Winter Ranges of Birds in New Hampshire; Changes in the Past Two Decades

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February 8, 2008

ACKNOWLEDGEMENTS

The research for this project was done at Plymouth Regional High School during the months of October through February 2008. The author would like to acknowledge the contributions by:

- Ms. Ina Ahern, science teacher at Plymouth Regional High School and advisor, for her time and guidance on this project
- Mrs. Stephanie Miller, statistics teacher at Plymouth Regional High School, for her help with the statistical analysis
- Dr. Nicholas Rodenhouse of Wellesley College and Hubbard Brook Ecosystem Study for the original idea.
- Carol Foss, Rebecca Suomala, Terry Bronson, and Dr. Pam Hunt of the New Hampshire Audubon Society for supplying and helping with Backyard Winter Bird Survey records and discussing plausible reasons of results
- Joe Homer and Donald Richard from the United States Department of Agriculture Natural Resources Conservation Service for supplying unofficial Hardiness Zone files
- NH GRANIT for the Political Boundaries data layer. The source agency for the Political Boundaries is the United States Geological Survey

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INTRODUCTION

The purpose of this research study was to evaluate the change in winter bird densities in New Hampshire over time. The hypothesis was that as time passed the ranges of the Tufted Titmouse (*Baeolophus bicolor*), Northern Cardinal (*Cardinalis cardinalis*), Mourning Dove (*Zenaida macroura*), and Northern Mockingbird (*Mimus polyglottos*) would expand farther north and into colder hardiness zones and show increased densities in these more northern and colder hardiness zones. To investigate this hypothesis, long term data on winter bird sightings across New Hampshire was gathered. This data was then mapped using a Geographic Information System. The number of birds observed was then compared to hardiness zones to see how their distribution across the state has changed over the last twenty years. These species were used because according to the New Hampshire Audubon Society they had seen the largest change over the span of their Backyard Winter Bird Survey as well as other winter bird surveys (Hunt 1997).

The Tufted Titmouse became common in southern parts of the state within the last 30 years and now inhabits New Hampshire year round (Foss 1994). The Tufted Titmouse prefers deciduous forests, swamps, orchards, and suburban areas for its habitat. Its food source is primarily insects and seeds. (Sibley 2003)

The Northern Cardinal began appearing in New Hampshire regularly in the late 1950s and is now common year round, though sightings of it are still rare in northern parts of the state. (Foss 1994) The habitat of the Northern Cardinal includes forest edges, hedgerows, suburbs, and any other areas that have shrubbery and small trees. Its diet consists mostly of seeds, fruits, buds, and insects. (Sibley 2003)

The Mourning Dove is numerous in New Hampshire, but notably less so in the winter, especially in northern regions. (Peterson 2004) Its numbers began increasing in the late 1940s and its habitat includes agricultural areas, open woods, deserts, forest edges, cities, and suburbs. Its primary food source is seeds. (Foss 1994)

The Northern Mockingbird began appearing in southern parts of New Hampshire in the early 1900s and is now common year round in southern parts of the state. Sightings of the Mockingbird are still rare in southwest and northern regions. (Peterson 2004) It was not until the 1960s that Northern Mockingbird started spreading to the Coastal Lowlands and lower Merrimack Valley (Foss 1994). The Northern Mockingbird is most commonly found in areas with open ground and shrubby vegetation such as cultivated land, suburbs, and parks and its primary food sources are fruits and insects. (Sibley 2003)

The best source of New Hampshire specific data on winter bird sightings is the New Hampshire Audubon Society-which is a non-profit organization dedicated to the conservation of wildlife and habitat throughout the state. It was established in 1914 and is independent from the National Audubon Society. Every year NH Audubon conducts the Backyard Winter Bird Survey on the second weekend of February to gather information on the distribution and abundance of winter bird species in New Hampshire. Observers participating in the survey report the highest number of a species seen at one time in their backyard or at their feeder. The survey originally began as the "Cardinal-Tufted Titmouse Census" in 1967, but was expanded in 1987 to include all wintering bird species. (Hunt 1997). The reason that the data collected from 1967 to 1986 was not used for this project was due to the fact that only the statewide totals are recorded. Since 1987, when the survey was expanded to all birds, the results have been reported by town and street address. This allowed for a more detailed analysis of the data to be conducted.

The data collected in the Backyard Winter Bird Survey was mapped using a Geographic Information System, or GIS. GIS is a collection of computer hardware and software that displays data in the form of a map by allowing information to be linked with a geographic location. (Ormsby 2001) The location may be an area such as a town or a specific longitude and latitude.

In addition, the data was analyzed relative to Plant Hardiness Zones, which are geographic sections of the country that are designated by their annual minimum temperature. (Arbor Day Foundation 2008) They are generally used to determine what plant life is capable in growing in areas across the United States and Canada. The hardiness zones were revised in 2006 due to minimum temperature change in some areas. (Arbor Day Foundation 2008) For this research, the hardiness zones were used as a way to compare the distribution of birds to temperature. To be consistent the hardiness zones used in this project are the 2006 versions, despite the fact that the data dates back to 1987.

MATERIALS AND METHODS

The New Hampshire Audubon Society converted the records of the annual Backyard Winter Bird Survey to ASCII files so they were compatible with Microsoft Excel. To minimize the impact of varying weather, such as mild and harsh winters and unusual weather conditions on the weekend of the survey, the files were then grouped into spans of 5 years (1987 to 1992, 1993 to 1998, 1999 to 2003, and 2004 to 2007). The fields for town, year, and the counts for the species to be examined were kept while the tallies of the other bird species and other unnecessary information provided by the survey participants were deleted.

Town totals were then calculated for each of the four species in each year span and then divided by the number of survey participants in each town to find the average number of bird sightings per observer. The purpose of using the average number of sightings per observer was to reduce the impact of towns which had a much higher number of participants in the Backyard Winter Bird Survey. The files for each year span were combined into one file and then saved as a DBF file.

In GIS, a layer depicting the political boundaries of New Hampshire towns was joined with the table of the sightings per observer for all of the years. The symbology property was then set to show the number of bird sightings per observer in each town from 1987 to 1992 using a graduated color scale. The intervals of the graduated colors for each species were taken from the natural breaks given by GIS to the year span with the highest number sightings per observer. This was repeated for the four bird species across each year span.

To compare the data with hardiness zones, every town was assigned a zone number. This was done because the bird data was grouped on a town wide scale. When towns included two different zones, the zone containing the larger geographic area was assigned.

The average bird sightings per observer in each hardiness zone was then found for each year span and graphed. An ANOVA test was then completed for each hardiness zone to determine the significance of the changes in bird distribution across New Hampshire.

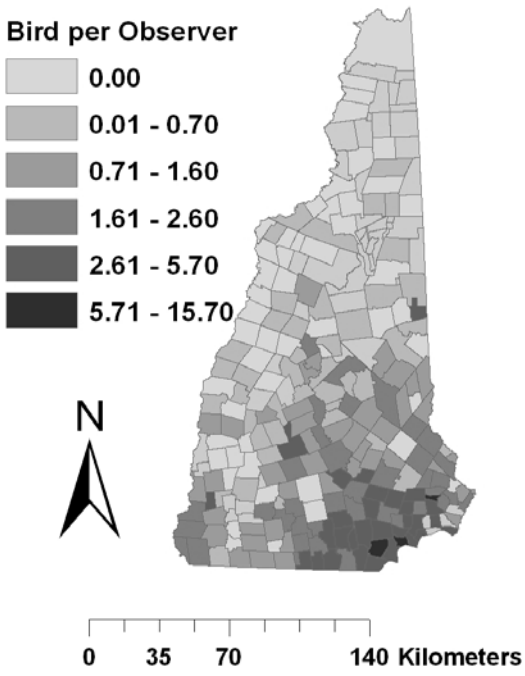


FIGURE 1. Tufted Titmouse: 1987-1992

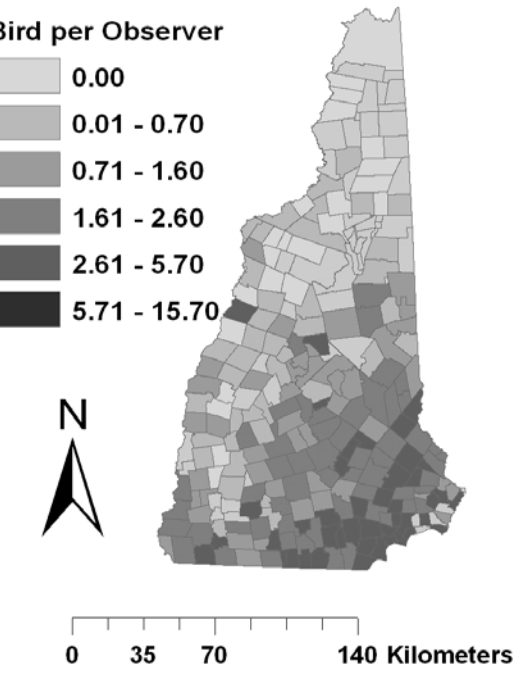


FIGURE 2. Tufted Titmouse: 1993-1998

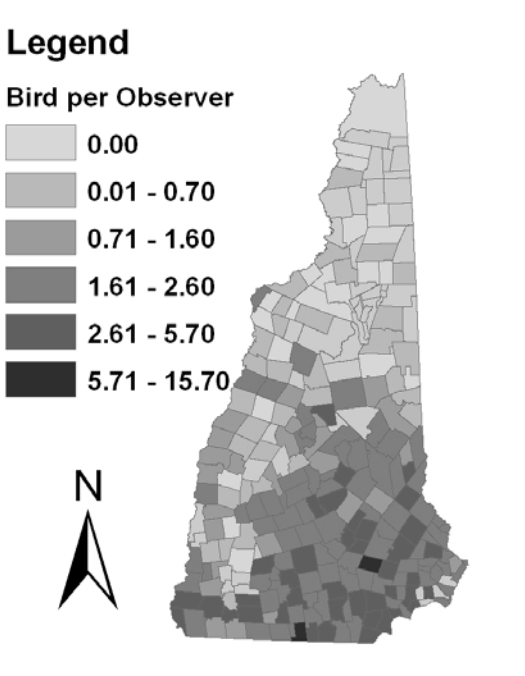


FIGURE 3. Tufted Titmouse: 1999-2003

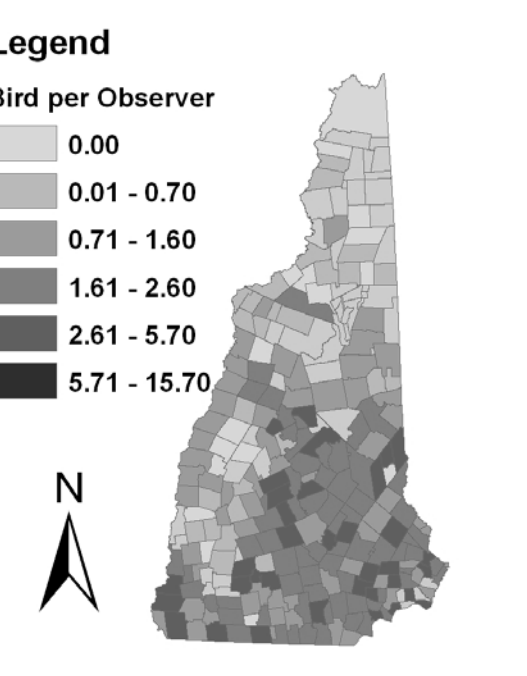
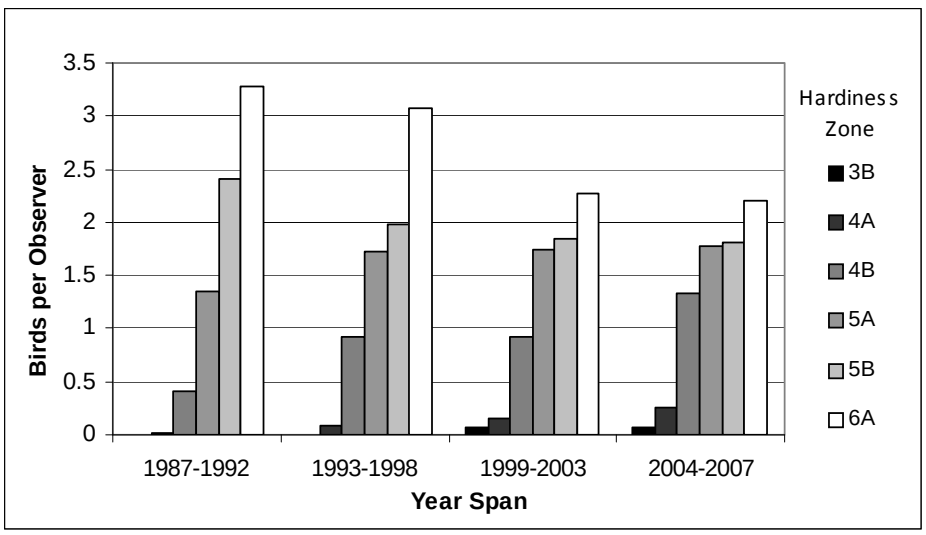


FIGURE 4. Tufted Titmouse: 2004-2007



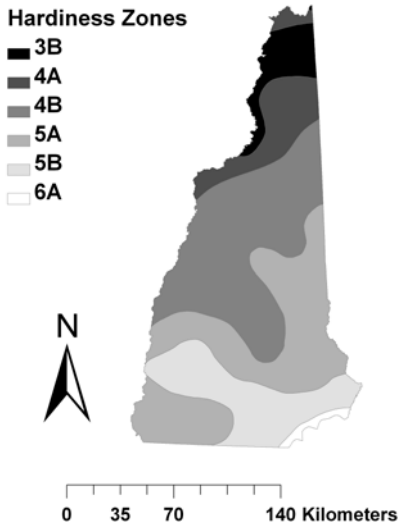


FIGURE 5. Tufted Titmouse per Observer Across Hardiness Zones by Year Span

TABLE 1. One-Way ANOVA Summary of Tufted Titmouse

Source	DF	SS	MS	F	P
Zone 3B					
Year Span	3	0.03	0.01	1.19	0.34
Error	40	0.13	0.01		
Total	43	0.16			
Zone 4A					
Year Span	3	0.306	0.10	1.51	0.23
Error	40	2.70	0.07		
Total	43	3.01			
Zone 4B					
Year Span	3	24.39	8.13	10.06	0.00
Error	224	181.05	0.07	0.81	
Total	227	205.43			
Zone 5A					
Year Span	3	9.78	3.26	2.36	0.07
Error	328	453.32	1.38		
Total	331	463.10			
Zone 5B					
Year Span	3	11.79	3.93	1.56	0.20
Error	212	533.89	2.52		
Total	215	545.68			
Zone 6A					
Year Span	3	7.11	2.37	1.84	0.16
Error	28	35.99	1.29		
Total	31	43.10			

When viewing figure 1, notice the larger number of birds per observer in the southern and southeastern parts of the state. As the years progress, notice the increase in the number of Tufted Titmouse in northern and western parts of the state. There is a vast difference between the population in the southern and the more northern hardiness zones, but as time passed, this difference decreased (see figure 5). After performing an ANOVA test, the only significant change in the number of Tufted Titmouse was seen in zone 4B (p=0.00).

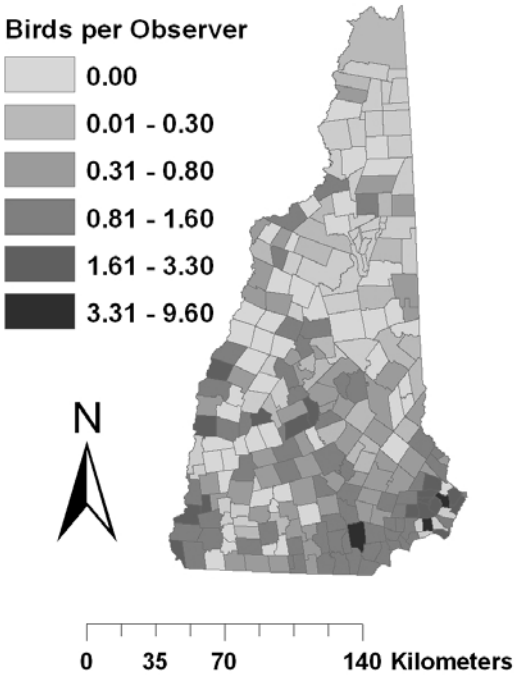


FIGURE 6. Northern Cardinal: 1987-1992

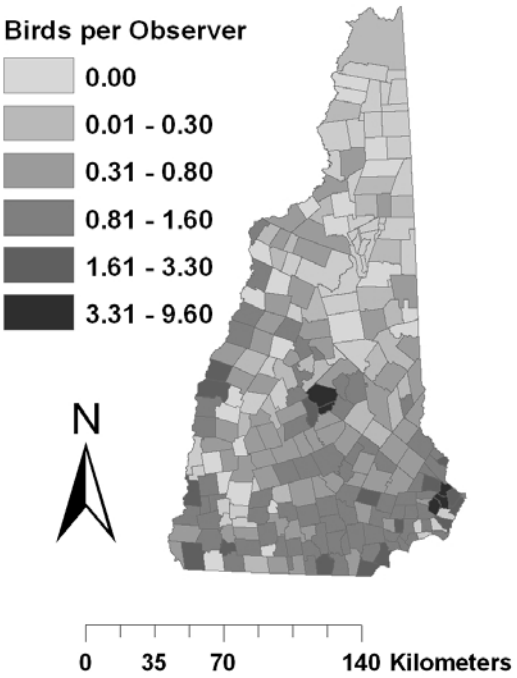


FIGURE 7. Northern Cardinal: 1993-1998

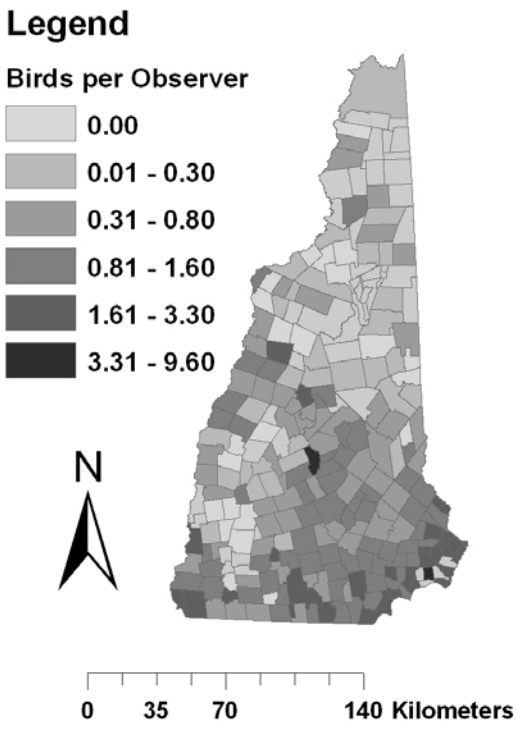


FIGURE 8. Northern Cardinal: 1999-2003

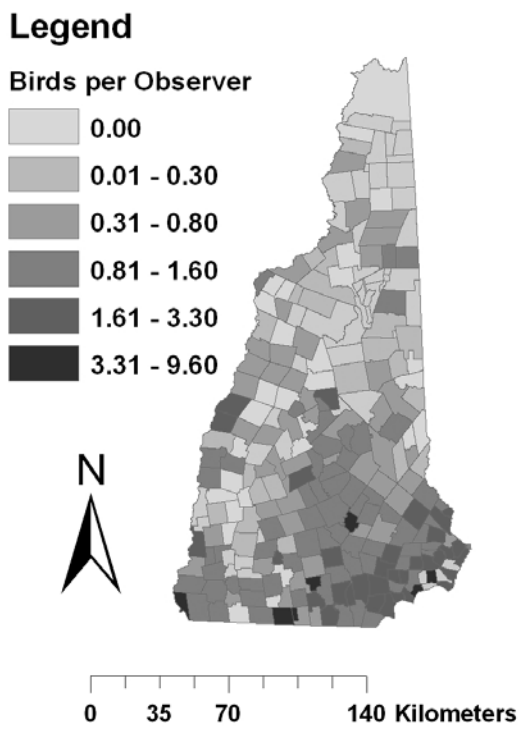
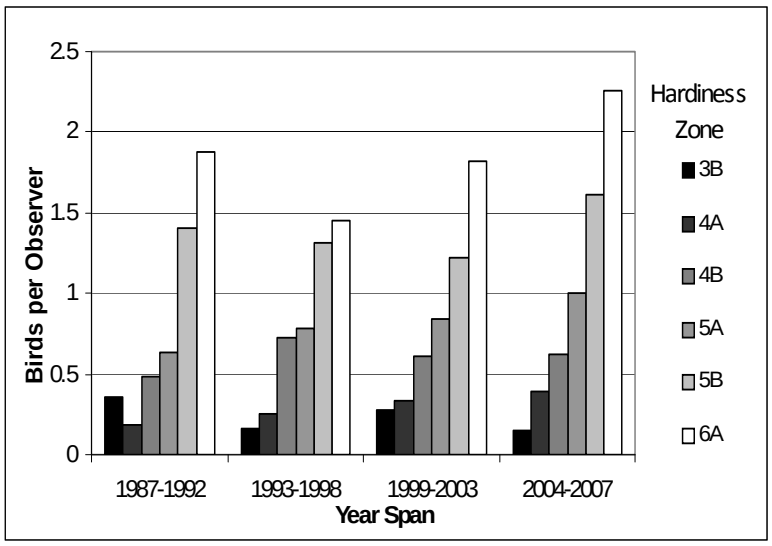


FIGURE 9. Northern Cardinal: 2004-2007



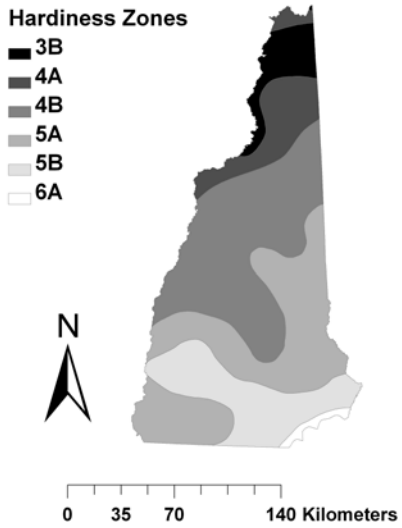


FIGURE 10. Northern Cardinal per Observer Across Hardiness Zones by Year Span

TABLE 2. One-Way ANOVA Summary of Northern Cardinal

Source	DF	SS	MS	F	P
Zone 3B					
Year Span	3	0.14	0.05	0.59	0.63
Error	16	1.32	0.08		
Total	19	1.46			
Zone 4A					
Year Span	3	0.258	0.09	0.69	0.57
Error	40	5.00	0.13		
Total	43	5.26			
Zone 4B					
Year Span	3	1.73	0.58	1.16	0.33
Error	224	111.62	0.50		
Total	227	113.35			
Zone 5A					
Year Span	3	5.60	1.87	3.79	0.01
Error	328	161.75	0.49		
Total	331	167.35			
Zone 5B					
Year Span	3	4.79	1.60	0.68	0.56
Error	212	494.43	2.33		
Total	215	499.22			
Zone 6A					
Year Span	3	2.63	0.88	0.87	0.47
Error	28	28.12	1.00		
Total	31	30.75			

As time passes there seems to be an increase in the number of northern cardinals per observer in northern parts of the state, but no change in the south (see figures 6-9). Figure 10 is a graph of the number of northern cardinals for each year span in comparison to plant hardiness zones. When viewing this, there does not seem to be a large change in the distribution across the hardiness zones or the overall population of northern cardinals, but according to the ANOVA test, the increase in the number of Northern Cardinals per observer in zone 5A was significant (p=0.01).

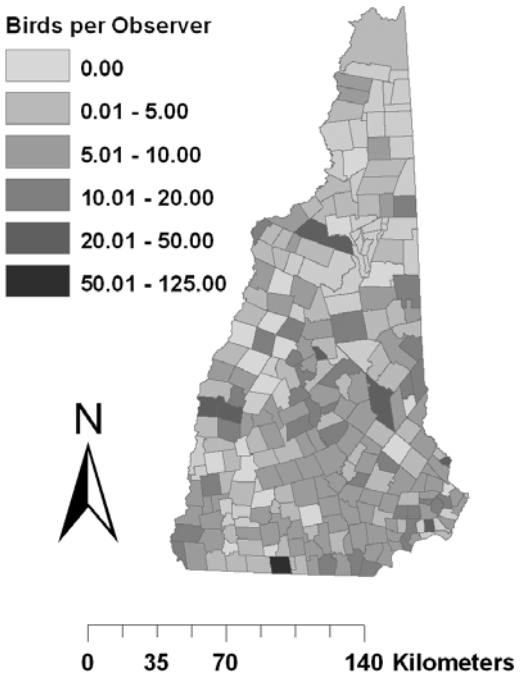


FIGURE 11. Mourning Dove: 1987-1992

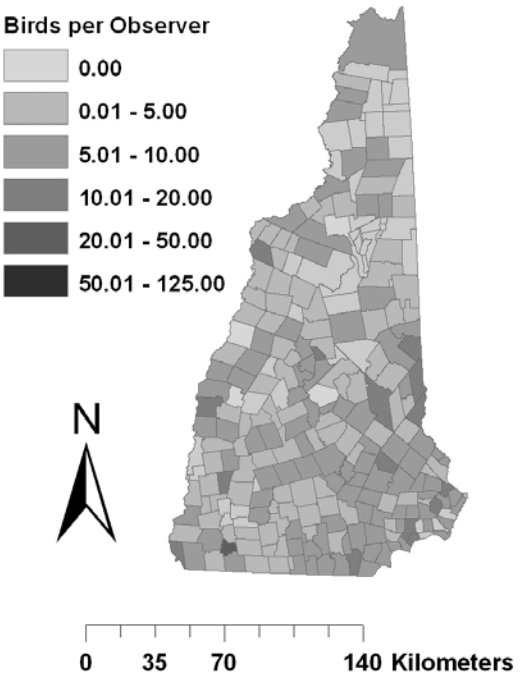


FIGURE 12. Mourning Dove: 1993-1998

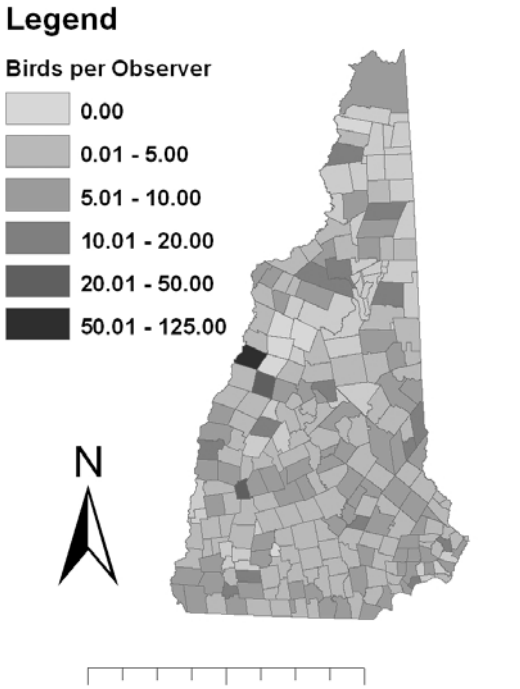


FIGURE 13. Mourning Dove: 1999-2003

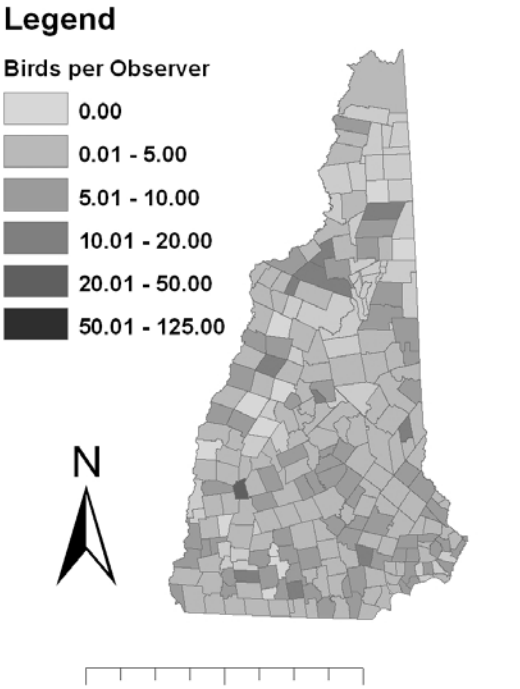
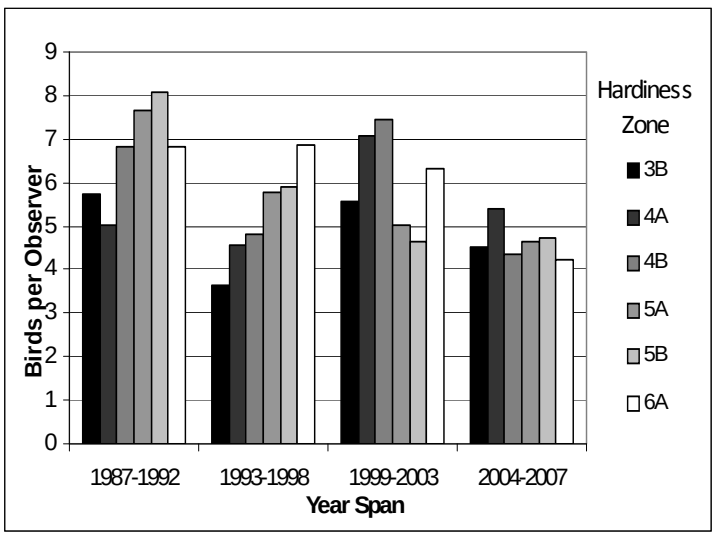


FIGURE 14. Mourning Dove: 2004-2007



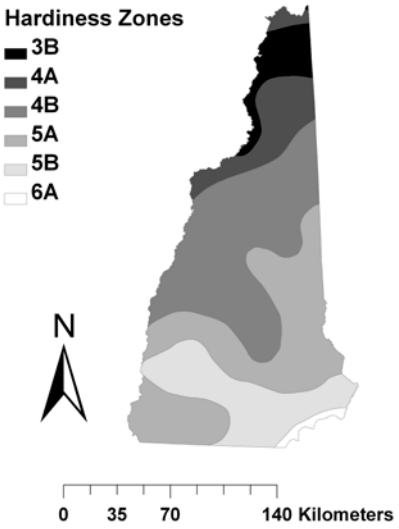


FIGURE 15. Mourning Doves per Observer Across Hardiness Zones by Year Span

TABLE 2. One-Way ANOVA Summary of Mourning Dove

Source	DF	SS	MS	F	P
Zone 3B					
Year Span	3	14.10	4.70	0.23	0.81
Error	16	237.70	14.90		
Total	19	251.90			
Zone 4A					
Year Span	3	38.5	12.80	0.78	0.51
Error	40	656.20	16.40		
Total	43	694.60			
Zone 4B					
Year Span	3	397.00	132.30	1.57	0.20
Error	224	18912.70	84.40		
Total	227	19309.70			
Zone 5A					
Year Span	3	442.80	147.60	7.09	0.00
Error	328	6830.00	20.80		
Total	331	7272.80			
Zone 5B					
Year Span	3	415.70	138.60	2.78	0.04
Error	212	10585.10	49.90		
Total	215	11000.80			
Zone 6A					
Year Span	3	37.90	12.60	1.01	0.40
Error	28	350.90	12.50		
Total	31	388.90			

The observed population of the Mourning Dove was much greater in comparison to the other 3 bird species, but as the years progressed there seemed to be a decrease in the number of Mourning Doves (see figures 11-14). When viewing figure 15, there seem so to be an evening out of the number of birds per observer across zones. There also appears to be a population decrease seen across each year span. According to the ANOVA test, zone 5A ($p=0.00$) and 5B ($p=0.04$) had a significant decrease in birds per observer across the year span.

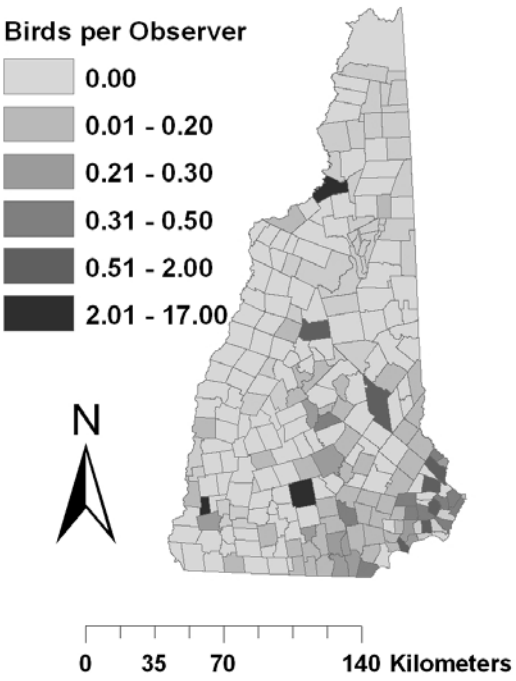


FIGURE 16. Northern Mockingbird: 1987-1992

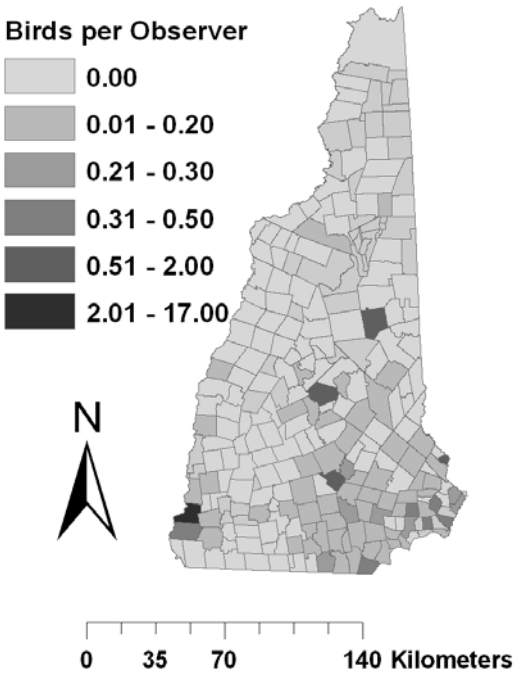


FIGURE 17. Northern Mockingbird: 1993-1998

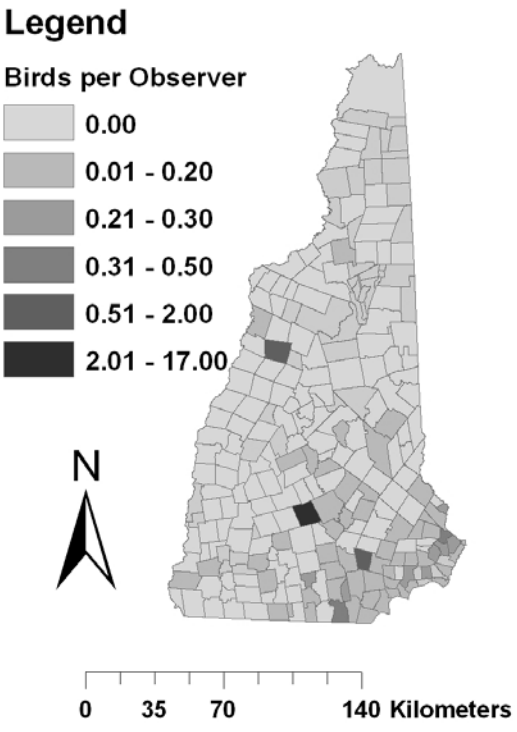


FIGURE 18. Northern Mockingbird 1999-2003

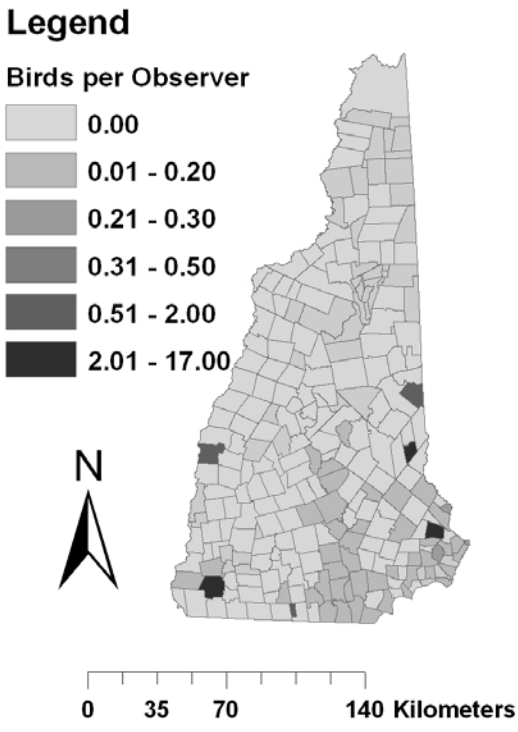
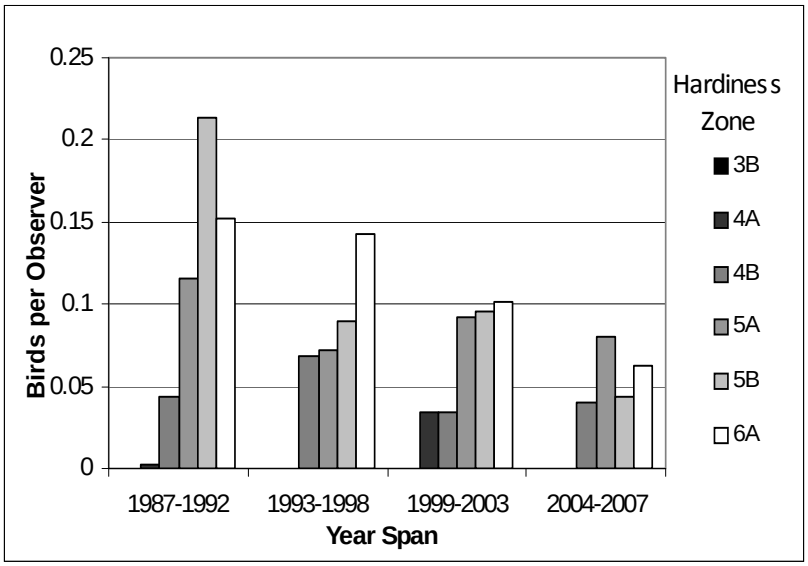


FIGURE 19. Northern Mockingbird: 2004-2007



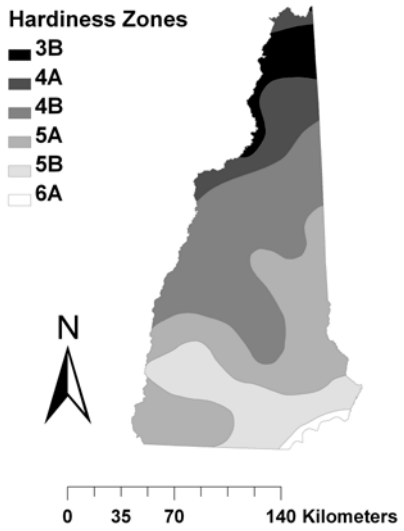


FIGURE 20. Northern Mockingbird per Observer Across Hardiness Zones by Year Span

TABLE 4. One-Way ANOVA Summary of Northern Mockingbird

Source	DF	SS	MS	F	P
Zone 3B					
Year Span	3	N/A	N/A	N/A	N/A
Error	16	N/A	N/A		
Total	19	N/A			
Zone 4A					
Year Span	3	0.00	0.00	0.68	0.57
Error	40	0.00	0.00		
Total	43	0.00			
Zone 4B					
Year Span	3	0.04	0.01	0.27	0.85
Error	224	11.01	0.50		
Total	227	11.05			
Zone 5A					
Year Span	3	0.09	0.03	0.14	0.93
Error	328	68.00	0.21		
Total	331	68.09			
Zone 5B					
Year Span	3	0.84	0.28	3.24	0.02
Error	212	18.42	0.09		
Total	215	19.27			
Zone 6A					
Year Span	3	0.04	0.01	1.13	0.36
Error	28	0.34	0.01		
Total	31	0.38			

When viewing figures 16-19, there seems to be a decrease in the number of northern mockingbirds per observer across New Hampshire. The overall decrease is apparent in figure 20. In addition to the decrease, there is less of a drastic difference between the hardiness zones as the years progressed. After performing an ANOVA test, the decrease in zone 5B ($p=0.02$) was the only significant decrease.

DISCUSSION AND CONCLUSION

It was hypothesized that the ranges of Tufted Titmouse (*Baeolophus bicolor*), Northern Cardinal (*Cardinalis cardinalis*), Mourning Dove (*Zenaida macroura*), and Northern Mockingbird (*Mimus polyglottos*) would expand into northern parts of New Hampshire as time passed and would increase densities in the colder hardiness zones. According to the observations per observer in each town and hardiness zone, the Tufted Titmouse has significantly increased its population in hardiness zone 4B, the Northern Cardinal has shown a significant increase in zone 5A, the Mourning Dove has significantly decreased in zones 5A and 5B, and the Northern Mockingbird has shown a significant decrease in zone 5B. There are many possible factors that could be contributing to the re-distribution of birds across the state, including climate change, habitat transformation, and supplemental feeding by humans.

An explanation for the decline in the number of Tufted Titmouse and Northern Cardinal in the warmer hardiness zones, such as 6A, could be in relation to urbanization. The population in southern New Hampshire counties is rising which has caused cities to expand and decrease the habitat for the Tufted Titmouse and Northern Cardinal, who prefer suburban areas (NHES 2004). .

The increase of the Tufted Titmouse and Northern Cardinal in zones 5A and 4B may be in response to global climate change, landscape changes, an increased number of people feeding birds in these areas, or a combination of these factors. Unfortunately, there is no easy way to separate out these factors to determine which factor is the main contributor to the increased densities of these species in these regions.

The change in human land use across New Hampshire may also be to blame for the decline in the number of Mourning Doves and Northern Mockingbirds. There has been a decrease in farm land across New Hampshire, which is the main habitat of the Mourning Dove and Northern Mockingbird (Yorke 1995). Another factor impacting the larger observed decrease in the Northern Mockingbird may be that it defends its territory from other Mockingbirds throughout the winter (Utter 1986). Because Northern Mockingbirds are territorial, the number of birds in an area is limited and the decrease in habitat decreases this even more so.

The limited number of sightings of the Northern Mockingbird in northern parts of the state could also be due to its dependence on the Multiflora Rose (*Rosa Multiflora*) in wintering months. The hardiness rating of the Multiflora Rose is that of zone 5, which could limit the Northern Mockingbird from expanding into more northern and colder hardiness zones (Cathey 2003).

Limitations of the data set used for this project include the lack of data from some towns, the limited types of habitat surveyed, and the relatively short time span of the data analyzed. The survey relies on voluntary responses, and some towns had very few or even no responses for certain year spans. Also, many observers tend not to report when they see no birds. In addition, most of the responses reflect observations at backyard bird feeders—emphasizing suburban habitats over undeveloped woodlands. This may mean that certain trends, such as population declines, may be more pronounced in the true population in comparison to the observed population. Also, the time span of the data is short since the data before 1987 was only available on a state level rather than a town level.

The combination of the small number of observers in certain towns and the small number of towns in certain hardiness zones may have had an impact on the determination of statistical significance. Significant increases and decreases were only shown in zones 4B through 5B, zones which generally contained both a large number of observers and large number of towns. There are only 5 towns in hardiness zone 3B in comparison to 83 towns in zone 4B. If there were more observers in a wider variety of towns, the changes in hardiness zones 3B, 4A, and 6A may be shown to be significant. As the years progress, hopefully more observers in different towns will participate in the survey.

The trends seen in this research are mirrored by those of the Christmas Bird Count, a national winter bird survey coordinated by the National Audubon Society which shows there is an increase in the observed population of the Tufted Titmouse and Northern Cardinal, while there has been a decrease in the Mourning Dove and Northern Mockingbird in New Hampshire (National Audubon Society 2008).

Recommendations for further research could include organizing the data from 1967 to 1986 so that it may be analyzed on a town level to increase the span of the data. Also, the scope of the project could be expanded to look at other species, particularly the Carolina Wren and Red-bellied Woodpecker whose expansion into New Hampshire began more recently.

An improvement to the GIS analysis of the data could include geocoding the exact location of observers within a town by street address. This would allow the bird sightings in towns that are in two hardiness zones to be assigned separate hardiness zones depending on their location.

Birds are often good bio-indicators as they change their ranges and breeding dates faster than many other animals. Bird mobility and physiological constraints make them effective indicators for New Hampshire's environmental conditions. For these reasons such studies should be continued or expanded.

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