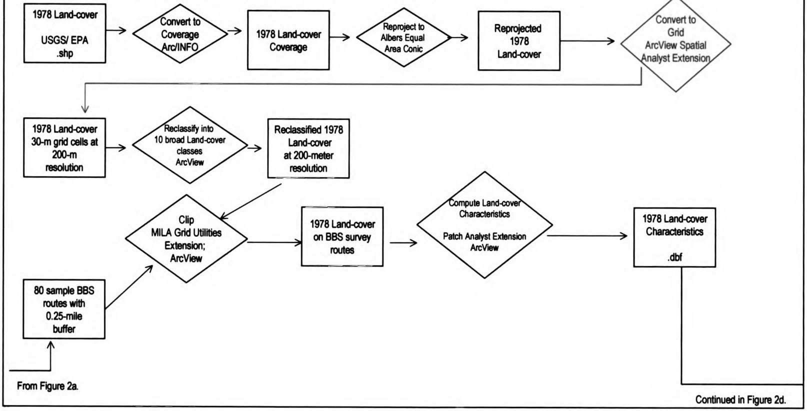


Figure 2 (cont'd).

Figure 2c. Cartographic Model: 1993 Land Cover Data

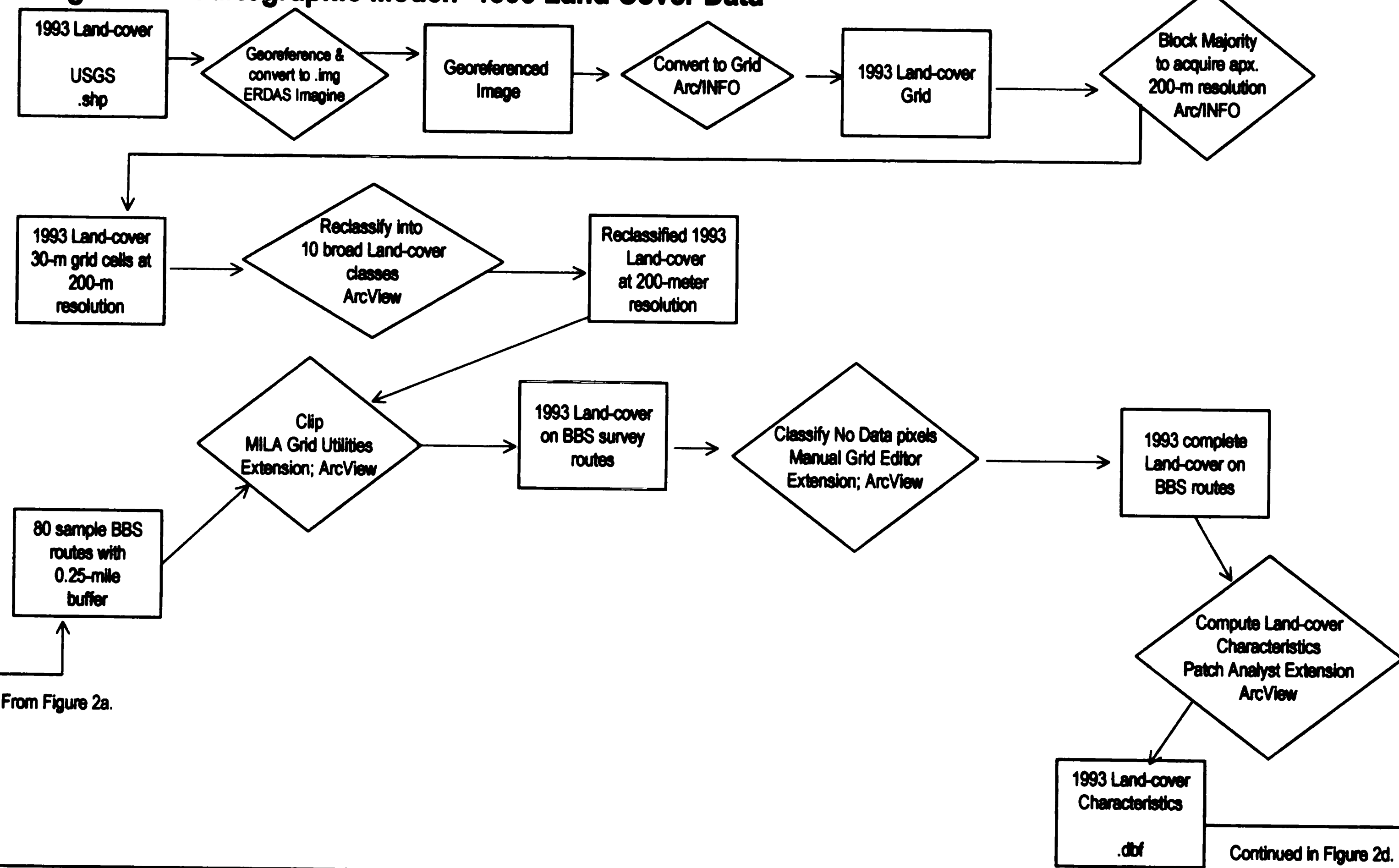
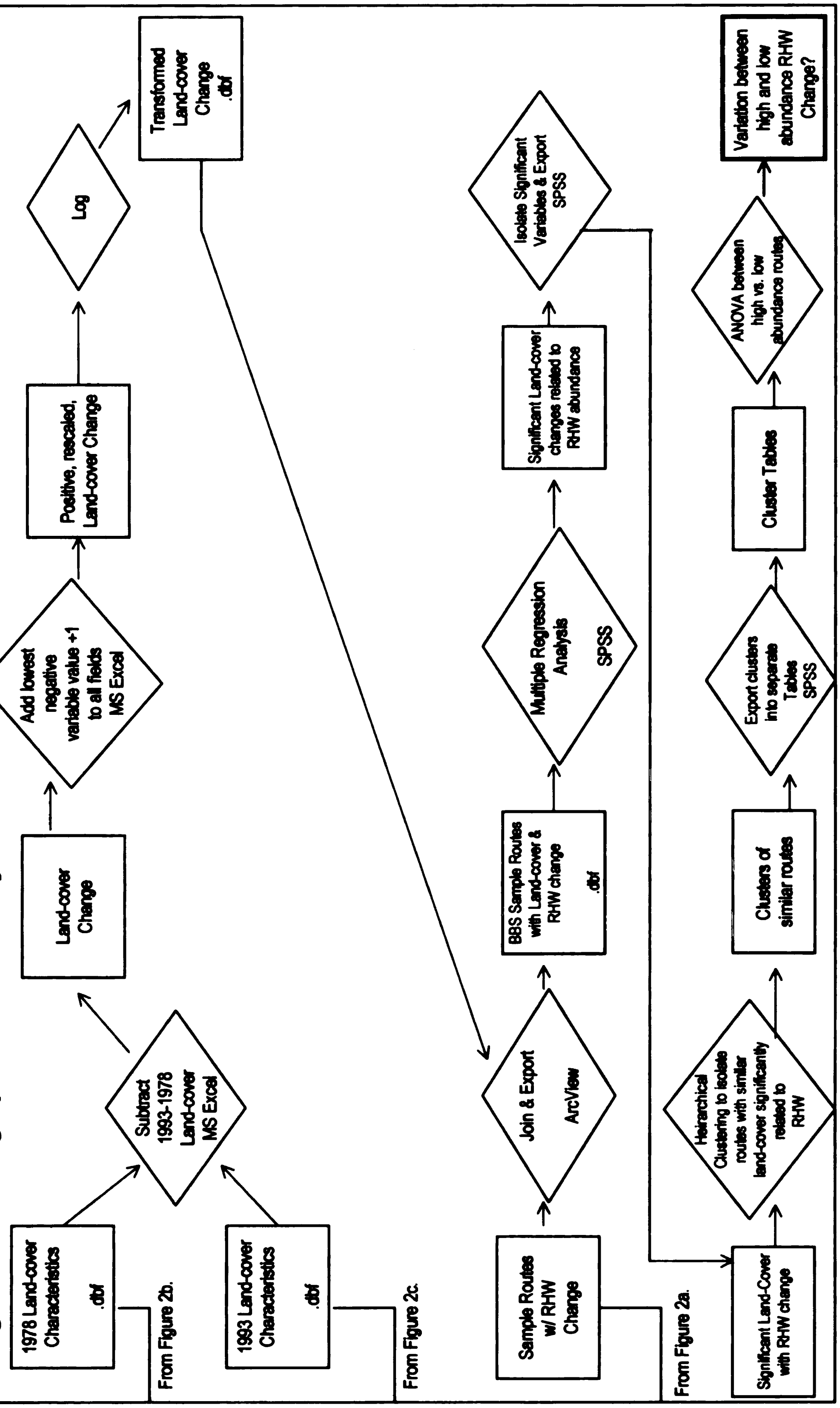


Figure 2 (cont'd).

Figure 2d. Cartographic Model: Analysis



3.2 Data Compatibility Issues

Three main GIS sources were used in this research. The BBS routes were in vector format and were downloaded from the USGS (2001); 1978 land cover data were also in vector format and were obtained from the USGS/EPA (1998); and the 1993 land cover data were in raster format and were available from the USGS (2001). Compatibility issues are almost certain when using data from varying sources and in different formats. The BBS routes and the 1978 land cover data were unprojected in decimal degree latitude and longitude. However, 1993 land cover data were projected in Albers Conical Equal Area, based in meters. These two geographic formats are not compatible. To overcome this, I projected all my GIS data into the Albers Conical Equal Area projection because it does not distort area. This was important because many area measurements were critical and necessary for my research. Additionally, the Albers projection is based in meters, making the calculation of the land cover metrics less complicated (Snyder 1993).

I chose to keep the land cover data in raster format and to retain the BBS buffers as vector data. The benefits of raster data in change analysis far outweigh vector data. Spatial analysis, filtering, and mathematical modeling are easy due to the simple shape of the pixels in raster analysis (Burrough and McDonnell 1998). The raster grids were clipped to the polygon- represented route buffers so that the 0.25-mile survey radius was upheld. If the center of the grid cell fell within the survey radius, then it was included in the output; this prevented sub-pixel fragments (ERSI 2000).

An additional data incompatibility was the resolution of the 1978 and 1993 land cover data. The 1978 data were determined from aerial photographs using a 200 x 200 meter minimum mapping unit. The 1993 data, in contrast, were classified from Landsat TM satellite imagery, which has a 30-meter resolution. Since my research attempts to identify changes in the landscape, it is imperative that the land cover data sets be at comparable resolutions. Using the 30-meter data with the 200-meter data will result in inaccurate representations of occurrences in the landscape, such as drastic increases in fragmentation in the 1993 data. To combat this problem, I degraded the 1993 data to a resolution of approximately 200 meters. This was accomplished by using a non-overlapping, majority filter. The majority filter uses a specified window size and reassigns all the pixels within that window with the modal pixel value. This preprocessing assured that the 1978 and 1993 data were at comparable resolutions for change analysis. However, degrading the resolution of the 1993 data created additional problems.

The non-overlapping window scrolls through a scene and reclassifies pixel values; reassigned values depend upon the placement of the window. For example, in the edges of the homogenous landscape of Figure 3, representing a coastline, window 1 would classify the aggregated pixel as water, but window placement one row over (window 2), would reclassify as sand. However, the land cover data are nominal, which are not suitable for an averaging filter, and the majority filter finds the modal value in the window, which is appropriate when aggregating to a coarser resolution. Thus, a non-overlapping majority filter was an efficient and feasible solution to my resolution issue, and determined to be adequate for the scope of this research.

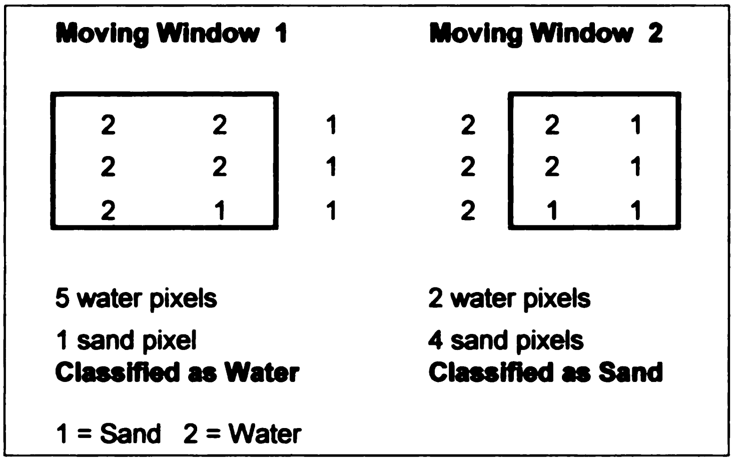


Figure 3. Majority Filter Example.

Finally, the 1978 land cover data were obtained from aerial photographs and 1993 land cover data were obtained from satellite imagery. The differences in source-document format may pose classification errors or discrepancies. For example, reflectance from satellite imagery may be difficult to interpret and pixels classified as residential from aerial photography may be classified as forest from satellite image interpretation. The 1978 data were classified into 37 different classes; the 1993 data were classified into 21 classes. I regrouped each year's classification scheme into ten classes. The classes I chose are easy to interpret from both aerial photography and satellite images. Thus, the chances for inaccurate representation of land cover due to the origins of the two land cover data sets were minimized.

3.3 Data Preparation

3.3.1 Bird Data

I attempted to minimize the potential biases in the BBS by 1.) sampling from continuously surveyed routes during my study years; 2.) assessing selected routes for excessive noise or traffic; and 3.) accounting for observer changes during my study period.

A power analysis was used to determine the number of BBS routes necessary to provide statistically significant results. The power analysis yielded a value of 45 routes to determine variation in bird abundance between core and periphery, and a maximum value of 200 routes to determine variation between the study years, 1978-1993, with a 0.9 alpha and beta level.

I decided to use 80 sample routes due to the practicality of assessing landscape attributes. A total number of 80 routes is in between the minimum and maximum sample values obtained from the power analysis, and I determined that 80 routes were the most data that could be processed within the time and computing constraints I had. Also, 80 routes should have been enough to determine the major changes in both landscape attributes and bird abundance.

The BBS data for red-headed woodpecker from 1977 to 1994 were downloaded from the BBS website (USGS and Patuxent Wildlife Research Center 2001). These data were brought into Microsoft Access (2000), and routes that were not surveyed continuously during my study period were deleted from the candidate pool. The remaining BBS data were brought into Microsoft Excel (2000) and average red-headed woodpecker abundance was calculated for the years between 1977 and 1994 for each potential sample route. Routes were numbered based on average abundance; the route with the highest average abundance was given a value of one.

The Excel file was saved as a database file (.dbf) and imported into ESRI ArcView 3.2 (2000) where it was joined to the BBS route shapefile that had been downloaded from the USGS National Atlas (2001). In an attempt to homogenize the land cover types occurring on the BBS routes, I only included routes occurring on glaciated landscapes. Glaciated landscapes provided some degree of normalization for topography, soils, and climate. Land cover changes would be more similar in Minnesota and Michigan, for example, than comparing changes occurring in Minnesota and Florida (Harpstead et al. 1980). The Major Land Resource Areas (MLRA) from the Natural Resources Conservation Service (NRCS) were downloaded from the NRCS website (2001) as an ArcInfo exchange file (.e00) and converted into a shapefile using the ArcView Import 71 program (ESRI 2000). The MLRA shapefile was queried for land areas containing glaciated landscapes using the landscape name field. The selected landscapes were converted into a shapefile. The BBS route shapefile was then clipped to the glaciated landscape shapefile using the Geoprocessing Wizard extension in ArcView (ESRI 2000). The remaining BBS routes were those that were surveyed every year between 1978 and 1993 and located in glaciated landscapes.

The ranked routes on glaciated landscapes were divided into four equal groups (i.e., quartiles), based on average abundance from 1977 to 1994. These four groups represent definite core (i.e., the uppermost quartile), transition core, transition periphery, and definite periphery (i.e., the lowermost quartile), and were labeled 1 through 4 correspondingly.

Twenty routes were selected from each quartile through a random numbers table and converted to a new shapefile. Figure 4 shows the BBS sample routes selected for this study.

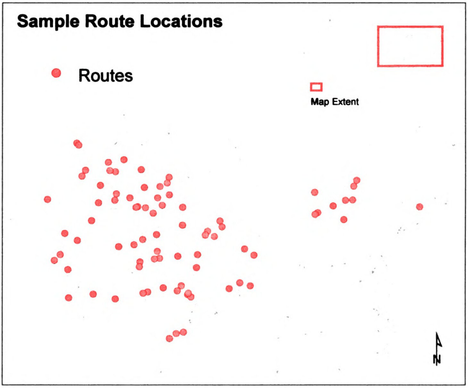


Figure 4. Sample Route Locations.

Figure 5 is the sample routes cartographically represented by their quartile ranking. Most of the routes categorized as a one, or core, are located in the center of the bird's range. The peripheral routes, or low-abundance, categorized as a four, are located on the perimeter of the red-headed woodpecker's range.

This pattern was expected based on the research findings of Hengeveld and Haeck (1982) and Brown (1984).

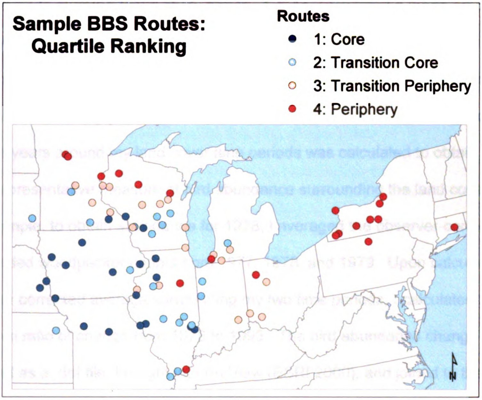


Figure 5. Sample BBS Routes Quartile Ranking.

I created a 0.25-mile buffer around the linear routes to represent the area surveyed by the BBS. BBS observers record birds seen and heard within 0.25-miles of survey stops (Sauer et al. 2001).

To calculate change in red-headed woodpecker abundance from 1978 to 1993, the sample routes table was exported and opened in MS Excel (2000). Dividing the 1993 abundance by 1978 abundance and taking the logarithm (to normalize data) of this value and adding a correction factor of 1.285, to ensure positive values, calculated a change ratio. However, I had to correct my data for BBS observer variation, due to problems with BBS data due to observer differences (Link et al. 1994). I accomplished this by calculating a mean count for each route over the entire study period. I, then, calculated a mean count for each individual observer on the route. A correction factor was obtained by subtracting the observer mean from the overall mean, and this correction factor was applied for every year of observation by that individual. The average count of three years around my land cover time periods was calculated to obtain a more representative measure of bird abundance surrounding the land cover year. For example, to obtain abundance for 1978, I averaged the observer-corrected, red-headed woodpecker counts from 1977, 1978, and 1979. Upon calculating an observer corrected average surrounding my two time periods, I calculated the logarithm ratio of change from 1978 to 1993. The bird abundance change was exported as a .dbf file, brought into ArcView (ESRI 2000), and joined to the corresponding route shapefile to be used in the final analysis.

3.3.2 Land Cover Data

Land cover data from 1978 and 1993 were reclassified, through aggregation, into ten broad classes based, primarily, on the red-headed woodpecker's habitat requirements and variables that the literature has suggested leads to a change in abundance: deciduous forest, agriculture, residential, urban (commercial and industrial areas), transitional, wetland, water, grassland, evergreen forest, and mixed forest. Table 1 outlines the land cover classes I regrouped the existing classes into and the corresponding justifications.

Table 1. Land Cover Classification and Justification.

Land Cover	Justification
Agriculture	Food source (Short 1982, Page 1996)
Deciduous Forest	Prefers deciduous forest (Page 1996, Williams 1975, Short 1982, Winkler et al. 1995)
Evergreen Forest	Not preferred (Page 1996)
Grassland	Open area for foraging (Page 1996)
Mixed Forest	Can't be further classified
Residential	Can thrive in parks and old residential neighborhoods (Winkler et al. 1995, Page 1996)
Transitional	Can't be further classified.
Urban	Loss of birds due to urban clean-up (removal of dead trees), competition, and destruction of habitat (Page 1996)
Water	Water source
Wetland	Utilizes lowland areas for water and food sources (Short 1982, Winkler et al. 1995, Page 1996)

After reclassifying the land cover classes, six landscape metrics were calculated based on these classes. Based on the literature, the following metrics are thought to impact red-headed woodpecker abundance: area, mean patch size, total edge, edge density, mean patch fractal dimension, and interspersion and juxtaposition measures. Table 2 outlines the calculations used in my research and a summary of what each attribute calculates.

Table 2. Land Cover Measures and Description.

Land Cover Measure	What it Measures
Area	Sum of area for each land cover class
Mean patch size	Mean area for each land cover class
Total edge	Sum of perimeter of each land cover class
Edge density	Sum of perimeter/ sum of area
Mean patch fractal dimension	Measures shape or complexity; fragmentation
Interspersion and Juxtaposition	The interspersion of the land class compared To other land classes on the BBS route

I will use area and mean patch size measurements to determine the impact that a loss or gain in a land cover may have on the species. Edge measurements, such as total edge and edge density, will isolate fragmentation effects at the patch level on red-headed woodpecker abundance. The mean patch fractal dimension measurement returns an index value between 1 and 2, where a measure of one indicates a simple shape and values approaching 2 reveal a more complex shape (Elkie et al. 1999). Mean patch fractal dimension evaluates shape complexity and reveals the type of fragmentation that is occurring providing more insight than a simple edge density or total edge measurement. Finally, the interspersion and juxtaposition measurement is the percentage of interspersion of the land cover types with other land cover types found along the BBS route. A value of 0 percent indicates that the land cover type is adjacent to only one other patch type and a value of 100 percent occurs when the land cover type is equally adjacent to all patch types found on the BBS route (Elkie et al. 1999). The interspersion and juxtaposition measurement is a good indicator of the fragmentation occurring among the land cover type as a group, and not just individual patches.

3.3.2.1 1978 Land Cover

Land cover data from 1978 were obtained from the United States Environmental Protection Agency (USEPA and USGS 1998). These data were originally collected by the USGS but were subsequently converted into digital format by the EPA. The USGS classified the landscape from aerial photography using a 10-acre minimum mapping unit (200-meter resolution).

Downloaded quadrangles from corresponding BBS sample routes were brought into Arc/INFO (ESRI 2000). The 1978 land cover coverage was reprojected into the Albers Equal Area Conic projection and converted into a grid file format at a 30-meter grid cell. The original data were classified using the Anderson et al. (1976) system at level 2. For the purposes of my research, I recoded the classification down to ten broad classes. Table 3 shows the original 1978 land classes and the corresponding new classification used for this research. All reclassification was completed in ArcView (ESRI 2000). The land cover data were clipped to the 80 sample BBS routes each with a 0.25-mile buffer using the MILA Grid Utilities Extension (Guissard 1999). The result is the land cover in 1978 surveyed by the BBS for the presence of songbirds. Finally, the Patch Analyst Extension (Rempel 2000) for ArcView (ESRI 2000) was used to calculate the selected landscape metrics for each of the ten land classes. The results were exported and brought into MS Excel (2000).

Table 3. Aggregation of 1978 Land Cover Data.

Original Classification	New Classification
Residential	Residential
Commercial and services	Urban
Industrial	Urban
Mixed urban	Urban
Other urban	Urban
Cropland and pasture	Agriculture
Orchards, groves, vineyards	Agriculture
Confined feeding Operations	Urban
Other agricultural	Agriculture
Herbaceous rangeland	Grassland
Mixed rangeland	Grassland
Deciduous forest	Deciduous Forest
Evergreen forest	Evergreen Forest
Mixed forest	Mixed Forest
Streams and canals	Water
Lakes	Water
Reservoirs	Water
Bays and estuaries	Water
Forested wetland	Wetland
Nonforested wetland	Wetland
Strip mines, quarries, gravel pits	Urban
Transitional Areas	Transitional

3.3.2.2 1993 Land Cover

Land cover from 1993 was obtained from the United States Geological Survey (2001). The National Land Cover Data (NLCD) were classified from Landsat TM imagery, which has a 30-meter resolution.

The 1993 NLCD can be downloaded by state (USGS 2001). Each state from the corresponding survey routes were downloaded, extracted, brought into ERDAS Imagine (1999), and converted to an image file. The image file was opened in ArcView (ESRI 2000) and converted to grid format using the Spatial

Analyst extension (ESRI 2000). For the purposes of my research, I recoded the classification (using ArcView) down to ten broad classes. Table 4 shows the original 1993 land cover classes and the corresponding new classification for this research. The grid for each state was processed in Arc/INFO Grid to aggregate the 30-meter pixels into approximately 200-meter blocks for compatibility with the 1978 data. I completed this task using the *block majority* function with a 7 by 7 non-overlapping window. *Block majority* takes the most frequently occurring pixel value in the specified window and converts all pixels within the window to that value. If there is a tie, and two values are equally abundant, then the filter classifies the pixels as "no data." A 7 by 7 pixel window for aggregation was selected to create a coarse resolution to compare with the 1978 data (30-meter * 7 =210-meter). The 200-meter, 1993 land cover data were brought into ArcView and clipped to the sample routes with a 0.25 mile buffer using the MILA Grid Utilities extension (Guissard 1999). The Manual Grid Editor extension (Luijten 2001) was used to add land cover values to any "no data pixels." The non-aggregated NLCD data and 1-km AVHRR imagery (EROS and USGS 2001) were used as reference, and no data pixels were, ultimately, assigned a value based on AVHRR classification.

Table 4. Aggregation of 1993 Land Cover Data.

Original Classification	New Classification
Open Water	Water
Low Residential	Residential
High Residential	Residential
Commercial	Urban
Strip Mines, gravel pits	Urban
Transitional	Transitional
Deciduous Forest	Deciduous Forest
Evergreen Forest	Evergreen Forest
Mixed Forest	Mixed Forest
Orchards, vineyards	Agriculture
Grassland	Grassland
Pasture, hay	Agriculture
Row crops	Agriculture
Small grain	Agriculture
Fallow	Agriculture
Urban grasses	Urban
Woody wetlands	Wetland
Herbaceous wetlands	Wetland

Upon identification and classification of all "no data pixels", the Patch Analyst Extension (Rempel 2000) in ArcView (ESRI 2000) was used to calculate the selected landscape metrics for each of the ten land classes. The results were exported and brought into MS Excel (2000).

3.4 Analysis

The 1978 and 1993 land cover characteristics table for each route were brought into MS Excel (2000) as separate tables. I subtracted each 1993 variable from the 1978 variable on each route. This provided a raw change number associated with the land cover measure, retaining the same measurement units as the original data. Change data for all routes were contained in one table. Since land cover change may be negative, the absolute value of the lowest negative value for each variable plus one was added to every entry. This ensured that the values were scaled, yet positive, with the lowest value in each variable expressed as one. This was necessary in an attempt to normalize the data for further analyses by taking the base ten logarithm of all values; the $\log_{10}$ transform is only possible on positive integers. A normal distribution of data is necessary for many statistical techniques, and taking the logarithm can rescale the original values to obtain a normal distribution (Diekhoff 1992). I copied the new change values for each route and corresponding land cover characteristics into a new table and exported them as a .dbf file. This database file was added into ArcView (ESRI 2000) and joined with the red-headed woodpecker change and sample route shapefile. The complete table of red-headed woodpecker change and land cover attribute changes for each sample route was brought into SPSS 11.0 (2001).

I used stepwise multiple regression, with entry F probability less than 0.5 and removal at 0.1, to decipher which variables were significantly related to red-headed woodpecker abundance change. Stepwise multiple regression was selected because it minimizes the impact of multicollinearity and removes or includes variables based on the effect this has on the R square value (Diekhoff 1992). Multicollinearity occurs when two or more variables are correlated, thus inclusion of such variables in the regression equation is redundant, does not add to the predictive power of the equation, and reduces the statistical significance of

R (Diekhoff 1992). Stepwise regression avoids these problems by not selecting strongly correlated variables for inclusion in the equation (Diekhoff 1992). This method evaluates each variable and includes only those that add to R-square. Variables can also be removed if their absence does not detract much from the equation's predictive power (Diekhoff 1992, SPSS 2001).

The variables found to be significantly related to the change in red-headed woodpecker abundance were isolated into a separate table. I used a hierarchical cluster analysis to isolate routes with similar land cover changes, which are significantly related to red-headed woodpecker change. The hierarchical clustering routine isolates relatively homogenous cases based on distance measures (SPSS 2001). Several clustering methods were attempted and the furthest neighbor method was selected as the clustering strategy because it provided distinct clusters with adequate numbers of routes for further analysis. Furthest neighbor uses the span between the least similar cases as the distance between the element and the cluster (Diekhoff 1992, SPSS 2001). I used the squared Euclidean distance to measure proximity of cases. This is computed by taking the sum of the squared differences between the case's variables. In my research, the cases are the BBS routes and the variables are the land cover characteristics significantly related to red-headed woodpecker abundance change. The result and interpretation of the hierarchical clustering analyses allows me to group routes with similar land cover changes, which will later be used in the analysis of differences in abundance changes occurring along high-populated and low-populated routes.

The groups of similar routes were isolated into their own table. The rankings of routes based on average abundance were used to analyze high-abundance routes (value of one) and low-abundance routes (value of four) with the analysis of variance method (ANOVA). ANOVA allows two or more samples to be compared with a single independent variable, red-headed woodpecker abundance change, for difference (Sprinthall 1990, Diekhoff 1992). The null hypothesis states that the mean change in abundance of group one is equal to the mean of group two. If the two means are significantly unequal, then I can conclude that woodpecker populations on high- abundance routes are changing at different rates than low-abundance routes. The ANOVA analysis was completed with routes classified in groups a.) one and two verses three and four b.) and one versus four. The results of the ANOVA analysis will detect whether, with external factors such as land cover change and broad landscape classes equivalent, core and peripheral responses to land cover changes are similar.

CHAPTER 4. RESULTS

4.1 Red-headed Woodpecker Population Change

The change analysis, with corrections for observer effects, is displayed in Table 5. The following formulas were used to calculate the red-headed woodpecker population change values found in Table 5:

$$\text{Percent} = \frac{1999 - 1978}{1978} \times 100$$

$$\text{Ratio} = \frac{1993}{1978}$$

$$\text{Correction} = \text{Ratio} + (\ |\text{Lowest Negative Value}| + 1\ )$$

$$\text{Log (bird)} = \log\text{ (Correction)}$$

Negative change values were calculated in instances where the observer correction indicated that the observer overestimated red-headed woodpecker abundance. Therefore, some adjusted change values were negative. A correction factor of the absolute value of the lowest negative value plus one was added to ratios to provide positive change values.

Table 5. Red-headed Woodpecker Change: 1978-1993.

Route	Percent	Ratio	Correction	Log(bird)	Route	Percent	Ratio	Correction	Log(bird)
18014	0.0%	0.00	1.29	0.11	50018	-58.2%	0.42	1.70	0.23
34002	-33.4%	0.67	1.95	0.29	50025	-47.9%	0.52	1.81	0.26
34009	-53.8%	0.46	1.75	0.24	50026	-47.7%	0.52	1.81	0.26
34010	-31.2%	0.69	1.97	0.30	52028	16.5%	1.17	2.45	0.39
34015	-100.0%	0.00	1.29	0.11	52029	-64.8%	0.35	1.64	0.21
34022	21.1%	1.21	2.50	0.40	54012	-58.6%	0.36	1.65	0.22
34024	-39.0%	0.61	1.90	0.28	54013	-64.0%	0.41	1.70	0.23
34026	-83.3%	0.17	1.45	0.16	61043	-78.9%	0.21	1.50	0.18
34037	36.4%	1.36	2.65	0.42	61047	-100.0%	0.00	1.29	0.11
34039	-2.3%	0.98	2.26	0.35	61052	-128.6%	-0.29	1.00	0.00
34040	-72.7%	0.27	1.56	0.19	61061	0.0%	1.00	2.29	0.36
34045	21.1%	1.21	2.50	0.40	61063	-49.2%	0.51	1.79	0.25
34046	-31.7%	0.68	1.97	0.29	61065	-80.0%	0.20	1.49	0.17
34047	-22.4%	0.78	2.06	0.31	61070	-69.2%	0.31	1.59	0.20
34048	26.6%	1.27	2.55	0.41	61072	0.0%	1.00	2.29	0.36
34059	109.1%	2.09	3.38	0.53	66002	100.0%	2.00	3.29	0.52
34061	50.0%	1.50	2.79	0.44	66033	2.9%	1.03	2.31	0.36
34062	15.8%	1.16	2.44	0.39	66060	8.6%	1.09	2.37	0.38
34064	-12.4%	0.88	2.16	0.33	66061	19.8%	1.20	2.48	0.40
35002	-25.6%	0.74	2.03	0.31	72022	0.0%	1.00	2.29	0.36
35010	-7.1%	0.93	2.21	0.35	81010	52.7%	1.53	2.81	0.45
35029	18.3%	1.18	2.47	0.39	91010	61.3%	1.61	2.90	0.46
36005	-44.7%	0.55	1.84	0.26	91011	-118.8%	-0.19	1.10	0.04
36006	-38.2%	0.62	1.90	0.28	91012	-20.3%	0.80	2.08	0.32
36008	-22.5%	0.78	2.06	0.31	91015	30.1%	1.30	2.59	0.41
36010	-52.5%	0.47	1.76	0.25	91020	-22.2%	0.78	2.06	0.31
36022	-39.0%	0.61	1.90	0.28	91034	-44.4%	0.56	1.84	0.27
36024	-8.7%	0.91	2.20	0.34	91036	6.0%	1.06	2.35	0.37
36027	-24.1%	0.76	2.04	0.31	91042	-47.9%	0.52	1.81	0.26
38027	-43.2%	0.57	1.85	0.27	91045	33.3%	1.33	2.62	0.42
49020	-81.3%	0.19	1.47	0.17	91046	-60.0%	0.40	1.69	0.23
49022	366.7%	4.67	5.95	0.77	91047	-87.4%	0.13	1.41	0.15
49032	-41.2%	0.59	1.87	0.27	91050	13.7%	1.14	2.42	0.38
49035	-77.8%	0.22	1.51	0.18	91051	-47.3%	0.53	1.81	0.26
49039	-36.2%	0.64	1.92	0.28	91054	-35.7%	0.64	1.93	0.29
50002	-73.4%	0.27	1.55	0.19	91055	-42.5%	0.58	1.86	0.27
50003	-37.1%	0.63	1.91	0.28	91056	33.7%	1.34	2.62	0.42
50007	-68.9%	0.31	1.60	0.20	91057	-54.8%	0.45	1.74	0.24
50008	-60.0%	0.40	1.69	0.23	91063	-83.3%	0.17	1.45	0.16
50017	10.6%	1.11	2.39	0.38	91070	-52.6%	0.47	1.76	0.25

Figure 6 shows the distribution of change across the sample routes. Overall, the red-headed woodpecker is experiencing declines from 1978 to 1993. Woodpecker abundance has decreased 22.2 percent across the sample routes taken as a whole.

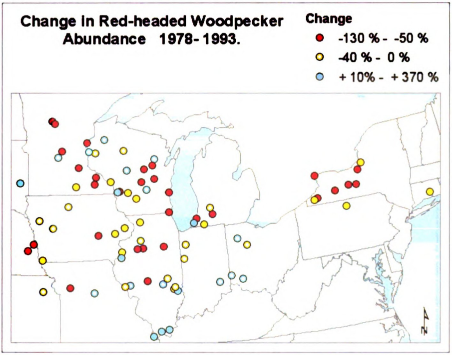


Figure 6. Change in Red-Headed Woodpecker Abundance: 1978-1993.

The distribution of declining and increasing abundance routes appears fairly random throughout the sample region. To test this general observation, route changes of quartile rankings were evaluated in an ANOVA. The ANOVA yielded an F ratio of 0.485, which is not significant at the 95 percent confidence level. Figure 7 is a box plot of change in each quartile. Woodpecker population change in quartile 1, core routes, is the least variable and quartile 4, peripheral routes, is the most variable. Yet, the ANOVA and visual inspection of median change values in the box plot indicates that mean change is similar across the sample region. Therefore, there are no significant differences in red-headed woodpecker population change based on range location; this upholds the general observation in Figure 6 that the distribution of declining and increasing abundance routes is random across the sample region.

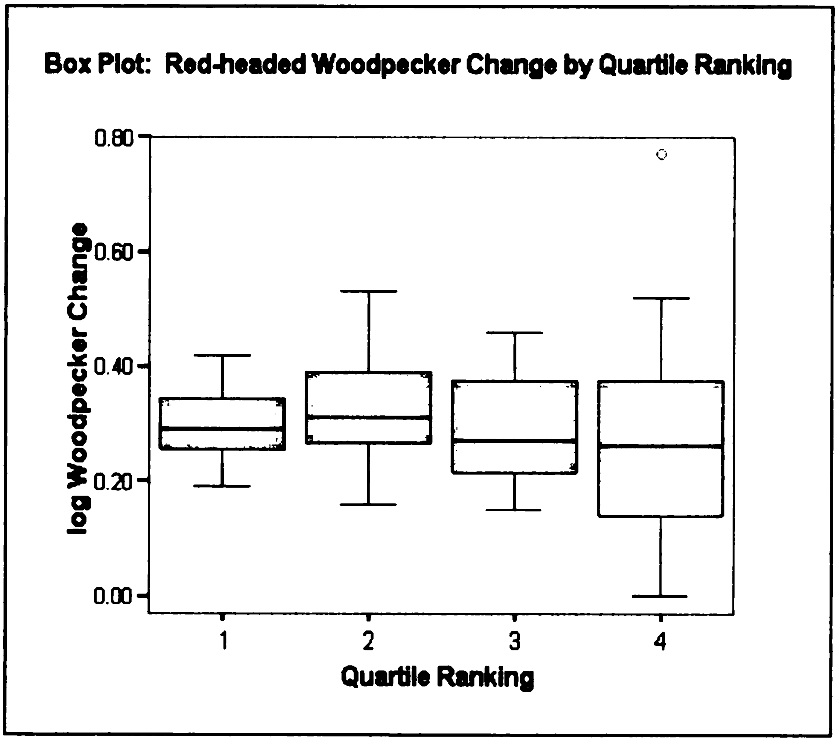


Figure 7. Box Plot: Red-headed Woodpecker Change by Quartile Ranking.

4.2 Land Cover Change

A complete table of log land cover variables with a correction factor to obtain positive values, and with the corresponding log red-headed woodpecker change by route can be found in Appendix A. Figure 8 is the land cover change occurring along BBS route 52029, which is considered a core route in my research. Figure 9 is the land cover change occurring along BBS route 91020, which is considered a peripheral route in my study. These figures provide a representative depiction of land cover change occurring across BBS routes.

Overall, the most prominent changes in land cover are occurring in agriculture, mixed forest, and deciduous cover types. Deciduous forest and agriculture types are increasing in edge and fragmentation, while the total acreage of deciduous forest is increasing and the total acreage of agriculture is decreasing. The amount of mixed forest is decreasing along BBS routes. Table 6 lists the land cover variables that were measured and the average change occurring along the BBS sample routes.

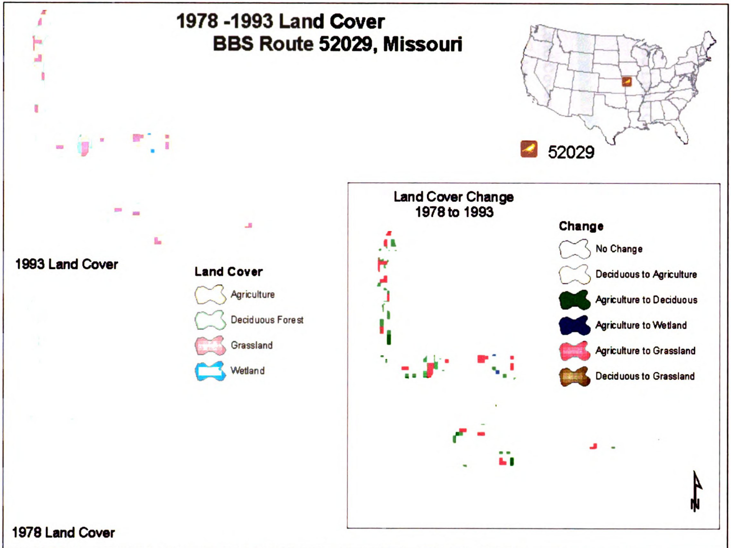


Figure 8. 1978-1993 Land Cover. BBS Route 52029, Missouri.

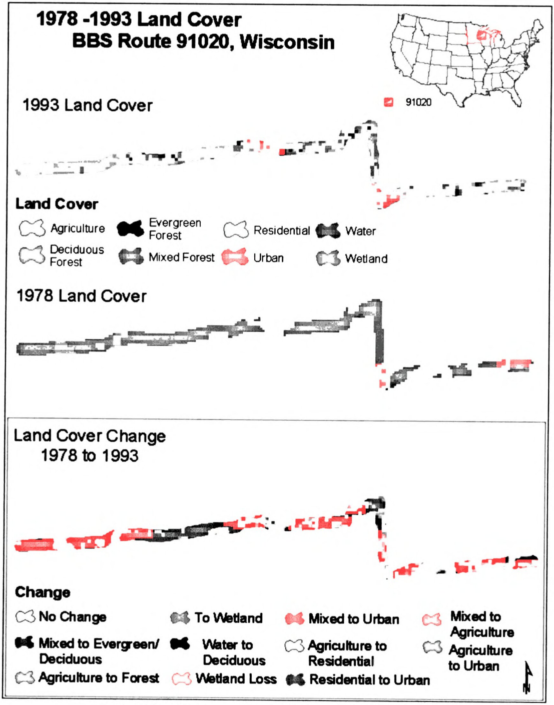


Figure 9. 1978-1993 Land Cover. BBS Route 91020, Wisconsin.

Table 6. Average Land Cover Change Occurring Along BBS Routes.

Land Cover	Area (Hectares)	Mean Patch Size (Hectares)	Edge (Meters)
Agriculture	-103.81	-69.41	10530.38
Deciduous Forest	204.02	-11.78	19671.89
Evergreen Forest	-2.75	-19.16	3746.79
Grassland	54.25	6.07	6590.45
Mixed Forest	-264.05	-41.13	-3310.00
Residential	-5.24	2.16	-1335.50
Transitional	-8.32	-10.32	216.00
Urban	-17.90	-4.01	-1781.74
Water	11.72	0.62	845.11
Wetland	27.34	-5.45	5225.89
Land Cover	**Edge Density (Meters/ Hectare)**	**Mean Patch Dimension (Index: 1 - 2)**	**Interspersion (Percent)**
Agriculture	3.78	-0.01	-14.71
Deciduous Forest	7.08	0.07	13.18
Evergreen Forest	1.32	0.38	25.41
Grassland	2.29	1.02	21.50
Mixed Forest	-1.13	0.00	7.43
Residential	-0.46	-0.12	-4.34
Transitional	0.14	-0.50	-7.21
Urban	-0.65	-0.24	-0.33
Water	0.30	0.07	12.58
Wetland	1.81	0.24	22.54

4.3 Analysis

4.3.1 Multiple Regression

Stepwise regression yielded three land cover variables that were significantly related to red-headed woodpecker abundance. Mean patch dimension of agriculture, agriculture edge density, and urban area were all significant predictors of red-headed woodpecker change at the 95 percent confidence level with an R^2 of 0.161. Table 7 summarizes the multiple regression statistics.

Table 7. Stepwise Regression Output.

Dependent: Red-headed woodpecker change
Independent: Log Agriculture Mean Patch Dimension (AGMPD), Log Agriculture Edge Density(AGED), Log Urban Area(URAR)

Model	R	R Square	Std. Error	F Change	df1	df2	Sig. F Change
1	0.4011	0.1609	0.0959	4.3737	1	76	0.0398

Model		Coefficients	Std. Error	t	Sig.
1	(Constant)	0.0707	0.0587	1.2029	0.2328
	AGMPD	2.2292	0.8047	2.7704	0.0070
	AGED	0.0937	0.0422	2.2227	0.0292
	URAR	0.0302	0.0144	2.0914	0.0398

The R value is the correlation observed between the independent and dependent variable; it ranges between 0 and 1, with higher values indicating stronger relationships. The significance of the multiple regression model is 0.0398, indicating that the model is a good predictor of red-headed woodpecker change at a 95% confidence level. The bottom section in Table 7 analyzes the coefficients. The t-statistics indicate the relative importance of each variable in the equation and their associated significance level. Each variable is significant at the 95 percent confidence level, therefore these variables were isolated for a hierarchical cluster analysis to separate the most similar routes.

4.3.2 Hierarchical Clustering Analysis

The three land cover variables significantly related to the abundance change of red-headed woodpecker were isolated into a table and evaluated using a hierarchical cluster analysis. The clustering routine isolated four clusters, which were most similar in land- cover characteristics significantly related to red-headed woodpecker abundance. Interpretation of a cluster dendrogram is fairly arbitrary. It is critical to look for gaps in the coefficients, as well as to visually inspect the cluster dendrogram for breaks or groupings. Upon inspection of the agglomeration schedule, Appendix B, and the dendrogram, Figure 10, I decided on four clusters of similar routes occurring along distance of five in the dendrogram. Each cluster is color coded in Figure 10. The routes of each cluster were isolated into a table for analysis of variance between routes of high-abundance and low-abundance. Figure 11 shows the location of these clusters in the sample region.

Figure 10. Hierarchical Cluster Analysis Results.

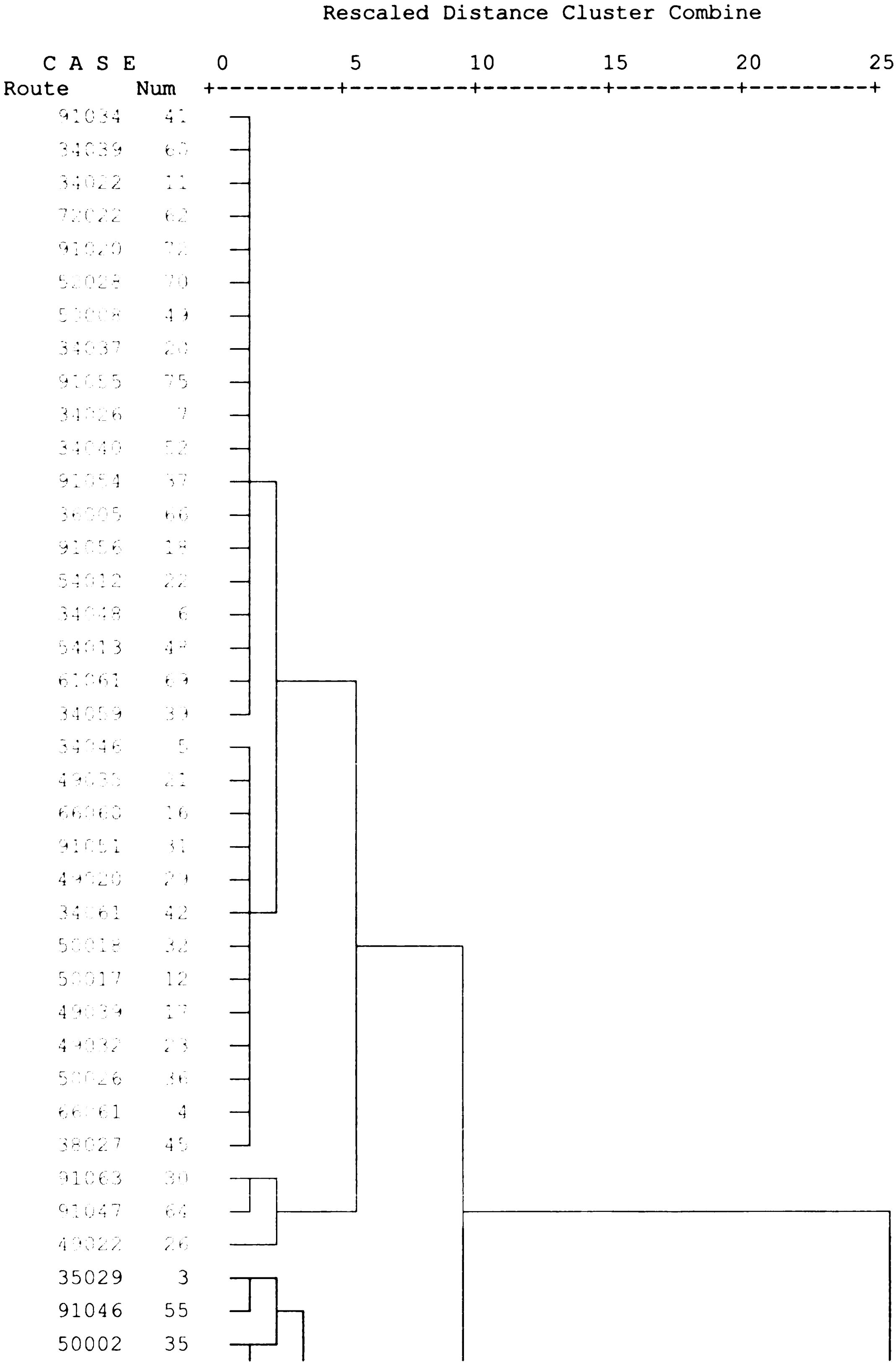
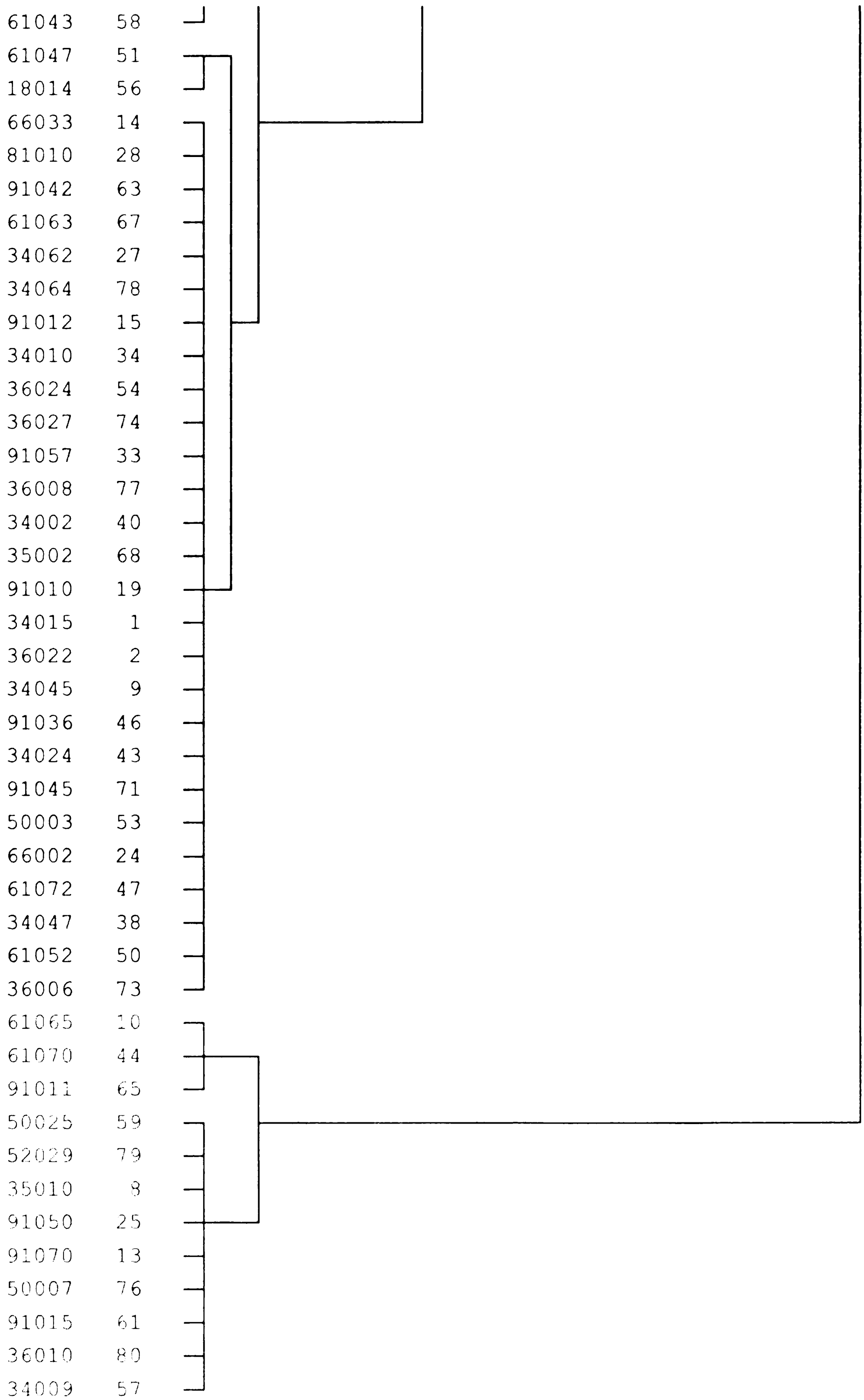


Figure 10 (cont'd).



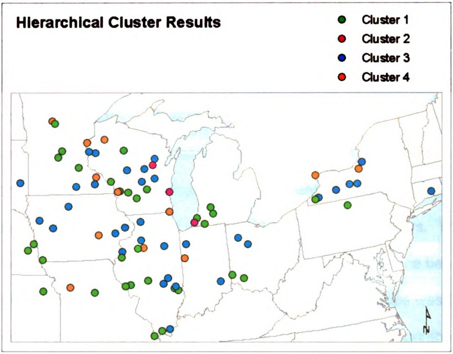


Figure 11. Hierarchical Cluster Distribution.

4.3.3 Analysis of Variance

The analysis of variance (ANOVA) looks for differences in means between groups. If there is a significant difference in the means between the two groups, then this indicates that the changes in red-headed woodpecker abundance occurring along high-abundance routes are not the same as the changes occurring along low-abundance routes in areas with similar land cover changes. This would indicate that range location does play a role in determining population changes.

Each route cluster (determined from the hierarchical cluster analysis) was divided into two groups; routes with a spatial ranking of one or two compared with routes spatially ranked routes three or four. This divides the sample routes into groups with similar land cover changes and similar abundance to determine whether range location makes the species more susceptible to decline. In addition, I separated routes with spatial ranking one or four for analysis of strictly high-abundance routes versus low-abundance routes.

Cluster one's analysis between ranking 1,2 versus 3,4 proved to be insignificant. There was no significant difference between the two group means. Table 8 is a detailed description of the ANOVA results for all clusters. The variability within groups for cluster 1 was 6.03. This is the difference between each variable and the group mean. The variability between groups was 0.22; this is the difference between each group mean and the total mean (Sprinthall 1990). The mean square (MS) is used to calculate the F ratio. The MS is the division of each respective variability by their degree of freedom. The division of the MS of the variability between groups by the MS of the variability within groups provides the F ratio.

The F ratio for cluster one (1,2 versus 3,4) was 1.11, which is not significant at the 95 percent confidence level. Therefore, the mean change between high-abundance routes and low-abundance routes is not statistically different.

ANOVA was completed for cluster one, spatial rank 1 versus 4. This provided the same results, with an F ratio of 0, which is not significant at the 95 percent confidence level.

I was not able to use cluster two in ANOVA because it only contained three routes, which all occurred within the spatial rank group 4.

Table 8. Analysis of Variance.

ANOVA. Cluster 1: Spatial rankings 1,2 vs. 3,4.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.22	1	0.22	1.11	0.30
Within Groups	6.03	30	0.20		
Total	6.26	31			

ANOVA. Cluster 1: Spatial rankings 1 vs. 4.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.00	1	0.00	0.00	0.96
Within Groups	1.52	13	0.12		
Total	1.52	14			

ANOVA. Cluster 3: Spatial rankings 1,2 vs. 3,4.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.00	1	0.00	0.00	0.99
Within Groups	7.79	31	0.25		
Total	7.79	32			

ANOVA. Cluster 3: Spatial rankings 1 vs. 4.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.01	1	0.01	0.04	0.85
Within Groups	5.23	15	0.35		
Total	5.24	16			

ANOVA. Cluster 4: Spatial rankings 1,2 vs. 3,4.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.01	1	0.01	0.08	0.78
Within Groups	1.88	10	0.19		
Total	1.89	11			

ANOVA. Cluster 4: Spatial rankings 1 vs. 4.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.00	1	0.00	0.00	0.97
Within Groups	1.22	5	0.24		
Total	1.22	6			

Cluster three provided insignificant results as well. The mean change between rankings 1 and 2 versus 3 and 4 yielded an F ratio of 0, which is not significant. The mean between rankings 1 versus 4 had an F ratio of 0.04, which is also not significant at the 95% confidence level.

Cluster four's analysis of low-abundance versus high-abundance routes resulted in an F ratio of 0.08, and the analysis of rankings 1 versus 4 resulted in an F ratio of 0. Both failed to reject the null hypothesis at a 95 percent confidence level.

The ANOVA failed to reject the null hypothesis in every cluster, which states that the mean change between low-abundance and high-abundance routes is equal. Therefore, the red-headed woodpecker is not sensitive to range location in this study, and core and peripheral populations, in similar land cover environments, are experiencing similar abundance changes.

CHAPTER 5. DISCUSSION AND CONCULSIONS

My study analyzed the impacts of land cover changes on the red-headed woodpecker by aggregating routes with similar land cover changes associated with woodpecker population change, and subsequently determining if variation in population changes were occurring as a result of range location. Current research in biogeography indicates that range location is not a key factor for survival in range collapse studies of endangered species (Lomolino and Channell 1995). However, translocation success appears to be impacted by range release location (Griffith et al. 1989, Wolf 1996). My study attempted to clarify this contradiction by connecting environmental variables to a species' population change and evaluating locations with comparable environmental conditions in order to isolate changes resulting from range location. It is important to look at routes with similar land cover structures so as to isolate the impact of range location on changes in species' abundance. Thus, this study is unique; it attempts to link abundance with land cover variables and analyze routes in the core and periphery in an attempt to determine if location has an effect on population change.

The red-headed woodpecker demonstrated no significant differentiation in changes between populations at high and low-abundance range locations on routes with similar land cover changes that were previously determined to be statistically significant to red-headed woodpecker population change. The ANOVA results range from significance at 1% through 70% confidence levels, indicating that red-headed woodpecker reintroduction efforts would do equally well in quality habitat locations in the core and periphery of it's range. Quality habitat locations should be evaluated based on environmental variables, with emphasis upon life requirements and those variables that research has indicated as a significant indicator of abundance. Three land cover variables were isolated by this research as significant in causing red-headed woodpecker abundance changes.

This study discovered that the woodpecker was statistically sensitive to changes in agricultural mean patch dimension, agricultural edge density, and urban area. These variables explain 16% of the variation in red-headed woodpecker population change. I expected the land cover variables to explain more of the fluctuation in red-headed woodpecker abundance. The low R^2 results may indicate that there are additional variables contributing to population change that were not evaluated in this study, i.e., temperature, competition, and disease. Errors in the bird or land cover data used in this study could also contribute to low R square values. For example, errors in the land cover data sets would result in miscalculations of real change occurring along the sample BBS routes, and could lead to low R^2 values when analyzed against red-headed woodpecker abundance.

Agricultural mean patch dimension is the average complexity or fragmentation measure of the agricultural parcels along a route. Woodpecker abundance was positively related with agriculture mean patch dimension; abundance increased with increases in agriculture mean patch dimension measures. A positive relationship was also revealed with agricultural edge density. These results were not surprising because the woodpecker has been documented as utilizing forest patches adjacent to agricultural fields, which are used as a food source (Page 1966, Brown et al. 1999). However, the relationship unveiled between urban area and abundance changes was not anticipated. A positive relationship, at the 95% confidence level, was calculated. This contradicts current literature, which has shown that urban clean up efforts and competition with the urban inhabitant European starling has resulted in population declines (Page 1966, Ingold 1989, Page 1996, Brown et al. 1999). Urban area change was included in the hierarchical cluster analysis because my data indicated it as a significant variable, however this result provoked some questions regarding the accuracy of the land cover data that were used in the analysis.

Aerial photography was the base for the 1978 data and satellite imagery was the source for the 1993 data. Theoretically, both data sets should accurately classify the level-1 land cover classes used in my analysis. The average changes occurring along my BBS sample routes (see Table 6, page 47) caused me to question this assumption. Most of the variables I measured produced expected results; agriculture is declining, deciduous forest is increasing, but becoming more fragmented, and residential patches are becoming larger in size. The urban and residential classes exhibited declines between 1978 and 1993, an average of –17.9 and –5.2 hectares per route, respectively. Built-up areas rarely are converted back to forest land or agriculture. This leads me to believe that commission errors are occurring in the 1993 data with some urban and residential pixels classified as another land cover type. If true, this would result in an inaccurate portrayal of the impact that these land cover variables are having on red-headed woodpecker populations.

In addition, I think that the mixed forest class is either over classified in the 1978 data or omitted in the 1993 data because an average decline of 264 hectares/ route was calculated for my study region. It seems unrealistic that 264 hectares of mixed forests have either become homogenous or were converted to another land cover type in the span of 15 years. However, without field-based error checking of this data set, I cannot accurately or concretely determine whether these are realistic changes occurring along my sample routes or not. Time and cost restraints prohibited an error checking effort, and I had to trust that the land cover classifications were completed thoroughly and accurately.

The unresponsiveness of red-headed woodpecker populations to range location has some implications in support of biogeographic research results and in advisement for species management. While my study only evaluates one species, it adds another piece of evidence in support of the utilization of peripheral range locations for endangered species management or translocations. While optimal habitat areas may be more prevalent in core locations, thus enabling the support of more individuals, optimal habitat regions in the periphery should not be disregarded for management activities. In the case study of the red-headed woodpecker, range location had no significant affect on population change.

With all significant environmental variables similar, range location had no impact on changes in red-headed woodpecker abundance. While the land cover data utilized in this study yielded some questionable change results, it was the best data to feasibly use and originated from the USGS, which I view as a reliable source. If time and monetary constraints were not an issue in this study, I would classify my own land cover data from strictly aerial photography or satellite imagery and not a mix of the two. Additionally, I would sample the maximum number of routes yielded in the power analysis, 200 routes, to ensure that alpha and beta errors are at acceptable levels. The red-headed woodpecker is one species on this planet, and more research is necessary to definitively resolve the impact of range location on changes in species' abundance.

Future research should continue to link species declines to their causes. While we can learn from observing general patterns of species distribution and decline, these patterns will not be useful to managers until the underlying reasons for the patterns are determined.

The implications of the case study of the red-headed woodpecker overwhelmingly suggest that wildlife managers should consider peripheral range locations for management activities. I recommend that habitats be evaluated on an individual basis. Management activities should be concentrated in areas that contain necessary life requirements for the species being managed, whether this location is in the core or periphery of the species' historic range.

APPENDICES

APPENDIX A

LOG_{10} LAND COVER AND RED-HEADED WOODPECKER CHANGE

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

		Agriculture					
Route	Bird	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	0.1091	2.89	3.20	3.63	0.42	0.03	1.99
34002	0.2903	2.93	3.32	4.17	0.79	0.05	1.91
34009	0.2423	2.96	3.21	4.38	0.97	0.05	1.99
34010	0.2954	2.92	3.15	4.09	0.74	0.03	1.89
34015	0.1091	2.95	3.21	3.90	0.59	0.04	0.00
34022	0.3975	2.85	3.10	4.39	1.01	0.03	1.71
34024	0.2777	2.95	1.27	3.85	0.56	0.03	1.93
34026	0.1621	2.90	3.20	4.37	0.94	0.03	1.61
34037	0.4231	2.91	3.20	4.38	0.96	0.05	1.80
34039	0.3547	3.00	3.18	4.39	0.99	0.04	2.00
34040	0.1900	2.88	0.00	4.30	0.94	0.00	1.97
34045	0.3974	2.94	3.33	4.01	0.66	0.05	1.64
34046	0.2942	2.84	3.25	4.53	1.14	0.06	1.51
34047	0.3142	2.95	3.21	4.00	0.67	0.04	1.91
34048	0.4069	2.92	3.07	4.18	0.82	0.03	1.56
34059	0.5285	2.80	3.20	4.32	0.93	0.05	1.91
34061	0.4449	2.73	3.13	4.48	1.08	0.02	1.92
34062	0.3881	2.71	3.20	4.13	0.78	0.04	1.85
34064	0.3347	3.01	3.25	4.15	0.78	0.05	2.18
35002	0.3075	2.89	3.16	4.11	0.77	0.03	2.04
35010	0.3452	2.92	3.19	4.18	0.82	0.05	1.63
35029	0.3925	2.95	3.56	3.69	0.43	0.08	1.34
36005	0.2646	2.86	3.09	4.35	0.91	0.05	2.04
36006	0.2796	2.94	3.20	4.06	0.70	0.04	2.08
36008	0.3140	2.90	3.05	4.12	0.76	0.03	2.17
36010	0.2457	2.90	3.18	4.29	0.89	0.05	2.24
36022	0.2777	2.93	3.20	3.93	0.61	0.04	0.18
36024	0.3421	2.93	3.20	4.06	0.70	0.04	1.97
36027	0.3107	2.99	3.57	4.05	0.71	0.08	2.09
38027	0.2681	2.55	3.04	4.80	1.33	0.03	1.94
49020	0.1683	2.82	2.87	4.48	1.06	0.04	1.86

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

		Agriculture					
Route	Bird	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
49022	0.2093	2.80	3.09	4.59	1.19	0.03	1.85
49032	0.2727	0.00	2.93	4.64	1.20	0.01	1.81
49035	0.1784	2.70	3.16	4.52	1.13	0.03	1.81
49039	0.2841	2.74	3.09	4.59	1.18	0.04	1.78
50002	0.1907	3.05	3.29	0.00	0.00	0.04	1.90
50003	0.2820	2.96	3.60	3.84	0.54	0.07	1.97
50007	0.2033	2.98	3.17	4.25	0.85	0.03	2.11
50008	0.2268	2.75	2.80	4.48	1.07	0.03	1.95
50017	0.3787	2.66	3.04	4.74	1.30	0.04	1.72
50018	0.2314	2.83	3.17	4.46	1.09	0.03	1.88
50025	0.2568	3.08	3.20	4.75	1.29	0.05	2.00
50026	0.2573	2.96	3.19	4.65	1.19	0.04	1.91
52028	0.3893	2.80	3.19	4.43	1.04	0.04	2.06
52029	0.2142	2.76	3.02	4.56	1.16	0.04	2.20
54012	0.2164	2.89	2.89	4.39	0.99	0.02	1.81
54013	0.2304	2.91	2.99	4.20	0.84	0.02	1.95
61043	0.1750	2.96	3.21	1.49	0.03	0.03	1.99
61047	0.1091	2.98	3.17	3.49	0.28	0.02	1.96
61052	0.0000	2.96	3.22	4.05	0.68	0.04	1.95
61061	0.3590	2.88	3.20	4.17	0.81	0.04	2.02
61063	0.2537	2.90	3.21	4.16	0.80	0.05	2.04
61065	0.1719	2.91	3.32	4.08	0.71	0.06	1.71
61070	0.2023	2.87	3.20	3.96	0.63	0.04	1.93
61072	0.3590	2.91	3.21	3.96	0.63	0.04	1.94
66002	0.5166	2.95	3.21	3.94	0.61	0.04	1.83
66033	0.3645	2.95	3.50	4.15	0.80	0.07	1.76
66060	0.3751	2.87	3.14	4.41	1.02	0.03	1.78
66061	0.3950	2.74	3.23	4.56	1.17	0.06	1.44
72022	0.3590	2.64	3.14	4.38	0.99	0.03	2.01
81010	0.4492	2.95	3.21	4.16	0.80	0.06	1.86
91010	0.4622	2.93	3.21	4.02	0.68	0.04	1.79

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

		Agriculture					
Route	Bird	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
91011	0.0407	2.92	3.21	3.74	0.46	0.04	2.02
91012	0.3186	2.97	3.18	4.10	0.76	0.03	1.76
91015	0.4127	2.97	3.20	4.25	0.86	0.04	2.00
91020	0.3146	2.98	3.20	4.43	1.01	0.04	2.07
91034	0.2651	2.95	3.19	4.40	0.99	0.04	1.92
91036	0.3702	2.97	3.22	3.96	0.63	0.03	1.94
91042	0.2568	2.99	3.21	4.14	0.80	0.04	2.01
91045	0.4181	2.98	3.22	3.88	0.58	0.05	2.06
91046	0.2268	2.98	3.21	3.65	0.40	0.04	1.98
91047	0.1497	3.02	3.20	4.01	0.66	0.03	2.02
91050	0.3842	2.88	3.18	4.15	0.81	0.03	1.83
91051	0.2584	2.83	3.17	4.39	1.02	0.03	1.88
91054	0.2852	2.93	3.19	4.27	0.92	0.04	1.91
91055	0.2697	2.90	3.20	4.36	0.98	0.04	2.10
91056	0.4188	2.96	3.18	4.28	0.91	0.04	1.79
91057	0.2399	2.92	3.20	4.13	0.77	0.04	1.89
91063	0.1621	2.91	3.25	4.10	0.76	0.04	1.87
91070	0.2453	2.92	2.54	4.22	0.86	0.02	1.74

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Deciduous Forest					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	1.50	0.00	4.52	1.11	0.45	1.67
34002	2.50	2.38	4.13	0.75	0.45	1.69
34009	2.62	2.40	4.35	0.95	0.45	1.69
34010	2.58	2.37	4.20	0.82	0.46	1.73
34015	0.00	0.00	0.00	0.00	0.00	0.00
34022	2.60	2.37	4.45	1.07	0.46	1.79
34024	2.42	2.37	3.86	0.56	0.46	1.69
34026	0.00	0.00	0.00	0.00	0.00	0.00
34037	2.58	2.38	4.40	0.97	0.45	1.87
34039	2.04	2.33	4.26	0.88	0.45	1.60
34040	2.50	2.37	4.22	0.87	0.45	1.89
34045	2.49	2.39	4.14	0.75	0.45	1.87
34046	2.69	2.39	4.56	1.17	0.45	1.68
34047	2.40	2.38	3.80	0.51	0.46	1.85
34048	2.53	2.39	4.18	0.82	0.45	1.69
34059	2.69	2.37	4.19	0.82	0.45	1.62
34061	2.76	2.38	4.53	1.12	0.46	1.80
34062	2.80	2.39	4.49	1.10	0.46	1.78
34064	1.64	2.27	3.98	0.65	0.45	1.94
35002	2.41	2.37	3.98	0.67	0.46	1.72
35010	2.50	2.38	4.13	0.78	0.46	1.69
35029	2.44	2.38	3.94	0.62	0.46	1.69
36005	2.44	2.38	3.92	0.59	0.46	1.85
36006	2.47	2.40	4.05	0.69	0.45	1.69
36008	2.51	2.47	4.02	0.68	0.46	1.01
36010	2.46	2.41	3.98	0.64	0.59	1.69
36022	0.00	0.00	0.00	0.00	0.00	0.00
36024	0.00	0.00	0.00	0.00	0.00	0.00
36027	1.95	2.34	2.52	0.04	0.45	1.60
38027	2.73	2.39	4.52	1.07	0.46	1.71
49020	2.66	2.39	4.47	1.05	0.45	1.81

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Deciduous Forest					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
49022	2.63	2.35	4.61	1.20	0.46	1.51
49032	2.98	2.39	4.80	1.35	0.45	1.94
49035	2.83	2.40	4.64	1.24	0.46	1.82
49039	2.89	2.39	4.76	1.35	0.46	1.73
50002	1.75	2.37	0.00	0.00	0.46	1.72
50003	2.44	2.39	3.89	0.58	0.45	1.69
50007	2.21	2.36	4.18	0.80	0.46	1.87
50008	2.56	2.40	4.19	0.81	0.45	1.89
50017	2.54	2.39	4.22	0.83	0.46	1.92
50018	2.73	2.39	4.56	1.18	0.45	1.94
50025	2.94	1.75	4.84	1.38	0.46	1.44
50026	2.97	2.41	4.70	1.23	0.46	1.92
52028	2.67	2.36	4.28	0.91	0.46	1.73
52029	2.59	2.38	4.33	0.95	0.46	1.92
54012	0.00	0.00	0.00	0.00	0.00	0.00
54013	2.47	2.40	4.03	0.70	0.45	1.69
61043	2.99	2.43	4.84	1.41	0.59	2.06
61047	2.79	2.41	4.64	1.26	0.59	1.88
61052	2.90	2.39	4.75	1.25	0.46	1.80
61061	2.17	2.36	4.42	1.03	0.45	1.87
61063	0.00	2.35	3.63	0.39	0.45	1.97
61065	2.70	2.38	4.40	0.97	0.45	1.62
61070	3.08	2.43	4.87	1.42	0.46	1.85
61072	3.12	2.36	4.88	1.46	0.45	1.61
66002	2.42	2.38	3.85	0.55	0.46	1.69
66033	2.55	2.39	4.28	0.93	0.46	1.78
66060	2.70	2.38	4.53	1.12	0.46	0.00
66061	2.79	2.38	4.59	1.20	0.45	1.64
72022	2.77	2.36	4.43	1.04	0.45	1.86
81010	0.00	0.00	0.00	0.00	0.00	0.00
91010	2.49	2.39	4.07	0.72	0.45	1.64

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Deciduous Forest					
Route	**Area**	**Mean Patch Size**	**Edge**	**Edge Density**	**Mean Patch Dimension**	**Interspersion**
91011	3.31	2.54	4.83	1.43	0.60	2.11
91012	2.71	2.38	4.35	1.01	0.45	1.79
91015	2.55	2.10	4.49	1.07	0.45	1.81
91020	3.25	2.48	4.92	1.47	0.59	2.09
91034	2.40	2.30	4.38	0.97	0.45	1.79
91036	2.29	2.36	4.05	0.73	0.46	1.91
91042	2.70	2.39	4.49	1.12	0.45	1.92
91045	2.83	2.43	4.30	0.88	0.46	1.73
91046	2.49	2.39	4.08	0.73	0.45	1.82
91047	2.69	2.39	4.51	1.08	0.46	1.97
91050	2.63	2.39	4.16	0.83	0.45	1.69
91051	2.72	2.39	4.41	1.04	0.45	1.67
91054	2.52	2.38	4.29	0.94	0.46	1.69
91055	2.60	2.37	4.32	0.93	0.45	1.84
91056	2.62	2.37	4.43	1.03	0.46	1.70
91057	2.80	2.38	4.72	1.28	0.46	2.00
91063	2.59	2.41	4.28	0.93	0.59	1.93
91070	2.54	2.40	4.26	0.90	0.45	1.85

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Grassland					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	0.00	0.00	0.00	0.00	0.00	0.00
34002	0.00	0.00	0.00	0.00	0.00	0.00
34009	0.00	0.00	0.00	0.00	0.00	0.00
34010	0.00	0.00	0.00	0.00	0.00	0.00
34015	0.00	0.00	0.00	0.00	0.00	0.00
34022	0.00	0.00	0.00	0.00	0.00	0.00
34024	0.00	0.00	0.00	0.00	0.00	0.00
34026	0.00	0.00	0.00	0.00	0.00	0.00
34037	0.00	0.00	0.00	0.00	0.00	0.00
34039	0.00	0.00	0.00	0.00	0.00	0.00
34040	0.00	0.00	0.00	0.00	0.00	0.00
34045	0.00	0.00	0.00	0.00	0.00	0.00
34046	0.21	0.21	2.56	-0.85	0.01	0.00
34047	0.00	0.00	0.00	0.00	0.00	0.00
34048	0.00	0.00	0.00	0.00	0.00	0.00
34059	0.00	0.00	0.00	0.00	0.00	0.00
34061	1.12	0.82	3.32	-0.12	0.00	1.52
34062	0.00	0.00	0.00	0.00	0.00	0.00
34064	0.00	0.00	0.00	0.00	0.00	0.00
35002	1.41	0.71	3.59	0.20	0.00	1.76
35010	0.00	0.00	0.00	0.00	0.00	0.00
35029	0.00	0.00	0.00	0.00	0.00	0.00
36005	2.06	0.85	4.14	0.60	0.01	1.09
36006	0.82	0.52	3.01	-0.46	0.01	0.00
36008	0.95	0.64	3.23	-0.21	0.00	1.69
36010	1.73	0.68	3.94	0.46	0.01	0.00
36022	1.18	1.18	3.20	-0.27	0.01	0.00
36024	1.25	0.77	3.47	0.00	0.00	0.00
36027	1.81	0.73	4.01	0.58	0.01	0.00
38027	2.48	1.10	4.50	1.00	0.01	1.22
49020	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Grassland					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
49022	2.02	1.02	3.95	0.52	0.01	1.64
49032	0.00	0.00	0.00	0.00	0.00	0.00
49035	0.00	0.00	0.00	0.00	0.00	0.00
49039	0.00	0.00	0.00	0.00	0.00	0.00
50002	0.00	0.00	0.00	0.00	0.00	0.00
50003	0.00	0.00	0.00	0.00	0.00	0.00
50007	0.00	0.00	0.00	0.00	0.00	0.00
50008	-0.20	-0.20	2.43	-1.00	0.04	0.00
50017	0.00	0.00	0.00	0.00	0.00	0.00
50018	0.00	0.00	0.00	0.00	0.00	0.00
50025	0.00	0.00	0.00	0.00	0.00	0.00
50026	0.00	0.00	0.00	0.00	0.00	0.00
52028	1.80	0.90	3.90	0.47	0.00	1.48
52029	2.27	1.06	4.29	0.87	0.01	1.56
54012	2.15	0.83	4.29	0.84	0.00	1.36
54013	1.08	0.78	3.25	-0.17	0.00	0.00
61043	0.00	0.00	0.00	0.00	0.00	0.00
61047	0.00	0.00	0.00	0.00	0.00	0.00
61052	0.00	0.00	0.00	0.00	0.00	0.00
61061	0.00	0.00	0.00	0.00	0.00	0.00
61063	0.00	0.00	0.00	0.00	0.00	0.00
61065	0.00	0.00	0.00	0.00	0.00	0.00
61070	0.00	0.00	0.00	0.00	0.00	0.00
61072	0.00	0.00	0.00	0.00	0.00	0.00
66002	0.00	0.00	0.00	0.00	0.00	0.00
66033	0.00	0.00	0.00	0.00	0.00	0.00
66060	0.00	0.00	0.00	0.00	0.00	0.00
66061	0.00	0.00	0.00	0.00	0.00	0.00
72022	0.00	0.00	0.00	0.00	0.00	0.00
81010	0.00	0.00	0.00	0.00	0.00	0.00
91010	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Grassland					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
91011	1.68	0.84	3.83	0.41	0.01	1.66
91012	0.00	0.00	0.00	0.00	0.00	0.00
91015	0.00	0.00	0.00	0.00	0.00	0.00
91020	0.00	0.00	0.00	0.00	0.00	0.00
91034	0.00	0.00	0.00	0.00	0.00	0.00
91036	0.00	0.00	0.00	0.00	0.00	0.00
91042	0.00	0.00	0.00	0.00	0.00	0.00
91045	0.00	0.00	0.00	0.00	0.00	0.00
91046	0.64	0.64	2.92	-0.51	0.00	1.48
91047	0.00	0.00	0.00	0.00	0.00	0.00
91050	0.00	0.00	0.00	0.00	0.00	0.00
91051	0.00	0.00	0.00	0.00	0.00	0.00
91054	0.00	0.00	0.00	0.00	0.00	0.00
91055	0.00	0.00	0.00	0.00	0.00	0.00
91056	0.64	0.64	2.92	-0.51	0.00	1.82
91057	0.00	0.00	0.00	0.00	0.00	0.00
91063	-1.05	-1.05	1.78	-1.70	0.00	0.00
91070	0.68	0.38	2.92	-0.48	0.01	1.62

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Mixed Forest					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	3.31	2.70	4.90	1.48	0.50	2.02
34002	0.00	0.00	0.00	0.00	0.00	0.00
34009	0.00	0.00	0.00	0.00	0.00	0.00
34010	0.00	0.00	0.00	0.00	0.00	0.00
34015	0.00	0.00	0.00	0.00	0.00	0.00
34022	0.00	0.00	0.00	0.00	0.00	0.00
34024	0.00	0.00	0.00	0.00	0.00	0.00
34026	0.00	0.00	0.00	0.00	0.00	0.00
34037	0.00	0.00	0.00	0.00	0.00	0.00
34039	0.00	0.00	0.00	0.00	0.00	0.00
34040	0.00	0.00	0.00	0.00	0.00	0.00
34045	0.00	0.00	0.00	0.00	0.00	0.00
34046	0.00	0.00	0.00	0.00	0.00	0.00
34047	0.00	0.00	0.00	0.00	0.00	0.00
34048	0.00	0.00	0.00	0.00	0.00	0.00
34059	3.24	2.69	4.59	1.22	0.49	2.05
34061	3.23	2.68	4.56	1.19	0.31	1.83
34062	3.23	2.68	4.61	1.24	0.31	1.58
34064	0.00	0.00	0.00	0.00	0.00	0.00
35002	0.00	0.00	0.00	0.00	0.00	0.00
35010	0.00	0.00	0.00	0.00	0.00	0.00
35029	0.00	0.00	0.00	0.00	0.00	0.00
36005	0.00	0.00	0.00	0.00	0.00	0.00
36006	0.00	0.00	0.00	0.00	0.00	0.00
36008	0.00	0.00	0.00	0.00	0.00	0.00
36010	0.00	0.00	0.00	0.00	0.00	0.00
36022	0.00	0.00	0.00	0.00	0.00	0.00
36024	0.00	0.00	0.00	0.00	0.00	0.00
36027	0.00	0.00	0.00	0.00	0.00	0.00
38027	3.24	2.69	4.58	1.21	0.50	1.73
49020	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Mixed Forest					
Route	**Area**	**Mean Patch Size**	**Edge**	**Edge Density**	**Mean Patch Dimension**	**Interspersion**
49022	0.00	0.00	0.00	0.00	0.00	0.00
49032	3.23	2.68	4.54	1.18	0.00	1.73
49035	0.00	0.00	0.00	0.00	0.00	0.00
49039	3.20	2.68	4.41	1.07	0.00	1.45
50002	0.00	0.00	0.00	0.00	0.00	0.00
50003	0.00	0.00	0.00	0.00	0.00	0.00
50007	3.24	2.69	4.57	1.20	0.49	1.73
50008	0.00	0.00	0.00	0.00	0.00	0.00
50017	3.22	2.65	4.53	1.17	0.00	1.28
50018	3.14	2.64	4.38	1.02	0.00	0.00
50025	2.33	2.48	3.85	0.79	0.30	1.38
50026	2.94	2.63	4.01	0.87	0.33	1.62
52028	0.00	0.00	0.00	0.00	0.00	0.00
52029	0.00	0.00	0.00	0.00	0.00	0.00
54012	0.00	0.00	0.00	0.00	0.00	0.00
54013	0.00	0.00	0.00	0.00	0.00	0.00
61043	3.10	2.68	4.50	1.15	0.32	1.73
61047	3.13	2.68	0.00	0.00	0.31	1.89
61052	3.12	2.66	4.45	1.13	0.31	1.67
61061	3.31	2.69	4.86	1.47	0.32	1.86
61063	3.32	2.67	4.82	1.43	0.32	2.00
61065	3.21	2.66	4.48	1.14	0.02	1.73
61070	3.05	2.67	3.55	0.64	0.31	1.78
61072	2.94	2.67	3.80	0.67	0.31	1.82
66002	0.00	0.00	0.00	0.00	0.00	0.00
66033	3.22	2.67	4.53	1.16	0.03	1.73
66060	0.00	0.00	0.00	0.00	0.00	0.00
66061	0.00	0.00	0.00	0.00	0.00	0.00
72022	3.24	2.69	4.59	1.22	0.50	1.95
81010	0.00	0.00	0.00	0.00	0.00	0.00
91010	3.24	2.69	4.57	1.20	0.50	1.91

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Mixed Forest					
Route	**Area**	**Mean Patch Size**	**Edge**	**Edge Density**	**Mean Patch Dimension**	**Interspersion**
91011	1.05	0.00	4.74	1.36	0.31	1.36
91012	3.18	2.58	4.57	1.20	0.31	1.99
91015	3.19	2.63	4.61	1.24	0.31	1.69
91020	0.00	2.54	4.59	1.21	0.32	1.76
91034	3.24	2.69	4.61	1.24	0.49	1.97
91036	3.24	2.69	4.60	1.23	0.49	1.98
91042	3.11	2.67	4.20	0.86	0.31	1.94
91045	3.20	2.65	4.48	1.14	0.32	1.79
91046	3.23	2.69	4.56	1.20	0.33	1.87
91047	3.24	2.69	4.57	1.20	0.50	1.73
91050	0.00	0.00	0.00	0.00	0.00	0.00
91051	0.00	0.00	0.00	0.00	0.00	0.00
91054	0.00	0.00	0.00	0.00	0.00	0.00
91055	3.23	2.69	4.56	1.20	0.01	1.73
91056	3.22	2.67	4.53	1.16	0.01	1.35
91057	3.12	2.64	4.31	1.01	0.32	1.86
91063	0.00	0.00	0.00	0.00	0.00	0.00
91070	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Evergreen Forest					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	2.51	2.39	3.73	0.47	0.49	2.01
34002	0.00	0.00	0.00	0.00	0.00	0.00
34009	0.00	0.00	0.00	0.00	0.00	0.00
34010	0.00	0.00	0.00	0.00	0.00	0.00
34015	0.00	0.00	0.00	0.00	0.00	0.00
34022	2.51	2.39	3.69	0.45	0.49	1.89
34024	0.00	0.00	0.00	0.00	0.00	0.00
34026	0.00	0.00	0.00	0.00	0.00	0.00
34037	0.00	0.00	0.00	0.00	0.00	0.00
34039	0.00	0.00	0.00	0.00	0.00	0.00
34040	0.00	0.00	0.00	0.00	0.00	0.00
34045	0.00	0.00	0.00	0.00	0.00	0.00
34046	0.00	0.00	0.00	0.00	0.00	0.00
34047	0.00	0.00	0.00	0.00	0.00	0.00
34048	0.00	0.00	0.00	0.00	0.00	0.00
34059	0.00	0.00	0.00	0.00	0.00	0.00
34061	0.00	0.00	0.00	0.00	0.00	0.00
34062	2.52	2.35	4.02	0.69	0.31	1.55
34064	0.00	0.00	0.00	0.00	0.00	0.00
35002	2.52	2.39	3.81	0.54	0.49	1.90
35010	0.00	0.00	0.00	0.00	0.00	0.00
35029	0.00	0.00	0.00	0.00	0.00	0.00
36005	0.00	0.00	0.00	0.00	0.00	0.00
36006	0.00	0.00	0.00	0.00	0.00	0.00
36008	0.00	0.00	0.00	0.00	0.00	0.00
36010	0.00	0.00	0.00	0.00	0.00	0.00
36022	0.00	0.00	0.00	0.00	0.00	0.00
36024	0.00	0.00	0.00	0.00	0.00	0.00
36027	0.00	0.00	0.00	0.00	0.00	0.00
38027	0.00	0.00	0.00	0.00	0.00	0.00
49020	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Evergreen Forest					
Route	**Area**	**Mean Patch Size**	**Edge**	**Edge Density**	**Mean Patch Dimension**	**Interspersion**
49022	2.53	2.39	3.93	0.62	0.49	2.02
49032	2.54	2.39	3.89	0.57	0.49	1.91
49035	2.53	2.39	3.89	0.59	0.49	1.89
49039	2.51	2.38	3.71	0.46	0.32	1.91
50002	0.00	0.00	0.00	0.00	0.00	0.00
50003	0.00	0.00	0.00	0.00	0.00	0.00
50007	0.00	0.00	0.00	0.00	0.00	0.00
50008	0.00	0.00	0.00	0.00	0.00	0.00
50017	0.00	0.00	0.00	0.00	0.00	0.00
50018	0.00	0.00	0.00	0.00	0.00	0.00
50025	2.64	2.40	4.27	0.86	0.49	1.96
50026	2.07	1.97	4.11	0.73	0.31	1.71
52028	0.00	0.00	0.00	0.00	0.00	0.00
52029	0.00	0.00	0.00	0.00	0.00	0.00
54012	0.00	0.00	0.00	0.00	0.00	0.00
54013	0.00	0.00	0.00	0.00	0.00	0.00
61043	2.47	2.35	3.32	0.25	0.30	1.60
61047	0.00	0.00	0.00	0.00	0.00	0.00
61052	2.47	2.38	2.68	0.17	0.30	1.32
61061	2.47	2.36	3.32	0.24	0.00	0.00
61063	0.00	0.00	0.00	0.00	0.00	0.00
61065	0.00	0.00	0.00	0.00	0.00	0.00
61070	2.49	2.36	3.55	0.36	0.31	1.59
61072	2.38	2.36	0.00	0.00	0.31	1.53
66002	0.00	0.00	0.00	0.00	0.00	0.00
66033	0.00	0.00	0.00	0.00	0.00	0.00
66060	0.00	0.00	0.00	0.00	0.00	0.00
66061	2.51	2.39	3.71	0.46	0.49	1.58
72022	0.00	0.00	0.00	0.00	0.00	0.00
81010	0.00	0.00	0.00	0.00	0.00	0.00
91010	2.53	2.39	3.83	0.54	0.49	2.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Evergreen Forest					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
91011	0.00	0.00	4.06	0.72	0.30	1.69
91012	2.46	2.33	3.45	0.28	0.30	1.58
91015	2.61	2.31	4.30	0.89	0.32	1.75
91020	2.62	2.39	4.29	0.89	0.49	2.02
91034	0.00	0.00	0.00	0.00	0.00	0.00
91036	2.52	2.39	3.78	0.52	0.49	1.58
91042	2.60	2.38	4.12	0.79	0.32	1.83
91045	2.54	2.35	4.05	0.68	0.30	1.64
91046	0.00	0.00	0.00	0.00	0.00	0.00
91047	2.50	2.37	3.70	0.45	0.32	1.72
91050	0.00	0.00	0.00	0.00	0.00	0.00
91051	0.00	0.00	0.00	0.00	0.00	0.00
91054	0.00	0.00	0.00	0.00	0.00	0.00
91055	2.48	2.30	3.92	0.61	0.32	2.00
91056	2.47	2.36	3.47	0.31	0.30	1.86
91057	2.61	2.39	4.23	0.85	0.49	2.03
91063	0.00	0.00	0.00	0.00	0.00	0.00
91070	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Residential					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	1.28	1.61	0.00	0.00	0.30	1.92
34002	2.22	1.68	4.11	0.74	0.02	1.95
34009	0.00	0.00	0.00	0.00	0.00	0.00
34010	2.22	1.71	4.18	0.79	0.31	2.12
34015	2.23	1.72	4.13	0.75	0.31	0.00
34022	2.24	1.72	4.12	0.75	0.31	1.93
34024	2.27	1.84	4.09	0.72	0.30	1.81
34026	2.17	1.49	4.05	0.69	0.00	1.95
34037	0.00	0.00	0.00	0.00	0.00	0.00
34039	2.18	1.54	4.08	0.71	0.30	1.73
34040	2.20	1.69	4.16	0.78	0.32	2.11
34045	2.18	1.53	4.07	0.71	0.01	1.95
34046	2.19	1.56	4.07	0.70	0.00	1.95
34047	2.18	1.66	4.06	0.69	0.31	1.95
34048	2.38	1.72	4.33	0.95	0.31	1.95
34059	2.21	1.71	4.10	0.72	0.31	1.95
34061	2.21	1.63	4.12	0.74	0.31	1.95
34062	2.24	1.78	4.12	0.74	0.31	1.95
34064	0.00	0.00	0.00	0.00	0.00	0.00
35002	2.19	1.75	4.04	0.67	0.31	1.88
35010	0.00	0.00	0.00	0.00	0.00	0.00
35029	0.00	0.00	0.00	0.00	0.00	0.00
36005	2.18	1.63	4.12	0.75	0.31	2.09
36006	2.26	1.81	4.16	0.77	0.32	1.57
36008	0.00	0.00	0.00	0.00	0.00	0.00
36010	0.00	0.00	0.00	0.00	0.00	0.00
36022	2.22	1.67	4.10	0.73	0.01	1.95
36024	0.00	0.00	0.00	0.00	0.00	0.00
36027	2.30	1.90	4.17	0.78	0.31	2.02
38027	2.18	1.68	4.09	0.72	0.31	1.80
49020	2.20	1.70	4.12	0.75	0.31	1.74

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Residential					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
49022	2.36	1.78	4.20	0.81	0.31	1.96
49032	2.18	1.66	4.01	0.66	0.00	1.73
49035	2.00	1.57	3.86	0.52	0.30	1.79
49039	2.26	1.79	4.18	0.79	0.49	2.18
50002	0.00	0.00	0.00	0.00	0.00	0.00
50003	2.16	1.60	4.03	0.67	0.30	1.91
50007	0.00	0.00	0.00	0.00	0.00	0.00
50008	2.33	1.88	4.21	0.82	0.32	1.81
50017	2.36	2.05	4.09	0.72	0.31	1.94
50018	2.45	1.71	4.35	0.96	0.31	2.06
50025	0.00	0.00	0.00	0.00	0.00	0.00
50026	2.36	2.11	4.19	0.80	0.33	2.02
52028	2.18	1.53	4.15	0.77	0.32	1.96
52029	0.00	0.00	0.00	0.00	0.00	0.00
54012	2.24	1.73	4.14	0.76	0.31	1.97
54013	2.32	2.08	4.19	0.81	0.32	1.85
61043	0.00	1.58	3.54	0.32	0.30	1.93
61047	2.11	1.69	3.91	0.54	0.30	1.97
61052	2.12	0.00	3.99	0.66	0.29	1.92
61061	2.23	1.71	4.10	0.72	0.29	2.10
61063	2.23	1.72	4.11	0.73	0.31	1.90
61065	2.27	1.78	4.12	0.75	0.31	1.98
61070	2.25	1.71	4.10	0.73	0.31	2.01
61072	2.22	1.64	4.12	0.74	0.31	1.90
66002	2.32	1.85	4.13	0.75	0.31	1.97
66033	2.13	1.66	4.08	0.70	0.32	1.95
66060	2.09	1.82	3.55	0.30	0.30	1.53
66061	2.19	1.66	4.06	0.68	-0.01	1.51
72022	2.16	1.39	4.09	0.72	0.31	1.77
81010	0.00	0.00	0.00	0.00	0.00	0.00
91010	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Residential					
Route	**Area**	**Mean Patch Size**	**Edge**	**Edge Density**	**Mean Patch Dimension**	**Interspersion**
91011	0.00	0.00	0.00	0.00	0.00	0.00
91012	0.00	0.00	0.00	0.00	0.00	0.00
91015	2.23	1.72	4.14	0.76	0.02	1.95
91020	2.21	1.69	4.12	0.74	0.31	1.88
91034	2.13	1.68	4.03	0.67	0.31	1.97
91036	2.21	1.72	4.08	0.70	0.31	1.69
91042	0.00	0.00	0.00	0.00	0.00	0.00
91045	2.18	1.75	4.01	0.66	0.31	1.87
91046	2.23	1.96	4.04	0.67	0.31	1.87
91047	2.32	1.90	4.13	0.75	0.31	1.93
91050	2.18	1.66	4.07	0.69	0.31	1.95
91051	2.19	1.83	3.90	0.53	0.31	1.95
91054	2.24	1.73	4.12	0.74	0.31	1.85
91055	0.00	0.00	0.00	0.00	0.00	0.00
91056	2.25	1.78	4.17	0.78	0.49	2.10
91057	0.00	0.00	0.00	0.00	0.00	0.00
91063	2.37	1.87	4.12	0.74	0.31	2.02
91070	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Transitional					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	0.00	0.00	0.00	0.00	0.00	0.00
34002	0.00	0.00	0.00	0.00	0.00	0.00
34009	0.00	0.00	0.00	0.00	0.00	0.00
34010	2.29	1.73	4.03	0.64	0.02	1.60
34015	0.00	0.00	0.00	0.00	0.00	0.00
34022	0.00	0.00	0.00	0.00	0.00	0.00
34024	0.00	0.00	0.00	0.00	0.00	0.00
34026	2.40	1.87	4.10	0.70	0.02	1.85
34037	0.00	0.00	0.00	0.00	0.00	0.00
34039	0.00	0.00	0.00	0.00	0.00	0.00
34040	2.42	1.91	4.12	0.72	0.04	1.85
34045	0.00	0.00	0.00	0.00	0.00	0.00
34046	0.00	0.00	0.00	0.00	0.00	0.00
34047	0.00	0.00	0.00	0.00	0.00	0.00
34048	0.00	0.00	0.00	0.00	0.00	0.00
34059	2.43	1.95	4.13	0.73	0.05	1.52
34061	2.42	1.92	4.11	0.70	0.04	1.58
34062	0.00	0.00	0.00	0.00	0.00	0.00
34064	0.00	0.00	0.00	0.00	0.00	0.00
35002	2.43	1.96	4.14	0.74	0.05	1.85
35010	0.00	0.00	0.00	0.00	0.00	0.00
35029	0.00	0.00	0.00	0.00	0.00	0.00
36005	2.43	1.95	4.13	0.73	0.03	1.18
36006	0.00	0.00	0.00	0.00	0.00	0.00
36008	0.00	0.00	0.00	0.00	0.00	0.00
36010	0.00	0.00	0.00	0.00	0.00	0.00
36022	0.00	0.00	0.00	0.00	0.00	0.00
36024	0.00	0.00	0.00	0.00	0.00	0.00
36027	0.00	0.00	0.00	0.00	0.00	0.00
38027	0.00	0.00	0.00	0.00	0.00	0.00
49020	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Transitional					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
49022	0.00	0.00	0.00	0.00	0.00	0.00
49032	0.00	0.00	0.00	0.00	0.00	0.00
49035	0.00	0.00	0.00	0.00	0.00	0.00
49039	0.00	0.00	0.00	0.00	0.00	0.00
50002	0.00	0.00	0.00	0.00	0.00	0.00
50003	0.00	0.00	0.00	0.00	0.00	0.00
50007	0.00	0.00	0.00	0.00	0.00	0.00
50008	0.00	0.00	0.00	0.00	0.00	0.00
50017	0.00	0.00	0.00	0.00	0.00	0.00
50018	0.00	0.00	0.00	0.00	0.00	0.00
50025	2.45	2.02	4.21	0.79	0.50	2.09
50026	2.45	1.98	4.19	0.78	0.50	2.00
52028	0.00	0.00	0.00	0.00	0.00	0.00
52029	0.00	0.00	0.00	0.00	0.00	0.00
54012	2.42	1.92	4.10	0.70	0.04	1.85
54013	0.00	0.00	0.00	0.00	0.00	0.00
61043	0.00	0.00	0.00	0.00	0.00	0.00
61047	0.00	0.00	0.00	0.00	0.00	0.00
61052	0.00	0.00	0.00	0.00	0.00	0.00
61061	0.00	0.00	0.00	0.00	0.00	0.00
61063	0.00	0.00	0.00	0.00	0.00	0.00
61065	0.00	0.00	0.00	0.00	0.00	0.00
61070	2.40	1.90	4.06	0.66	0.04	1.01
61072	0.00	0.00	0.00	0.00	0.00	0.00
66002	0.00	0.00	0.00	0.00	0.00	0.00
66033	0.00	0.00	0.00	0.00	0.00	0.00
66060	0.00	0.00	0.00	0.00	0.00	0.00
66061	0.00	0.00	0.00	0.00	0.00	0.00
72022	2.45	1.98	4.19	0.78	0.50	2.02
81010	0.00	0.00	0.00	0.00	0.00	0.00
91010	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Transitional					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
91011	2.73	2.02	4.58	1.17	0.50	2.13
91012	0.00	0.00	0.00	0.00	0.00	0.00
91015	0.00	0.00	0.00	0.00	0.00	0.00
91020	0.00	0.00	0.00	0.00	0.00	0.00
91034	0.00	0.00	0.00	0.00	0.00	0.00
91036	0.00	0.00	0.00	0.00	0.00	0.00
91042	0.00	0.00	0.00	0.00	0.00	0.00
91045	0.00	0.00	0.00	0.00	0.00	0.00
91046	0.00	0.00	0.00	0.00	0.00	0.00
91047	0.00	0.00	0.00	0.00	0.00	0.00
91050	0.00	0.00	0.00	0.00	0.00	0.00
91051	0.00	0.00	0.00	0.00	0.00	0.00
91054	0.00	0.00	0.00	0.00	0.00	0.00
91055	0.00	0.00	0.00	0.00	0.00	0.00
91056	0.00	0.00	0.00	0.00	0.00	0.00
91057	0.00	0.00	0.00	0.00	0.00	0.00
91063	0.00	0.00	0.00	0.00	0.00	0.00
91070	2.42	2.44	4.11	0.71	0.04	1.85

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Urban					
Route	**Area**	**Mean Patch Size**	**Edge**	**Edge Density**	**Mean Patch Dimension**	**Interspersion**
18014	2.28	1.81	4.43	1.01	0.33	1.92
34002	2.14	1.84	4.30	0.89	0.50	1.99
34009	0.00	0.00	0.00	0.00	0.00	0.00
34010	2.12	1.81	4.26	0.86	0.33	2.15
34015	2.10	1.76	4.24	0.85	0.04	0.00
34022	2.20	1.91	4.30	0.90	0.34	1.94
34024	2.07	1.79	4.21	0.83	0.33	1.98
34026	2.16	1.90	4.32	0.91	0.33	2.19
34037	2.12	1.80	4.27	0.87	0.03	1.99
34039	2.18	1.93	4.32	0.91	0.35	2.18
34040	2.13	1.83	4.28	0.88	0.32	2.12
34045	2.11	1.78	4.23	0.84	0.00	1.99
34046	1.95	1.70	4.14	0.75	0.03	1.96
34047	1.99	1.80	4.22	0.82	0.34	2.10
34048	2.01	1.56	4.21	0.81	0.04	1.99
34059	2.01	1.55	4.18	0.79	0.02	1.42
34061	2.08	1.72	4.23	0.84	0.32	1.68
34062	2.09	1.80	4.24	0.84	0.33	1.89
34064	2.11	1.79	4.26	0.86	0.06	1.99
35002	2.19	1.95	4.32	0.92	0.51	2.18
35010	0.00	0.00	0.00	0.00	0.00	0.00
35029	2.00	1.74	4.12	0.73	0.03	1.99
36005	2.24	1.93	4.37	0.94	0.51	2.23
36006	2.02	1.82	4.19	0.80	0.33	1.91
36008	2.14	1.84	4.30	0.89	0.50	1.99
36010	0.00	0.00	0.00	0.00	0.00	0.00
36022	2.12	1.80	4.26	0.86	0.06	1.99
36024	2.07	1.76	4.23	0.84	0.06	1.99
36027	2.11	1.79	4.27	0.87	0.33	2.17
38027	2.05	1.58	4.28	0.88	0.33	1.98
49020	2.09	1.75	4.22	0.82	0.00	1.87

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Urban					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
49022	1.24	1.78	3.87	0.52	0.32	1.90
49032	2.13	1.82	4.29	0.88	0.33	2.15
49035	2.01	1.78	4.19	0.79	0.32	1.91
49039	1.89	1.58	4.19	0.80	0.06	1.91
50002	2.07	1.70	4.20	0.81	0.32	1.99
50003	2.12	1.89	4.25	0.85	0.34	2.04
50007	0.00	0.00	0.00	0.00	0.00	0.00
50008	2.23	1.86	4.30	0.89	0.33	1.93
50017	1.88	1.72	4.15	0.77	0.34	1.92
50018	2.05	1.83	4.18	0.78	0.33	2.00
50025	0.00	0.00	0.00	0.00	0.00	0.00
50026	2.14	1.92	4.24	0.85	0.33	1.99
52028	2.15	1.84	4.31	0.91	0.33	2.18
52029	0.00	0.00	0.00	0.00	0.00	0.00
54012	1.84	1.75	4.22	0.82	0.33	2.14
54013	1.99	1.63	4.28	0.88	0.33	1.93
61043	1.82	1.70	4.29	0.89	0.33	2.01
61047	2.18	1.79	4.33	0.93	0.33	1.85
61052	2.01	1.81	4.15	0.79	0.33	1.97
61061	1.90	1.76	4.06	0.67	0.32	2.09
61063	2.10	1.80	4.24	0.84	0.05	1.76
61065	0.00	0.00	0.00	0.00	0.00	0.00
61070	0.00	1.81	0.00	0.00	0.32	1.99
61072	1.92	1.76	4.15	0.76	0.33	1.96
66002	1.92	1.74	4.13	0.72	0.05	1.54
66033	2.08	1.72	4.25	0.84	0.05	1.99
66060	2.05	1.81	4.20	0.80	0.34	1.70
66061	2.08	1.77	4.20	0.80	0.03	1.99
72022	2.15	1.87	4.30	0.90	0.50	2.12
81010	2.08	1.71	4.24	0.84	0.05	1.99
91010	2.20	1.96	4.32	0.91	0.51	2.11

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Urban					
Route	**Area**	**Mean Patch Size**	**Edge**	**Edge Density**	**Mean Patch Dimension**	**Interspersion**
91011	0.00	0.00	0.00	0.00	0.00	0.00
91012	2.08	1.72	4.25	0.84	0.06	1.99
91015	0.00	0.00	0.00	0.00	0.00	0.00
91020	2.14	1.80	4.31	0.90	0.33	2.02
91034	2.19	1.97	4.29	0.89	0.33	1.91
91036	2.07	1.69	4.24	0.83	0.05	1.38
91042	2.10	1.78	4.25	0.85	0.06	1.99
91045	2.06	1.82	4.23	0.84	0.33	1.99
91046	1.78	1.79	4.06	0.68	0.33	1.97
91047	1.62	1.66	4.14	0.76	0.33	2.01
91050	0.00	0.00	0.00	0.00	0.00	0.00
91051	2.06	1.78	4.26	0.86	0.33	2.01
91054	2.09	1.80	4.24	0.84	0.33	1.97
91055	2.12	1.81	4.28	0.87	0.06	1.99
91056	1.84	0.00	4.21	0.82	0.05	1.95
91057	2.14	1.85	4.29	0.89	0.51	2.08
91063	1.52	1.74	4.08	0.67	0.33	2.00
91070	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Wetland					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	2.61	1.76	4.22	0.84	0.49	2.03
34002	0.00	0.00	0.00	0.00	0.00	0.00
34009	0.00	0.00	0.00	0.00	0.00	0.00
34010	2.53	1.65	3.95	0.63	0.31	2.05
34015	0.00	0.00	0.00	0.00	0.00	0.00
34022	2.51	1.73	3.79	0.52	0.49	1.64
34024	0.00	0.00	0.00	0.00	0.00	0.00
34026	2.50	1.71	3.76	0.50	0.49	1.64
34037	2.44	1.06	3.75	0.49	0.31	2.13
34039	2.57	0.00	4.06	0.71	0.32	1.99
34040	2.56	1.53	4.05	0.73	0.32	1.98
34045	2.50	1.71	3.76	0.50	0.49	1.64
34046	2.51	1.76	3.80	0.53	0.49	1.64
34047	2.57	1.76	4.12	0.76	0.49	1.73
34048	2.50	1.72	3.78	0.51	0.49	1.64
34059	2.62	1.27	4.10	0.75	0.30	1.54
34061	2.58	1.74	4.04	0.70	0.29	1.88
34062	2.55	1.80	3.94	0.63	0.50	2.06
34064	2.61	1.82	4.10	0.74	0.49	2.09
35002	0.00	0.00	0.00	0.00	0.00	0.00
35010	0.00	0.00	0.00	0.00	0.00	0.00
35029	2.50	1.71	3.76	0.50	0.50	1.64
36005	0.00	0.00	0.00	0.00	0.00	0.00
36006	0.00	0.00	0.00	0.00	0.00	0.00
36008	0.00	0.00	0.00	0.00	0.00	0.00
36010	0.00	0.00	0.00	0.00	0.00	0.00
36022	0.00	0.00	0.00	0.00	0.00	0.00
36024	2.52	1.80	3.82	0.53	0.32	1.64
36027	0.00	0.00	0.00	0.00	0.00	0.00
38027	0.00	0.00	0.00	0.00	0.00	0.00
49020	2.60	1.75	4.24	0.85	0.49	1.99

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Wetland					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
49022	2.52	1.58	3.88	0.58	0.31	1.78
49032	2.67	1.64	4.38	0.97	0.31	1.72
49035	2.40	1.48	3.84	0.56	0.31	1.69
49039	2.47	1.63	3.87	0.58	0.30	1.87
50002	2.48	1.65	3.59	0.39	0.01	1.14
50003	2.50	1.62	3.81	0.53	0.31	1.87
50007	2.58	1.83	4.06	0.71	0.49	2.03
50008	2.67	1.83	4.23	0.86	0.49	1.80
50017	2.85	1.71	4.71	1.26	0.32	1.81
50018	2.72	1.62	4.50	1.13	0.31	2.03
50025	2.88	1.63	4.66	1.21	0.31	1.30
50026	2.79	1.58	4.64	1.18	0.31	1.56
52028	0.00	0.00	0.00	0.00	0.00	0.00
52029	2.51	1.73	3.83	0.55	0.49	1.64
54012	2.51	1.73	3.85	0.56	0.29	2.07
54013	0.00	0.00	0.00	0.00	0.00	0.00
61043	2.51	1.73	3.82	0.54	0.49	2.02
61047	2.50	1.68	3.77	0.51	0.31	1.92
61052	2.48	1.63	3.64	0.44	0.31	1.70
61061	0.00	0.00	0.00	0.00	0.00	0.00
61063	2.51	1.73	3.76	0.50	0.30	2.09
61065	2.45	1.67	3.39	0.32	0.31	1.92
61070	2.41	1.69	3.81	0.53	0.32	1.55
61072	2.52	1.70	3.86	0.57	0.30	1.93
66002	0.00	0.00	0.00	0.00	0.00	0.00
66033	0.00	0.00	0.00	0.00	0.00	0.00
66060	0.00	0.00	0.00	0.00	0.00	0.00
66061	0.00	0.00	0.00	0.00	0.00	0.00
72022	0.00	0.00	0.00	0.00	0.00	0.00
81010	2.52	1.13	4.18	0.81	0.31	1.85
91010	2.45	1.68	2.88	0.14	0.30	1.48

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Wetland					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
91011	2.45	1.60	3.44	0.31	0.00	0.00
91012	2.42	1.51	3.45	0.28	0.31	1.86
91015	2.35	1.49	3.78	0.51	0.31	1.60
91020	2.55	1.48	4.27	0.88	0.31	1.86
91034	2.51	1.77	3.82	0.54	0.49	1.82
91036	2.52	1.72	3.84	0.56	0.31	1.72
91042	2.51	1.62	3.91	0.62	0.31	1.77
91045	2.45	1.56	3.92	0.60	0.31	1.60
91046	2.38	1.66	0.00	0.00	0.31	1.66
91047	0.00	1.43	3.88	0.58	0.31	1.80
91050	0.00	0.00	0.00	0.00	0.00	0.00
91051	0.00	0.00	0.00	0.00	0.00	0.00
91054	2.50	1.66	3.70	0.45	0.01	1.64
91055	0.00	0.00	0.00	0.00	0.00	0.00
91056	2.48	1.73	3.77	0.51	0.32	1.54
91057	2.50	1.65	4.29	0.90	0.31	1.72
91063	2.50	1.67	3.72	0.47	0.31	1.83
91070	2.51	1.74	3.84	0.56	0.49	2.06

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Water					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
18014	1.73	1.79	3.53	0.35	0.31	1.80
34002	0.00	0.00	0.00	0.00	0.00	0.00
34009	0.00	0.00	0.00	0.00	0.00	0.00
34010	1.52	1.78	3.44	0.30	0.02	0.99
34015	0.00	0.00	0.00	0.00	0.00	0.00
34022	0.00	0.00	0.00	0.00	0.00	0.00
34024	0.00	0.00	0.00	0.00	0.00	0.00
34026	0.00	0.00	0.00	0.00	0.00	0.00
34037	0.00	0.00	0.00	0.00	0.00	0.00
34039	1.46	1.71	3.53	0.35	0.30	1.59
34040	1.91	1.89	3.74	0.48	0.31	1.85
34045	1.67	1.87	3.59	0.38	0.32	1.97
34046	1.77	1.88	3.76	0.49	0.49	1.79
34047	1.68	1.85	3.69	0.44	0.49	1.92
34048	0.00	0.00	0.00	0.00	0.00	0.00
34059	0.00	1.77	0.00	0.00	0.31	1.85
34061	1.60	1.83	3.53	0.34	0.31	1.93
34062	0.00	0.00	0.00	0.00	0.00	0.00
34064	0.00	0.00	0.00	0.00	0.00	0.00
35002	1.87	1.92	3.78	0.51	0.49	2.04
35010	1.60	1.83	3.57	0.37	0.31	1.60
35029	0.00	0.00	0.00	0.00	0.00	0.00
36005	0.00	0.00	0.00	0.00	0.00	0.00
36006	0.00	0.00	0.00	0.00	0.00	0.00
36008	1.60	1.83	3.57	0.37	0.31	1.60
36010	0.00	0.00	0.00	0.00	0.00	0.00
36022	0.00	0.00	0.00	0.00	0.00	0.00
36024	1.79	1.95	3.76	0.48	0.49	1.60
36027	0.00	0.00	0.00	0.00	0.00	0.00
38027	1.69	0.00	3.69	0.43	0.32	1.01
49020	1.44	1.81	3.24	0.22	0.31	1.91

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Water					
Route	**Area**	**Mean Patch Size**	**Edge**	**Edge Density**	**Mean Patch Dimension**	**Interspersion**
49022	0.00	0.00	0.00	0.00	0.00	0.00
49032	1.97	1.84	3.84	0.53	0.31	1.83
49035	2.17	1.83	4.14	0.79	0.31	1.79
49039	1.67	1.79	3.79	0.51	0.31	2.03
50002	0.00	0.00	0.00	0.00	0.00	0.00
50003	1.68	1.85	3.74	0.46	0.49	1.93
50007	0.00	0.00	0.00	0.00	0.00	0.00
50008	1.80	1.96	3.62	0.39	0.31	1.29
50017	1.76	1.84	3.78	0.49	0.31	1.89
50018	1.58	1.82	3.46	0.30	0.31	1.77
50025	1.71	1.82	3.73	0.45	0.32	1.74
50026	1.69	1.86	3.68	0.43	0.31	1.65
52028	1.60	1.83	3.60	0.39	0.49	1.60
52029	0.00	0.00	0.00	0.00	0.00	0.00
54012	1.75	1.92	3.60	0.38	0.31	1.38
54013	0.00	0.00	0.00	0.00	0.00	0.00
61043	0.00	0.00	0.00	0.00	0.00	0.00
61047	0.00	0.00	0.00	0.00	0.00	0.00
61052	1.59	1.80	3.58	0.37	0.30	1.72
61061	0.00	0.00	0.00	0.00	0.00	0.00
61063	1.58	1.81	3.54	0.34	0.00	1.60
61065	1.68	1.87	3.70	0.44	0.49	1.60
61070	1.93	1.85	4.01	0.66	0.31	1.82
61072	0.00	0.00	0.00	0.00	0.00	0.00
66002	1.65	1.86	3.57	0.36	0.31	1.63
66033	0.00	0.00	0.00	0.00	0.00	0.00
66060	1.44	1.74	3.36	0.26	0.01	0.57
66061	0.00	0.00	0.00	0.00	0.00	0.00
72022	1.55	1.82	3.45	0.30	0.31	0.87
81010	1.46	1.79	3.53	0.34	0.31	2.05
91010	1.49	1.77	3.57	0.37	0.31	1.71

Appendix A. Log10 Land Cover and Red-headed Woodpecker Change.

	Water					
Route	Area	Mean Patch Size	Edge	Edge Density	Mean Patch Dimension	Interspersion
91011	1.69	1.88	3.59	0.38	0.31	0.00
91012	1.69	1.82	3.72	0.48	0.32	1.53
91015	2.02	1.80	3.76	0.48	0.31	1.79
91020	1.73	1.83	3.61	0.39	0.31	1.77
91034	0.00	0.00	0.00	0.00	0.00	0.00
91036	0.00	0.00	0.00	0.00	0.00	0.00
91042	1.62	1.83	3.58	0.38	0.31	1.60
91045	1.53	1.85	3.80	0.50	0.31	1.11
91046	1.93	1.79	3.81	0.53	0.31	1.49
91047	1.69	1.83	3.71	0.45	0.31	1.83
91050	0.00	0.00	0.00	0.00	0.00	0.00
91051	0.00	0.00	0.00	0.00	0.00	0.00
91054	1.31	1.68	3.18	0.15	0.30	1.57
91055	0.00	0.00	0.00	0.00	0.00	0.00
91056	0.00	0.00	0.00	0.00	0.00	0.00
91057	1.69	1.84	3.73	0.46	0.31	1.47
91063	1.66	1.84	3.61	0.39	0.32	1.95
91070	1.63	1.82	3.66	0.42	0.31	1.77

APPENDIX B

HEIRARCHICAL CLUSTERING ANALYSIS AGGLOMERATION SCHEDULE

	Appendix B. Hierarchical Clustering Analysis Agglomeration Schedule.					
				State Cluster		
	Cluster Combined		Coefficients	First Appears		Next Stage
Stage	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	41	60	1E-04	0	0	19
2	63	67	0.0001	0	0	14
3	14	28	0.0001	0	0	22
4	16	31	0.0001	0	0	35
5	13	76	0.0002	0	0	7
6	33	77	0.0002	0	0	21
7	13	61	0.0004	5	0	25
8	24	47	0.0004	0	0	51
9	38	50	0.0005	0	0	23
10	8	25	0.0005	0	0	43
11	27	78	0.0005	0	0	14
12	20	75	0.0005	0	0	32
13	62	72	0.0006	0	0	27
14	27	63	0.0006	11	2	22
15	1	2	0.0008	0	0	36
16	43	71	0.0009	0	0	38
17	6	48	0.0009	0	0	45
18	29	42	0.0009	0	0	28
19	11	41	0.0009	0	1	33
20	23	36	0.0011	0	0	39
21	33	40	0.0013	6	0	30
22	14	27	0.0017	3	14	44
23	38	73	0.0018	9	0	51
24	7	52	0.0018	0	0	32
25	13	80	0.002	7	0	43
26	15	34	0.002	0	0	40
27	62	70	0.0026	13	0	33
28	29	32	0.0026	18	0	35
29	9	46	0.0029	0	0	36
30	33	68	0.0033	21	0	49
31	54	74	0.0033	0	0	40
32	7	20	0.0033	24	12	37
33	11	62	0.0041	19	27	46
34	5	21	0.0046	0	0	56
35	16	29	0.005	4	28	56
36	1	9	0.0051	15	29	48
37	7	37	0.0054	32	0	53
38	43	53	0.0056	16	0	48
39	4	23	0.0059	0	20	57
40	15	54	0.0059	26	31	44
41	10	44	0.0068	0	0	64
42	18	22	0.0068	0	0	63
43	8	13	0.0068	10	25	54
44	14	15	0.011	22	40	59
45	6	69	0.0123	17	0	55
46	11	49	0.0128	33	0	60
47	12	17	0.0145	0	0	66

	Appendix B. Hierarchical Clustering Analysis Agglomeration Schedule.					
				State Cluster		
	Cluster Combined		Coefficients	First Appears		Next Stage
Stage	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
48	1	43	0.0149	36	38	61
49	19	33	0.0158	0	30	59
50	59	79	0.017	0	0	70
51	24	38	0.0181	8	23	61
52	30	64	0.0201	0	0	74
53	7	66	0.0227	37	0	60
54	8	57	0.026	43	0	70
55	6	39	0.0266	45	0	63
56	5	16	0.0274	34	35	68
57	4	45	0.0278	39	0	66
58	51	56	0.0297	0	0	72
59	14	19	0.0297	44	49	67
60	7	11	0.0422	53	46	69
61	1	24	0.049	48	51	67
62	3	55	0.0509	0	0	71
63	6	18	0.0579	55	42	69
64	10	65	0.0629	41	0	76
65	35	58	0.0635	0	0	71
66	4	12	0.0797	57	47	68
67	1	14	0.0986	61	59	72
68	4	5	0.1109	66	56	73
69	6	7	0.1778	63	60	73
70	8	59	0.2308	54	50	76
71	3	35	0.2441	62	65	75
72	1	51	0.2829	67	58	75
73	4	6	0.293	68	69	77
74	26	30	0.4253	0	52	77
75	1	3	0.6845	72	71	78
76	8	10	0.689	70	64	79
77	4	26	1.0788	73	74	78
78	1	4	2.1051	75	77	79
79	1	8	5.9557	78	76	0

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