CHANGES IN THE BREEDING DISTRIBUTION OF THREE SPECIES OF WARBLERS: BLACK-AND-WHITE WARBLER (*Mniotílta vária*), PINE WARBLER (*Dendroíca pínus*) AND KENTUCKY WARBLER (*Oporórnis philadélphia*)

THESIS

Presented to the Graduate Council of
Southwest Texas State University
in Partial Fulfillment of the Requirements

for the Degree of

Master of Applied Geography

By

Kathleen Michele Martel Dupuis

San Marcos, Texas
August, 1998

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE PAGE

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Birds have been an important cultural icon and popular field of study throughout history, and continue to be a popular pursuit today. Birds have been used as subjects of art in ancient cave drawings and in Greek poetry as early as the fifth century BC. Not only do birds appeal to many cultures, they also have many beneficial ecological and economic uses.

Birds are a rich component to the earth's biological diversity, and fill a variety of niches useful to man and the natural world (McNeely 1988, Rose 1992, Snow 1976). For example, they are widely recognized for their role in seed dispersal for many species including such beneficial species to man as pine, fruit and other harvestable trees (Hernandez 1993, Kollmann and Schneider 1997, McClanahan and Wolfe 1993, Snow 1976). Another example of their usefulness is pest control. Most songbirds are insectivorous, feeding on disease carrying pests and crop damaging insects (Klich et al. 1996, Parasharya et al 1996). Wild and domestic birds are also an important food source for some cultures. Many people depend on their harvest as an important part of their diet (Cooper 1995).

Not only are birds beneficial in the biological world, they also are important economically. The 1994-1995 National Survey on Recreation and the Environment reported an increase in recreational birdwatching of 155% across the United States during those years. It also reported that in 1991, birding activities generated $5.2 billion dollars, and it has been estimated that rare bird sightings can generate approximately $100,000 per year in local spending. For both ecological and economical reasons, avian conservation is a subject worthy of academic and professional study.

Birds are susceptible to changes in the environment, and are therefore sensitive indicators of environmental change. Changes in climate, food and nesting resources, toxins, availability of edge or deep forest habitats, and parasitic species can quickly alter the nesting ability and productivity of a bird species. Songbirds are important indicators of environmental change, it is therefore important to analyze changes in their distribution. Changes in their distribution may be an early sign of the loss of suitable habitat. This research hypothesizes that geographical and temporal changes in breeding bird ranges can be used to identify possible changes in the quality of avian habitats. The purpose of this study is to test a procedure by which distributional changes in breeding bird nesting sites can be detected. The procedure used is a time and space-mode factor analysis that has been used previously in the field of political geography (Shelley et al. 1996). In Shelley et al. (1996) the procedure was used to show major shifts in voting patterns in presidential elections. Shelley et al. found strong correlations between region and voting patterns using this procedure. If the procedure is successfully applied to Breeding Bird Survey point count data, it could be used to detect changes in distributional patterns of breeding birds. The study attempts to answer this question: can time and space-mode factor analysis applied to the Breeding Bird Survey point counts be used as a preliminary step to understand changes of site selection of breeding birds?

CHAPTER 2

AVIAN POPULATION RESEARCH

There is a rich and well-established literature on monitoring bird populations and nesting habits. Within this body of work, there is a strong emphasis on population trends and trend projections of neotropical migrant species. Long-term studies that have been performed continentally, regionally and locally, suggest that there are many species of migrant birds that are experiencing population declines in their breeding, migratory and wintering habitats (Conway et al. 1992; Hagen 1995; Petit et al. 1992; Petit et al. 1995).

Most of the research on the distribution of birds concentrates on the habitat needs of wintering or breeding birds. In addition, there is a vast literature on rare and endangered birds (Hutto 1992, Litwin and Smith 1992, Lynch 1992, Petit et al 1992, Sherry and Holmes 1992). However, consideration of systematic spatial and temporal trends in bird abundance patterns is lacking, particularly with regard to common, widely dispersed species.

Of what importance are avian population monitoring studies? Thomas and Martin state that monitoring populations serves three functions. They are (1) early identification of species or habitats experiencing changes in quality to focus research on those species or habitats (2) determination of the relationships of population change to environmental factors to develop theories regarding the causes of decline and (3) continued evaluation of populations allows for the assessment of conservation strategy effectiveness (Thomas and Martin 1994).

This study serves each of these functions. The study of geographical and temporal changes of breeding ranges can help distinguish troubled species and habitats, accentuate the relationship between population changes and environmental factors, and allow for the evaluation of management effectiveness by identifying avian infidelity to their traditional breeding range.

James et al. (1996) state that there may be a discrepancy in the literature regarding population trends. While much of the literature suggests that during the decade of the 1980s there was a decline in bird populations in the eastern forests, their analyses suggest that many species have maintained or increased in number over the past twenty-five years. As a response to this discrepancy, James et al. propose a new perspective examining multi-species patterns that detect trends in regions over time. James et al. suggest analyzing temporal and spatial changes found within the Breeding Bird Survey as a useful method of early detection of troubled species. This study attempts to provide early detection of changes in breeding bird distribution patterns that may signal population change or habitat instability.

There are many variables that cause population change. It is therefore useful to look at the breeding requirements of the species, and determine if and how those requirements are being altered in the breeding range. The following table from DeGraaf and Rappole (1995) shows some variables that affect changes in bird populations, including habitat loss, habitat fragmentation and alteration, contaminants, and the procedural biases of researchers (Table 1).

Habitat loss is an important factor that effects the fecundity of a species. Habitat fragmentation manifests itself in many different and harmful ways. Discontinuity in forest habitats in both the breeding and wintering ranges are thought to be the main threat to songbird populations (Kricher and Davis 1992, Lynch 1992, Martin 1992, Robbins et al. 1992, Robinson 1992, Sherry and Holmes 1992). In addition, forest fragmentation can be a crucial factor in the success of a migratory songbird species. In general, migrant species tend to be resource specialists (evolved to exploit a very narrow niche for food or nesting materials) while resident species tend to be resource generalists (when necessary they can use a variety of food types and nesting materials). As a result, resident species do better as "edge" or "edge/interior" competitors than do the migrant "forest interior" species.

Most Warblers belong to the foliage insect feeding guild. Foliage insectivores eat invertebrates found in woody plants (Vale et al. 1982). Broadleaf deciduous forests, coniferous forests, mixed forest, woodlots and scrubs are all considered to be important habitat types for foliage insectivores. Grasslands, shrub habitats and agriculture are often the end-result of habitat alteration. These types of habitats do not attract foliage insectivores, so the greater the amount of forest fragmentation, the greater the ability for non-migratory resident species to out-compete migrant species (DeGraaf and Rappole 1995, Vale et al. 1982).

While DeGraaf and Rappole offer many possible reasons for population loss, only one possibility, interspecific competition, will be examined closely in this study. If time and space-mode factor analysis can be used to uncover meaningful changes in Warbler

TABLE 1

CAUSES OF AVIAN POPULATION LOSS

Reason	Source
Loss of breeding-ground habitat	USFWS 1987
Habitat fragmentation	
Island biogeography effects	Lynch & Whitcomb 1978
Area effect	Galli et al. 1976
Brood parasitism by cowbirds	Brittingham & Temple 1983
Nest predation	Wilcove 1985
Loss of critical microhabitats	Robbins et al. 1989a
Interspecific competition	Butcher et al. 1981
Successional changes to breeding-ground habitat	Litwin & Smith 1992
Breeding habitat alteration by white-tailed deer	Baird 1990
Contaminant poisoning	Newton 1979
Normal population fluctuation	
Variation in food resources on breeding sites	Holmes et al. 1986
Climatic cycles on the breeding ground	Blake et al. 1992
Procedural biases	
Assumptions	Rappole et al. 1993
Analytical errors	James et al. 1992
Sampling errors	Hutto 1988
Stopover habitat alteration	Howe et al. 1989
Winter habitat alteration	Rappole et al. 1983:73-75

(DeGraaf, Richard M. and John H. Rappole. Neotropical migratory birds : natural history, distribution, and population change. Ithaca, N.Y. : Comstock Publishing Associates, a division of Cornell University Press, 1995) site selection, then the procedure can also be used to expose changes in the site selection of interspecific competitors. Using both sets of findings, one can begin to determine whether the interspecific competitors are a possible factor in the changes of site selection of the Warblers.

Forests fragmented by suburban and agricultural development often offer food that is exploited by competitor species (O'Conner and Faaborg 1992, Robinson et al. 1995). This study will examine the distribution of three migratory breeding birds and will compare the findings with these competitor species of birds. The study will use the data taken from the Breeding Bird Survey raw database.

North American Breeding Bird Survey Data

There are many regional surveys that count bird populations in North America. However, only one, the North American Breeding Bird Survey (BBS), covers the entire North American continent. The BBS is widely accepted as the most reliable source of bird population data available in North America (Böhning-Gaese et al. 1993, Erskine 1978, James et al. 1996, Robbins 1986, Thomas and Martin 1994). Not only does it have a large geographic study area, but it is also a long-running census, having just finished its thirty-second year in 1997. The raw data produced by the BBS offer ample opportunity for research that examines geographic patterns of North American land birds over an extended period of time (Villard and Maurer 1996).

The Department of the Interior established North American Breeding Bird Survey in 1965. Skilled volunteers run the BBS routes. They drive twenty-four-and-a-half mile routes with fifty designated stops at half-mile intervals along secondary roads. At each stop, they take a "point count," during which the observer records all species seen or heard at that location during a three-minute period.

There are difficulties involved with the BBS data. Errors in data collection, observer subjectivity, and inconsistencies within the BBS routes all pose problems that must be acknowledged by any researcher. First, collection and tabulation are problematic. In such a vast effort, they must maintain that strict controls kept the data "clean." The Office of Migratory Bird Management of the U.S. Fish and Wildlife Service (USFWS), follows this protocol to insure the highest quality data available (1) the data are submitted to the Office of Migratory Bird Management on both the original field sheets and on summary sheets (2) USFWS employees examine the data for transcription errors, mathematical miscalculations, or biological mistakes (3) USFWS employees entered survey summaries into a database and verify their accuracy (4) computers examine the data for mathematical and clerical errors (5) species range maps are compared with the survey data to identify species that were found outside of their expected habitats. Surveyors that report species outside their expected ranges are asked to verify and justify their sighting, and (6) data collected during adverse weather conditions are excluded from any analyses
(Droege 1990).

A far more subtle set of problems stems from survey design and skillful implementation. Missing data, variations over space and time, variations in weather and time of day, skill of the observer, and non-random placement of routes are complex ingredients that determine and occasionally undermine the quality of the BBS (Böhning-Gaese et al. 1993, James et al. 1996, Thomas and Martin 1994).

The objectivity of and observational skills of survey teams effect the quality of the data produced. Observer bias has been studied extensively. Observers differ in their competency as well as their ability to hear, see, identify and estimate bird numbers (Bart and Schoultz 1984, Faanes and Bystrak 1981, Kendall et al. 1996, Peterjohn et al. 1995, Sauer and Droege 1990, Sauer, Peterjohn, and Link 1994). The National Biological Service tries to reduce bias by codifying observers by skill level, and by collecting, but not including the data generated by first-time volunteers in their analyses. There is, however, no way of completely equalizing the skill and quality of each surveyor.

Routes selected for the survey are not field-tested, yet are believed to adequately represent their respective regions. Routes, however, may undergo changes that are not common to the entire region (Bart et al. 1995). For example, a route in a forested area may experience losses of forest cover due to development. If only a corridor along the route is developed and the remaining region remains forested, then the survey would contain an "unnatural" habitat and include species that do not reside in the region it is intended to represent (Bart et al. 1995).

In addition, survey routes are more densely distributed in the eastern United States than in the western and northern states. This patterns reflects the lack of secondary roads in western and northern states. This skews the data by showing greater avian population densities in the eastern states (Curnutt et al. 1996, Droege 1990).

The BBS data have been used extensively in population studies, and have been interpreted through many types of statistical analyses. BBS analyses have used base-year indexing, linear regression, route regression, and linear-multiplicative models. Analyses to determine population trends, to design conservation prioritization schemes, and to validate surveillance programs have been undertaken (Robbins et al. 1986, Thomas 1996, Thomas and Martin 1994).

CHAPTER 3

METHODOLOGY

Time and space-mode factor analysis was applied to populations of three Warbler species: Black-and-white Warbler (*Mniotílta vária*), Pine Warbler (*Dendroíca pínus*) and Kentucky Warbler (*Oporórnis philadélphia*). Each of the three species of Warblers is a neotropical migrant, and each is common in North America during the breeding season.

The three species selected were chosen using the following selection process. First, Warblers and vireos were selected from the original BBS set of more than 500 species. Following Reed (1992) the fifty-seven Warbler and vireo species were ranked based on relative susceptibility to extinction (Reed 1992). From the group of fifty-seven, only three were chosen based on the quality of the data available.

To overcome bad data, special precautions were taken. In the early years of the BBS, many of the routes were not run resulting in large gaps in the data. To help correct this, the methods of Böhning-Gaese et al. (1993) were employed. Only data collected from the years 1968 through 1996 were used. Data from 1965 through 1967 were discarded because of inconsistency during those years. Furthermore, cases missing more than two counts over the course of the twenty-nine years, cases missing two consecutive years of data, and cases missing data from either 1968 or 1996 were discarded (Böhning-Gaese et al. 1993). In addition, one more step was taken beyond the Böhning-Gaese data selection methodology. All cases that had five or more instances of no sightings were removed. This was done to improve the effectiveness of the statistical method (Shelley et al. 1996).

The process described above reduced the number of species from fifty-seven to twelve. From the remaining twelve species, three species of Warblers were chosen. They are the Pine Warbler, the Black-and-white Warbler, and the Kentucky Warbler. Each is in different genera, and has different habitat requirements, and nest types. The Pine Warbler breeds from southeast Canada and central Maine to the Texas gulf coast and east to Florida. The Black-and-white Warbler breeds from throughout Canada south to eastern Montana, and throughout the south from central Texas through Louisiana, Alabama, Georgia and North Carolina. The Kentucky Warbler breeds from southeast Nebraska, and southwest Wisconsin, southern Michigan, central Ohio, southern Pennsylvania, and southeastern New York south to east Texas, the Gulf Coast, central Georgia and South Carolina. Each of the three Warblers is primarily insectivorous, feeding on insects, spiders, grasshoppers, caterpillars, moths, beetles, ants, flies, leafhoppers, aphids, and bugs. The Pine Warbler will also supplement its diet with grass, weeds, seeds, and berries (Table 2).

The BBS data pertaining to the three species were analyzed using time and space-mode factor analysis. The factor analyses are applied to data matrices consisting of observations of some phenomenon over time and space. Time-mode factor analysis allows the researcher to reduce a large number of time periods, or years, to a smaller number of more meaningful time periods or epochs. Each epoch consists of periods of

TABLE 2

NATURAL HISTORIES OF THE PINE, BLACK-AND-WHITE AND KENTUCKY WARBLERS

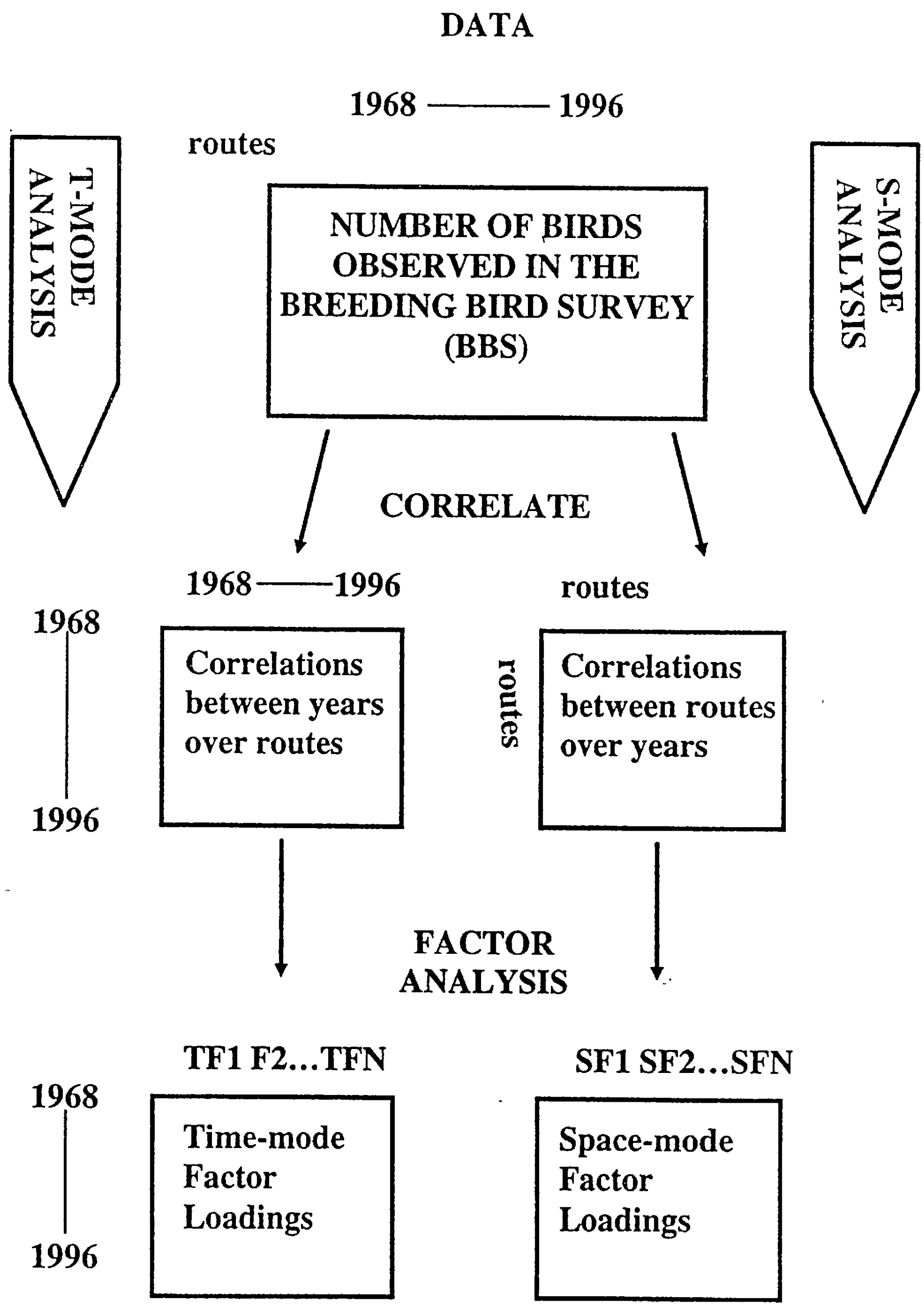
	Pine Warbler (*Dendroica pinus*)	**Black &White Warbler** (*Mniotilta varia*)	**Kentucky Warbler** (*Oporornis formosus*)
Common Names	Canada (Quebec): Fauvette des Pins, Mexico: Chipe Nororiental, West Indies: Petit-Chitte de Bois Pin, Siguita del Pinar	Canada (Quebec): Fauvette Noire et Blanche, Costa Rica, Puerto Rico, and Venezuela: Reinita Trepadora; Guatemala: Chipe Rayado, Pepino, Reinita Trepadora; Mexico: Chipe Trepador; West Indies: Bijirita Trepadora, Madras, Mi-Dueil, Reinita Trepadora.	Canada (Quebec): Fauvette de Kentucky; Costa Rica: Reinita Cachetinegra; Guatemalea: Chipe Cachetinegra, Reinita Cachetinegro; Mexico: Chipe Cachetinegro; Puerto Rico: Reinita de Kentucky; Venezuela: Reinita Hermosa.
Range	Breeds from southeastern Canada and central Maine south to the Texas Gulf Coast, southern Florida, and the Bahamas Winters in the se. United States south to the Texas Gulf Coast to southern Florida, and the Bahamas.	Breeds from throughout Canada south to eastern Montana, central Texas, Louisiana, Alabama, Georgia and North Carolina Winters from southern Texas and Florida through Mexico, the Caribbean and Central America to northern South America.	Breeds from southeast. Nebraska, sw. Wisconsin, southern Michigan, cen Ohio, southern Pennsylvania, and southeastern New York south to eastern Texas, the Gulf Coast, central Georgia and South Carolina Winters in Mexico, Virgin Islands, south to Columbian.
Habitat	Open pine forests and pine barrens, loblolly pine plantations, especially jack pine in Minnesota and upland southern pines. Generally avoids tall, moist, and dense coniferous forests. Apparently rarely parasitized by cowbirds.	Deciduous and mixed deciduous-coniferous forest and woodland Somewhat open deciduous or mixed forests Usually not in coniferous forests Found in mature and second-growth forests, especially those composed of immature or scrubby trees	Large, mature forests with a dense understory Woodland undergrowth. Deep shaded woods with dense, humid thickets, bottomlands near creeks and rivers, ravines in upland deciduous woods, and edges of swamps
Diet	Mostly insects, spiders, grasshoppers, caterpillars, moths, beetles, ants, bugs Supplemented with seeds of pine, grass, and weeds, seeds, berries Will visit bird feeders for suet and seed.	Insects. Feeds on a wide variety of caterpillars (including those of gypsy moths), beetles, ants, flies, bugs, leafhoppers, aphids, and other insects Spiders and daddy longlegs.	Mostly insects including moths, bugs, grasshoppers, beetles, caterpillars, aphids, and grubs. Also spiders, and a few berries
Nests	Nest sites are located toward the ends of limbs of pines Usually 30-50 feet above the ground Cypress trees extremely rare Concealed from below by foliage. Nest is deep, open cup of weeds stalks, grass stems, strips of bark, pine needles, twigs, spider web; lined with fern down, hair, pine needles and feathers.	Nest built in a slight depression in the ground, usually at the base of a tree or stump and concealed in a drift of leaves Nest built of dry skeletonized leaves, inlaid with some grasses, weed fibers, inner bark strips, rootlets, sometimes hair Commonly parasitized by Brown-headed cowbirds Also nests in dry portions of wooded swamps	Nest is a bulky open cup of leaves, with a cores of weeds, grass stems, lined with rootlets and hair
Status	Locally common, stable, possibly slightly increasing	Common, widespread Has disappeared from some former nesting areas, especially in south and Midwest	Has declined with clearing of forests in some areas. Is becoming vulnerable to cowbird parasitism as forest fragment

(DeGraaf and Rappole 1995, Harrison 1995, Kaufman 1996, AOU checklist) time when the years that are highly correlated with one another, and are distinctly different from theperiods of time found in other epochs. Any two years assigned to the same epoch will have similar curves when plotted on a graph. Similarly, space-mode analysis allows a large number of places to be grouped into a small number of geographical regions. Regions are grouped together based on the similarity of the patterns found in that region. To put it succinctly, the data in any single observation within a time epoch or geographical region will have similar patterns to any other single observation grouped in the same time epoch or geographic region. Changes in epochs or regions can be thought of as points at which natural or human induced changes occurred. Changes that occurred may be factors that influenced the site selection of breeding Warblers.

This schematic diagram illustrates how the technique works. It is based on a study in political geography done by Shelley et al (1996). The illustration shows how the technique is applied to a matrix of Breeding Bird Survey routes by state between the years of 1968 through 1996. In the time-mode factor analysis, correlations between each pair of years that the survey was run are calculated, and factors representing epochs are extracted. In space-mode factor analysis, the correlations between each pair of routes that represent regions are extracted. In this study, the data matrix consisted of the number of Pine, Black-and-white, and Kentucky Warblers sighted or heard at each point count in the BBS between 1968 and 1996 (Figure. 1).

FIGURE 1

TIME AND SPACE-MODE FLOW CHART



CHAPTER 4

ANALYSIS

Time-Mode Analysis

Time-mode factor analyses were applied to the BBS route data. The data is a matrix of the number of birds seen or heard in the BBS per year. The time matrix was analyzed with principal components analysis using varimax rotation and the missing values were replaced with the mean. Using this technique, twenty-nine years of data were grouped together into small groups or "epochs." Epoch is used in this sense to refer to groups of years in which patterns within each epoch are similar. Each epoch is a collection of years that correlate strongly to one another.

The principal components analysis distinguished five epochs for each of the three species. The epochs for the Black-and-white Warbler accounted for 76.6% of the variance, for the Pine Warbler 81.9% of the variance and for the Kentucky Warbler 81.2% of the variance. What this means is that there were five epochs selected by principal components analysis that are representative of the birds distributional trends over the study period.

In the Black-and-white Warbler data, five epochs were identified. The epochs distinguished are the mid 1970s through 1980s epoch, the 1990s epoch, the late 1980s epoch, the mid-1980s epoch and the late 1960s epoch (Table 3).

There were five epochs identified with the Pine Warbler. The Pine

TABLE 3
BLACK-AND-WHITE WARBLER TIME-MODE EPOCHS

	Factor 1 mid-70s & 80s Epoch	Factor 2 1990s Epoch	Factor 3 late 80s Epoch	Factor 4 mid-1980s Epoch	Factor 5 late 60s Epoch
Y1968	0.2434	-0.0178	0.2503	0.2425	**0.7059**
Y1969	0.4890	0.2950	0.1742	0.0684	**0.5285**
Y1970	0.2332	0.0916	**0.8259**	0.0952	0.2245
Y1971	0.3835	0.2787	**0.6921**	0.0021	0.3047
Y1972	**0.6225**	0.1867	0.6342	0.0199	0.1422
Y1973	0.4073	0.0911	**0.6294**	0.2387	0.3713
Y1974	**0.6923**	-0.0303	0.4115	-0.0205	0.1161
Y1975	**0.6620**	0.1644	0.2594	0.0121	0.4107
Y1976	**0.7438**	0.2525	0.1480	0.1811	0.3176
Y1977	**0.8182**	0.1054	0.2656	0.2928	0.0601
Y1978	**0.7722**	0.0101	0.1432	0.3582	0.0862
Y1979	**0.6872**	0.2570	0.3024	-0.1119	0.2307
Y1980	**0.6934**	0.2598	0.0522	0.4032	0.1382
Y1981	**0.7624**	0.1881	0.2851	0.3446	0.0420
Y1982	**0.6722**	0.4846	0.1474	0.0479	-0.0332
Y1983	**0.5774**	0.1399	0.0387	0.4440	-0.3238
Y1984	0.3439	0.4758	0.2905	**0.6188**	0.0781
Y1985	0.2125	0.2922	0.2134	**0.7389**	0.2600
Y1986	0.3859	0.3570	0.2334	**0.6112**	0.1975
Y1987	0.2513	0.3581	**0.7034**	0.3708	-0.0002
Y1988	0.1573	0.3924	**0.7882**	0.1893	0.0773
Y1989	0.2166	0.4226	**0.5731**	0.2945	-0.2396
Y1990	0.0629	**0.5836**	0.4566	0.3955	0.0096
Y1991	0.2127	**0.7542**	0.4244	0.0333	0.1073
Y1992	0.2977	**0.6653**	0.4243	0.2582	0.1506
Y1993	0.1428	**0.8001**	0.2507	0.2915	-0.0655
Y1994	0.1243	**0.9008**	0.1228	0.1380	0.1008
Y1995	0.2027	**0.9136**	0.0696	0.0012	0.0630
Y1996	0.0766	**0.8466**	0.0794	0.2217	0.0408

Warbler epochs found in the mid-1980s and 1990sepoch, the 1960s through mid-1970s epoch, the late 1980s epoch, the mid-1980s epoch and the late 1970s epoch (Table 4).

There were also five epochs associated with the Kentucky Warbler. The Kentucky Warbler epochs are the 1970s and 1980s epoch, the late 1960s epoch, the early 1990s epoch, the mid-1990s epoch, and the early 1980s epoch (Table 5).

This procedure is intended to identify the periods when changes in site selection took place. The analysis shows each of the breaks in the time line in each of the factors, or epochs as a time during which some sort of disturbance occurred. From this point, further analysis of the possible variables that caused the break in the timeline should be investigated. As it is beyond the scope of this study, a conclusive finding of what caused the changes in distribution will not be attempted.

Space-mode Analysis

Once the time-mode analysis was completed, the next step was to examine distributional changes with regard to changes in place as a variable. One of the categories available in the BBS data is strata. The strata refer to the different ecological regions or biomes that are similar in vegetation, climate, and physical characteristics. The strata are delineated on a BBS map, but the descriptions of the compositional make-up of the ecological regions have never been recorded (Figure. 2). Space-mode analyses were applied to the strata. To prepare the data, the data were transposed so that each of the strata, rather than each year, were shown as variables. Using this matrix, the data were analyzed using principal components analysis with varimax rotation and missing values

TABLE 4

PINE WARBER TIME-MODE EPOCHS

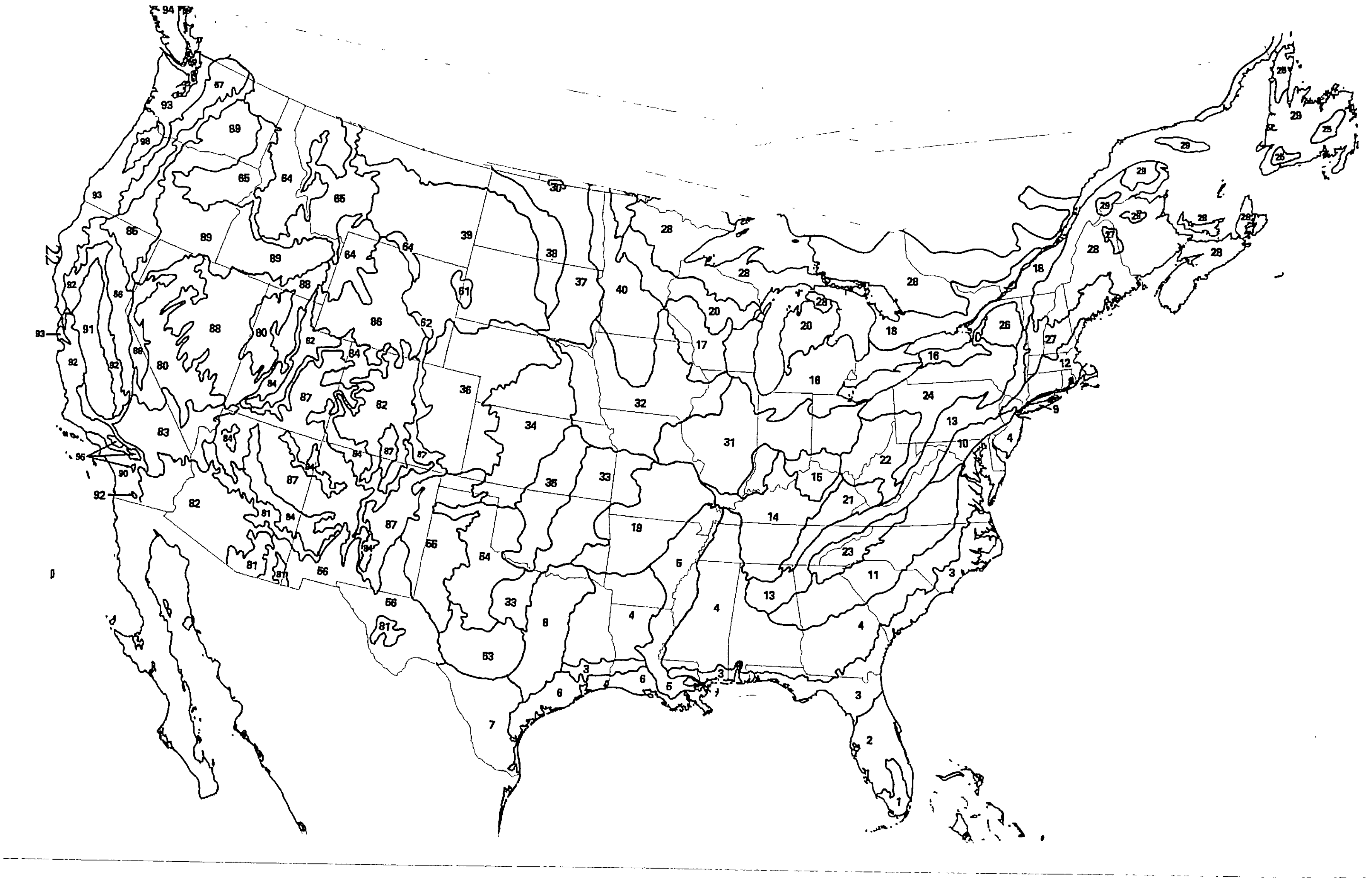
	Factor 1 1970S Epoch	Factor 2 1980s Epoch	Factor 3 early 70s Epoch	Factor 4 disparate Epoch	Factor 5 early 90s Epoch
Y1968	0.0420	0.0465	0.2687	**0.7793**	0.0153
Y1969	0.0061	-0.0279	**0.7639**	0.3809	0.0792
Y1970	0.2074	0.1415	**0.8621**	-0.0379	0.1911
Y1971	0.1357	0.0563	**0.6173**	0.5691	0.1552
Y1972	0.0489	0.4835	**0.5943**	0.3459	0.0824
Y1973	**0.6109**	0.4362	0.4846	0.0778	0.0424
Y1974	**0.6256**	0.1964	0.6059	0.0961	0.2949
Y1975	0.4558	0.2726	-0.0113	**0.6056**	0.4402
Y1976	**0.7787**	0.3156	0.1046	0.1415	0.2208
Y1977	**0.8585**	0.1165	0.1441	0.2224	0.0583
Y1978	**0.5834**	0.3628	0.0490	0.5943	-0.0846
Y1979	0.4657	**0.7184**	0.1069	0.3424	-0.1449
Y1980	**0.5184**	0.5923	0.0485	0.3385	0.0130
Y1981	0.2881	**0.6267**	0.1738	0.4687	0.0532
Y1982	0.4852	0.4610	**0.6220**	0.1943	0.1742
Y1983	0.4500	**0.5773**	0.1579	-0.0556	0.3388
Y1984	0.2380	**0.8485**	0.1544	0.0409	0.1669
Y1985	**0.7841**	0.1936	0.1449	-0.0398	0.3586
Y1986	0.1951	**0.7217**	0.3580	-0.0161	0.3979
Y1987	0.4416	0.3044	-0.0467	0.0166	**0.5896**
Y1988	0.0811	**0.5644**	-0.0738	0.5628	0.2823
Y1989	0.1658	0.4720	**0.5467**	-0.0872	0.4132
Y1990	0.0795	0.2076	0.1017	0.4173	**0.5703**
Y1991	-0.0126	0.1712	0.3741	0.4258	0.3885
Y1992	0.2375	0.0457	0.1764	**0.5727**	0.3704
Y1993	0.1509	0.1247	0.3298	0.1696	**0.7950**
Y1994	0.1476	-0.0228	0.2889	0.0906	**0.6082**
Y1995	-0.0499	0.0104	0.0065	-0.0928	0.0191
Y1996	-0.0235	-0.0169	-0.0494	0.1033	0.0796

TABLE 5

KENTUCKY WARBLER TIME-MODE EPOCHS

	Factor 1 70s & 80s Epoch	Factor 2 late 60s Epoch	Factor 3 early 90s Epoch	Factor 4 mid-90s Epoch	Factor 5 early 80s Epoch
Y1968	0.3428	**0.8979**	-0.0258	-0.1236	0.0755
Y1969	0.0546	**0.8381**	0.1848	0.1522	0.0397
Y1970	0.2751	**0.6074**	0.2770	0.0506	0.4529
Y1971	**0.5692**	0.2658	0.1453	0.3419	0.3450
Y1972	**0.6392**	0.3062	0.4236	0.2126	0.3118
Y1973	**0.6396**	0.3094	0.2972	0.2199	0.4605
Y1974	0.3584	**0.5946**	0.2678	0.0871	0.4858
Y1975	**0.7870**	0.1875	0.1751	0.2396	0.2494
Y1976	**0.5442**	0.1523	0.3616	0.3124	0.4731
Y1977	**0.6276**	0.4556	0.2125	0.1600	0.4585
Y1978	0.3262	**0.7195**	0.1989	0.1360	0.3401
Y1979	**0.5965**	0.4864	0.2010	0.1462	0.3903
Y1980	0.3126	0.1710	0.1360	0.2167	**0.7989**
Y1981	0.3548	0.2914	0.2284	0.2677	**0.7057**
Y1982	**0.7542**	0.3136	0.0455	0.2560	0.2567
Y1983	**0.7733**	0.0908	0.0385	0.2646	0.2478
Y1984	**0.5278**	0.3872	0.3103	0.0478	0.3204
Y1985	**0.5747**	-0.0577	0.7145	0.1003	0.0935
Y1986	**0.5271**	0.0426	0.6578	0.1942	0.2931
Y1987	**0.7702**	0.3483	0.3591	0.2552	0.0232
Y1988	**0.7070**	0.3784	0.3966	0.1755	0.0471
Y1989	0.1871	0.2924	**0.8142**	0.1451	0.2930
Y1990	0.0122	0.3693	**0.7868**	0.3059	0.1404
Y1991	0.2660	0.2376	**0.5950**	0.5276	0.0287
Y1992	0.2217	**0.5041**	0.3318	0.5673	0.2413
Y1993	**0.6231**	0.0052	0.1489	0.6875	0.1232
Y1994	0.1841	-0.0594	0.3577	**0.7794**	-0.0383
Y1995	0.1559	0.0966	0.0965	**0.8469**	0.3997
Y1996	0.2916	0.0888	0.0659	**0.7989**	0.1679

FIGURE 2
BREEDING BIRD SURVEY STRATA MAP



were replaced with the mean.

This technique reduced the large number of strata to small groups of strata that are called regions. Regions that shared similar patterns in the BBS data were grouped together. For instance, when Black-and-white Warblers nested in high numbers in region four, they also tended to nest strongly in region thirteen. The reverse of this is also true. When Black-and-white Warblers did not have high nest rates in region four, they tended to also have low nesting rates in region thirteen (Table 6).

Again it is important to note that this procedure is intended to show early changes in breeding bird behavior. Early recognition of changes in time and space are thought to be early signs of population disruption. As mentioned above, this study is limited to what possible variables that affected the site selection can be further investigated. From this point, other researchers are encouraged to investigate the possible changes that may have caused the shift in site selection.

TABLE 6
DISTRIBUTION OF WARBLERS BY STRATA

Pine Warbler					
Region 1	**Strat 3**	**Strat 4**	**Strat 5**	**Strat 19**	
# of birds in each Strat	7	32	1	6	
# of birds identified in region	1	10	1	2	
% of birds in region	14%	31%	100%	33%	
Region 2	**Strat 3**	**Strat 4**	**Strat 13**	**Strat 19**	**Strat 21**
# of birds in each Strat	7	32	7	6	1
# of birds identified in region	1	11	3	2	1
% of birds in region	14%	34%	43.00%	33%	100%
Region 3	**Strat 4**	**Strat 13**	**Strat 28**		
# of birds in each Strat	32	7	2		
# of birds identified in region	7	1	1		
% of birds in region	22%	14%	50%		

Kentucky Warbler							
Region 1	**Strat 4**	**Strat 13**	**Strat 14**	**Strat 15**	**Strat 19**	**Strat 21**	**Strat 22**
# of birds in each Strat	16	3	2	1	5	5	4
# of birds identified in region	3	1	1	1	1	1	1
% of birds in region	19%	33%	50%	100%	20%	20%	25%
Region 2	**Strat 22**						
# of birds in each Strat	4						
# of birds identified in region	2						
% of birds in region	50%						
Region 3	**Strat 4**	**Strat 19**	**Strat 21**				
# of birds in each Strat	16	5	4				
# of birds identified in region	1	1	1				
% of birds in region	0%	20%	25%				

Black-and White Warbler				
Region 1	**Strat 4**	**Strat 13**	**Strat 18**	**Strat 28**
# of birds in each Strat	3	4	4	20
# of birds identified in region	1	2	3	3
% of birds in region	33%	50%	75%	15%
Region 2	**Strat 22**	**Strat 27**	**Strat 28**	
# of birds in each Strat	1	12	20	
# of birds identified in region	1	2	1	
% of birds in region	100%	17%	0.05%	
Region 3	**Strat 12**	**Strat 19**		
# of birds in each Strat	7	4		
# of birds identified in region	2	1		
% of birds in region	29%	25%		
Region 4	**Strat 21**	**Strat 26**	**Strat 28**	
# of birds in each Strat	4	1	20	
# of birds identified in region	1	1	2	
% of birds in region	25%	100%	10%	

CHAPTER 5

DISCUSSION

This paper is not able to investigate each of the variables listed in DeGraaf and Rapole, however, the study would be remiss if it did not include the evaluation of at least one of the factors. Therefore, the study of interspecific competition will be examined as a possible variable for the shift in Warbler site selection.

Interspecific Competition

As described in the DeGraaf and Rappole chart, there are many variables that may affect a bird's choice of breeding site. One of the variables is competition between the Warblers and other bird species that compete for the same resources. The following discussion compares the time and space-mode analysis of three interspecific species with each of the three Warblers. Interspecific species are species which compete for similar food or nesting resources.

Brown-headed Cowbird (*Molothrus ater*), Blue Jay (*Cyanocitta cristata*) and American Crow (*Corvus brachyrhynchos*) are three specie of brood parasites and predator species that present problems in edge forests, and are particularly devastating to ground and low nesting birds (O'Conner and Faaborg 1992, Strausberger and Ashley 1997). Each of these species is considered a threat to songbirds. The Brown-headed Cowbird, which has been expanding its range into eastern North America in recent years, has been known to lay eggs in the nests of more than 100 species of birds (Collias and Collias 1984). Cowbirds tend to parasitize forest edges with openings in the canopy, areas with high densities of snags and vegetation types and areas that have a great richness of bird species (Evans and Gates 1997). Kentucky Warblers, and other ground and low-nesting Warblers, tend to be infested by Brown-headed Cowbirds in broken forests (Robinson et al. 1995). The widely dispersed American Crow is also a threat to songbird nests. Crows roost in urban areas (Gorenzel and Salmon 1995, Houston and Houston 1997, Ward and Low 1997). The increase of predator species has led to higher numbers of songbirds that are now victims of brood parasitism and interspecific predation (Mark and Stutchbury 1994).

Interspecific Competitor Species Time-Mode Analysis

Three competitor species, the Brown-headed Cowbird, American Crow and Blue Jay, were examined as possible variables that infuenced changes in the distribution of Warblers. The time-mode factor analysis that was used on each of the Warbler species was also applied to each of the competitor species. For each of the competitor analyses, only routes that correlated with each Warbler species were analyzed.

The Black-and-white Warbler's Competitors

Factor analysis for the American Crow distinguished three clearly defined epochs. The epochs can be seen as the late 1980s and 1990s epoch, the mid-1970s epoch and the early 1970s epoch (Table 7).

TABLE 7

AMERICAN CROW TIME-MODE FACTOR ANALYSIS IN BLACK-AND-WHITE WARBLER ROUTES

	Factor 1 80s & 90s Epoch	Factor 2 mid-70s Epoch	Factor 3 early 70s Epoch
Y1968	0.3835	0.3672	**0.7422**
Y1969	0.1806	0.2214	**0.7952**
Y1970	0.2337	0.1987	**0.6905**
Y1971	0.4453	0.2622	**0.6766**
Y1972	0.2078	0.3344	**0.7436**
Y1973	0.2630	0.4189	**0.6106**
Y1974	0.1512	**0.5256**	0.5846
Y1975	0.2344	0.4745	**0.5741**
Y1976	0.2533	**0.7479**	0.3165
Y1977	0.1482	**0.7368**	0.2930
Y1978	0.2192	**0.7278**	0.2162
Y1979	0.2834	**0.5483**	0.3414
Y1980	0.3778	**0.5317**	0.2955
Y1981	0.3312	**0.6672**	0.4147
Y1982	**0.5125**	0.4817	0.5369
Y1983	0.4721	**0.6681**	0.3415
Y1984	**0.5729**	0.6320	0.1583
Y1985	0.4829	**0.5409**	0.4269
Y1986	**0.6112**	0.5095	0.2661
Y1987	0.4262	**0.6764**	0.2307
Y1988	**0.6390**	0.3660	0.3306
Y1989	**0.6431**	0.4451	0.3706
Y1990	**0.7819**	0.1782	0.4052
Y1991	**0.7271**	0.5162	0.1058
Y1992	**0.6752**	0.2789	0.2198
Y1993	**0.7104**	0.2098	0.4860
Y1994	**0.6490**	0.1072	0.5151
Y1995	**0.6608**	0.2370	0.0362
Y1996	**0.7024**	0.2450	0.4037

Factor analysis for the Blue Jay distinguished three clear epochs, and one epoch (the 1990s disparate epoch) which did not show a strong linear relationship. The Blue Jay's epochs are the the mid 1970s through late 1980s epoch, the late 1960s through mid-1970s epoch, the early to late 1990s epoch and the disparate 1990s epoch (Table 8).

The factor analysis for the Brown-headed Cowbird detected four clearly defined epochs, and one miscellaneous year. The epochs identified with the Brown-headed Cowbird are the 1970s epoch, the late 1970s through mid-1980s epoch, the late 1980s through 1990s epoch, and the late 1960s epoch (Table 9).

The Pine Warbler's Competitors

Factor analysis for the American Crow distinguished four epochs. The American Crow's epochs are the 1970s epoch, the late 1980s epoch, the 1990s epoch, and the late 1960s through early 1970s epoch (Table 10).

There are three epochs associated with the Blue Jay's factor analysis. The Blue Jay epochs are the 1970s epoch, the 1990s epoch, and the 1980s epoch (Table 11).

The factor analysis for the Brown-headed Cowbird shows four clear epochs, and one disparate epoch. The epochs found for the Brown-headed Cowbird are the 1970s epoch, the 1980s epoch, the early 1970s epoch, the early 1990s epoch and the disparate epoch (Table 12).

The Kentucky Warbler's Competitors

Factor analysis for the American Crow turned up four clear epochs and one

TABLE 8

BLUE JAY TIME-MODE FACTOR ANALYSIS IN BLACK-AND-WHITE WARBLER ROUTES

	Factor 1 70s & 80s Epoch	Factor 2 early 70s Epoch	Factor 3 1990s Epoch	Factor 4 disparate Epoch
Y1968	0.4011	**0.5852**	0.2189	0.2594
Y1969	0.2997	**0.7756**	0.2169	0.1747
Y1970	0.2669	**0.5361**	0.3241	0.0169
Y1971	0.2347	**0.7708**	0.2392	-0.0646
Y1972	0.4194	**0.5061**	0.4644	0.1882
Y1973	0.4059	**0.5608**	0.1774	0.2877
Y1974	0.4696	**0.5366**	0.0965	-0.0289
Y1975	**0.6870**	0.2414	0.2879	0.1883
Y1976	0.3249	0.1431	0.2293	0.2181
Y1977	**0.6005**	0.2653	0.3083	0.3141
Y1978	**0.6923**	0.4558	0.1283	0.2317
Y1979	**0.7175**	0.4184	0.1014	0.1640
Y1980	**0.7085**	0.2205	0.2763	0.2417
Y1981	**0.7760**	0.3112	0.2379	0.0870
Y1982	**0.7699**	0.0920	0.2237	0.1998
Y1983	**0.7691**	0.1762	0.0030	-0.1286
Y1984	**0.7397**	0.2071	0.5068	-0.0069
Y1985	**0.7919**	0.2658	0.3580	0.0715
Y1986	**0.6057**	0.3363	0.3492	0.3343
Y1987	**0.6082**	0.3065	-0.0573	0.5234
Y1988	0.2994	**0.6984**	0.2773	0.3558
Y1989	0.2237	**0.6306**	0.4217	0.3280
Y1990	**0.5145**	0.2132	0.4293	0.4650
Y1991	0.3016	0.2763	**0.6608**	0.3913
Y1992	0.3650	0.4913	0.2402	**0.6040**
Y1993	0.1557	0.4756	**0.7474**	0.0294
Y1994	0.2436	0.1254	**0.8077**	0.1731
Y1995	-0.0090	0.0740	0.0755	**0.8950**
Y1996	0.2104	0.2691	**0.6372**	-0.1283

TABLE 9

BROWN-HEADED COWBIRD TIME-MODE ANALYSIS IN BLACK-AND-WHITE WARBLER ROUTES

	Factor 1 1970s Epoch	Factor 2 1980s Epoch	Factor 3 1990s Epoch	Factor 4 1960s Epoch	Factor 5 1995 Epoch
Y1968	0.2802	0.0826	0.1606	**0.7228**	0.1678
Y1969	0.1116	0.3530	0.2396	**0.7917**	-0.1816
Y1970	**0.6375**	0.3684	0.2962	0.4599	0.0789
Y1971	**0.7927**	0.0605	0.2323	0.4239	0.0776
Y1972	**0.6268**	0.4175	0.1801	0.1619	-0.0545
Y1973	0.3694	**0.6820**	0.3032	0.1862	-0.0966
Y1974	**0.7753**	0.4127	0.2173	-0.0188	-0.0061
Y1975	**0.8850**	0.0935	0.1080	0.2049	0.2737
Y1976	**0.7774**	0.2633	0.1326	0.1028	0.2544
Y1977	**0.8083**	0.2345	-0.0673	0.4345	0.0497
Y1978	**0.9070**	0.0787	0.1443	0.0340	-0.0231
Y1979	0.5871	**0.6412**	-0.0686	0.2295	-0.1514
Y1980	0.4513	**0.6001**	-0.1808	0.3283	0.1055
Y1981	**0.7237**	0.4649	0.1347	0.1721	0.3240
Y1982	0.5821	**0.6696**	0.2080	0.0013	0.1771
Y1983	0.2267	**0.6591**	0.2106	0.3717	0.3939
Y1984	0.0707	**0.8412**	0.0595	0.1426	0.2384
Y1985	**0.6123**	0.6024	-0.0606	0.2979	0.1280
Y1986	0.5280	**0.6941**	0.1457	0.0303	0.3382
Y1987	0.4234	**0.7593**	0.3005	-0.0104	0.0169
Y1988	0.0445	0.3078	**0.7672**	0.1693	-0.0759
Y1989	0.0255	**0.6605**	0.4130	0.2690	-0.2552
Y1990	**0.8338**	0.3038	0.3171	0.0168	-0.0493
Y1991	0.0989	0.3184	**0.7528**	-0.0695	0.3933
Y1992	0.2239	-0.0635	**0.8560**	0.0320	-0.1204
Y1993	0.3738	0.4145	0.4006	0.4303	0.1750
Y1994	0.3820	0.3330	**0.6149**	0.3548	0.2786
Y1995	0.1332	0.0975	0.0432	0.0379	**0.8192**
Y1996	0.1516	0.0026	**0.8930**	0.2346	0.1030

TABLE 10

AMERICAN CROW TIME-MODE FACTOR ANALYSIS IN PINE WARBLER ROUTES

	Factor 1 70s mid-80s Epoch	Factor 2 late 80s Epoch	Factor 3 1990s Epoch	Factor 4 60s & mid-70s Epoch
Y1968	0.2520	0.1031	0.1604	**0.7469**
Y1969	0.2788	0.2510	0.2390	**0.7569**
Y1970	0.3518	0.2444	0.0952	**0.7790**
Y1971	0.3295	0.3336	0.1162	**0.7536**
Y1972	0.4852	0.1623	0.1113	**0.6379**
Y1973	**0.6594**	0.1347	0.3500	0.4854
Y1974	**0.6047**	0.2658	0.2613	0.4040
Y1975	**0.8472**	0.1438	0.1817	0.2915
Y1976	**0.7735**	0.2308	0.1473	0.3501
Y1977	**0.7276**	0.2130	0.3413	0.3105
Y1978	**0.7291**	0.3047	0.1717	0.2229
Y1979	**0.7655**	0.2743	0.0795	0.2064
Y1980	0.3823	0.4738	0.2090	0.3460
Y1981	**0.7538**	0.2990	0.2794	0.2459
Y1982	**0.5475**	0.4599	0.2983	0.2715
Y1983	**0.6583**	0.4896	0.0544	0.2662
Y1984	**0.5646**	0.5309	0.1763	0.1884
Y1985	0.3898	**0.5635**	0.4090	0.3193
Y1986	0.2392	**0.6692**	0.3513	0.2984
Y1987	0.4389	**0.7339**	0.2535	0.1747
Y1988	0.2578	**0.6538**	0.4610	0.2720
Y1989	0.2992	**0.6280**	0.5056	0.0962
Y1990	0.3923	**0.6640**	0.3204	0.2914
Y1991	0.2589	0.4957	**0.6286**	0.2867
Y1992	0.0768	0.4179	**0.7685**	0.1817
Y1993	0.1782	0.4484	**0.6960**	0.2333
Y1994	0.2131	0.2349	**0.8525**	0.2089
Y1995	0.2208	0.2081	**0.5324**	-0.1085
Y1996	0.1305	0.0038	**0.8760**	0.2011

TABLE 11

BLUE JAY FACTOR ANALYSIS IN PINE WARBLER ROUTES

	Factor 1 60s & 70s Epoch	Factor 2 1990s Epoch	Factor 3 1980s Epoch
Y1968	**0.8424**	0.2907	0.2074
Y1969	**0.7261**	0.2767	0.2788
Y1970	**0.7536**	0.3102	0.2296
Y1971	**0.8293**	0.3300	0.1708
Y1972	**0.8123**	0.4193	0.2210
Y1973	**0.7887**	0.2464	0.1472
Y1974	**0.8422**	0.1831	0.3402
Y1975	**0.8333**	0.0835	0.1685
Y1976	**0.6132**	0.2477	0.5108
Y1977	**0.7959**	0.1960	0.4401
Y1978	**0.8430**	0.1365	0.2993
Y1979	0.4852	0.1285	**0.5898**
Y1980	**0.6114**	0.3128	0.5744
Y1981	**0.7260**	0.2821	0.3164
Y1982	**0.5778**	0.0472	0.6676
Y1983	0.4803	0.2595	**0.6665**
Y1984	0.3919	0.4901	**0.6454**
Y1985	0.1858	0.4032	**0.7650**
Y1986	0.1749	0.2938	**0.8851**
Y1987	0.3284	0.2396	**0.7812**
Y1988	0.4667	**0.6775**	0.3893
Y1989	0.3382	**0.7261**	0.3410
Y1990	0.3166	**0.6276**	0.6087
Y1991	0.4073	**0.7615**	0.3456
Y1992	0.2428	**0.7942**	0.3777
Y1993	0.3417	**0.7588**	0.3983
Y1994	0.3130	**0.7612**	0.2923
Y1995	-0.0475	**0.8505**	-0.1655
Y1996	0.2818	**0.6326**	0.3662

TABLE 12

BROWN-HEADED COWBIRD TIME-MODE FACTOR ANALYSIS IN PINE WARBLER ROUTES

	Factor 1 1970S Epoch	Factor 2 1980s Epoch	Factor 3 early 70s Epoch	Factor 4 disparate Epoch	Factor 5 early 90s Epoch
Y1968	0.0420	0.0465	0.2687	**0.7793**	0.0153
Y1969	0.0061	-0.0279	**0.7639**	0.3809	0.0792
Y1970	0.2074	0.1415	**0.8621**	-0.0379	0.1911
Y1971	0.1357	0.0563	**0.6173**	0.5691	0.1552
Y1972	0.0489	0.4835	**0.5943**	0.3459	0.0824
Y1973	**0.6109**	0.4362	0.4846	0.0778	0.0424
Y1974	**0.6256**	0.1964	0.6059	0.0961	0.2949
Y1975	0.4558	0.2726	-0.0113	**0.6056**	0.4402
Y1976	**0.7787**	0.3156	0.1046	0.1415	0.2208
Y1977	**0.8585**	0.1165	0.1441	0.2224	0.0583
Y1978	**0.5834**	0.3628	0.0490	0.5943	-0.0846
Y1979	0.4657	**0.7184**	0.1069	0.3424	-0.1449
Y1980	**0.5184**	0.5923	0.0485	0.3385	0.0130
Y1981	0.2881	**0.6267**	0.1738	0.4687	0.0532
Y1982	0.4852	0.4610	**0.6220**	0.1943	0.1742
Y1983	0.4500	**0.5773**	0.1579	-0.0556	0.3388
Y1984	0.2380	**0.8485**	0.1544	0.0409	0.1669
Y1985	**0.7841**	0.1936	0.1449	-0.0398	0.3586
Y1986	0.1951	**0.7217**	0.3580	-0.0161	0.3979
Y1987	0.4416	0.3044	-0.0467	0.0166	**0.5896**
Y1988	0.0811	**0.5644**	-0.0738	0.5628	0.2823
Y1989	0.1658	0.4720	**0.5467**	-0.0872	0.4132
Y1990	0.0795	0.2076	0.1017	0.4173	**0.5703**
Y1991	-0.0126	0.1712	0.3741	0.4258	0.3885
Y1992	0.2375	0.0457	0.1764	**0.5727**	0.3704
Y1993	0.1509	0.1247	0.3298	0.1696	**0.7950**
Y1994	0.1476	-0.0228	0.2889	0.0906	**0.6082**
Y1995	-0.0499	0.0104	0.0065	-0.0928	0.0191
Y1996	-0.0235	-0.0169	-0.0494	0.1033	0.0796

disparate epoch. The American Crow's epochs are the late 1970s through 1980s epoch, the 1990s epoch, the mid-1980s epoch, the early 1970s epoch and one disparate epoch including 1974, 1980 and 1989 (Table 13).

There are five epochs for the Blue Jay data in the Kentucky Warbler routes. The Blue Jay epochs are the mid-1980s epoch, the late 1980s through mid-1990s epoch, the 1970s epoch, the mid-1970s epoch, and the early-1970s epoch (Table 14).

The factor analysis for the Brown-headed Cowbird distinguished five different epochs. The epochs found in the Brown-headed Cowbird's data were the late 1960s through mid-1970s epoch, and mid-1990s epoch, the early 1990s epoch, the mid 1970s through mid-1980s epoch, and the early 1970s epoch (Table 15).

Interspecific Competitor Species Space-mode Analysis

The competitor species were examined geographically in two different ways. They were first examined by strata to look at possible changes in the distribution of the choice of stratum. Next, they were examined by state to see if there were possible changes occurring in those geographic regions.

Unfortunately, the BBS used a numerically coded description of the strata. The strata were defined many years ago by Danny Bystrak, a former BBS coordinator. Bystrak, never documented how he delineated the various strata throughout North America. Therefore, while it would be far more useful to discuss the stratum by a description of the region (e.g., Northern Hardwood Conifers, or Closed Boreal) this study is limited to referring to the strata only by its numeric code (Peterjohn, 1998).

TABLE 13

AMERICAN CROW TIME-MODE FACTOR ANALYSIS IN KENTUCKY WARBLER ROUTES

	Factor 1 70s & 80s Epoch	Factor 2 80s & 90s Epoch	Factor 3 mid-1980s Epoch	Factor 4 early 70s Epoch	Factor 5 disparate Epoch
Y1968	0.3734	0.0358	0.4174	**0.5544**	-0.2759
Y1969	0.3176	0.1147	-0.1468	**0.8303**	0.1504
Y1970	0.3242	0.1372	0.3717	**0.6985**	0.0311
Y1971	0.0026	0.2278	0.3181	**0.8279**	0.1187
Y1972	0.3684	0.1628	0.3769	**0.6148**	0.0770
Y1973	**0.6644**	0.4234	0.1175	0.2914	0.1358
Y1974	0.3886	0.2552	0.1381	0.2374	**0.7238**
Y1975	**0.5918**	0.2878	0.4746	0.3743	0.0559
Y1976	**0.8050**	0.2584	0.2796	0.1590	0.1607
Y1977	**0.7789**	0.2139	0.2593	0.1219	0.2903
Y1978	**0.7685**	0.2864	0.2728	0.2637	0.1122
Y1979	**0.7840**	0.2185	0.2271	0.2700	-0.0024
Y1980	0.4826	0.4187	0.2370	0.3037	-0.3911
Y1981	**0.8014**	0.3067	0.2703	0.1717	0.0044
Y1982	**0.5028**	0.3518	0.5543	0.3384	-0.1617
Y1983	**0.5099**	0.2021	0.6987	0.2716	0.0075
Y1984	0.4123	0.3467	**0.7001**	0.1780	0.0811
Y1985	0.3514	0.3986	**0.5012**	0.3825	0.2603
Y1986	0.4467	0.3677	**0.6650**	0.1418	0.2498
Y1987	0.2029	0.3584	**0.6887**	0.2592	0.4136
Y1988	0.3343	**0.5606**	0.5855	0.2385	0.1793
Y1989	0.4912	0.4943	0.4466	0.2040	**0.0569**
Y1990	0.2885	**0.6413**	0.1979	0.1330	0.2853
Y1991	0.2069	**0.7981**	0.1511	0.1072	-0.0380
Y1992	0.1604	**0.7759**	0.3006	0.2014	0.0932
Y1993	0.3310	**0.7709**	0.3012	0.2550	0.0642
Y1994	0.2113	**0.8128**	0.1809	0.1653	0.1697
Y1995	0.0109	**0.5442**	0.3130	0.0184	0.5963
Y1996	0.3194	**0.8048**	0.0673	-0.0114	0.1073

TABLE 14

BLUE JAY TIME-MODE FACTOR ANALYSIS IN KENTUCKY WARBLER ROUTES

	Factor 1 1960s Epoch	Factor 2 1980s Epoch	Factor 3 1990s Epoch	Factor 4 mid-70s Epoch	Factor 5 early 70s Epoch
Y1968	**0.8103**	0.1432	0.2988	0.0527	0.2524
Y1969	**0.9020**	0.1281	0.2235	0.1333	0.0862
Y1970	**0.7216**	0.2083	0.0918	0.5866	0.0807
Y1971	**0.8046**	0.0953	0.1120	0.2423	0.3182
Y1972	0.4956	0.0703	0.4043	0.0858	**0.5025**
Y1973	0.3329	0.1288	0.2695	0.2066	**0.7274**
Y1974	0.4134	0.1438	0.1180	**0.7926**	0.2143
Y1975	**0.5740**	0.1621	0.1568	0.5122	0.4701
Y1976	0.3662	0.4472	-0.0790	**0.5624**	0.3961
Y1977	**0.6631**	0.3711	0.1960	0.4693	0.1251
Y1978	**0.7292**	0.2539	0.1621	0.2909	0.3769
Y1979	**0.6941**	0.6082	0.0549	0.1535	0.0527
Y1980	**0.5412**	0.5683	0.2287	0.3257	0.1332
Y1981	0.4451	0.3619	0.0818	0.4471	0.4506
Y1982	**0.5761**	0.7428	0.0575	0.0637	-0.0488
Y1983	0.4502	**0.6706**	0.0889	0.1282	0.3229
Y1984	0.3441	**0.5893**	0.2430	0.1591	0.5665
Y1985	-0.0541	**0.8317**	0.2716	0.2026	0.2283
Y1986	0.1053	**0.8031**	0.2961	0.2649	-0.0770
Y1987	0.3081	**0.7409**	0.2322	0.0877	0.2538
Y1988	0.4912	0.3021	**0.6420**	-0.0370	0.1660
Y1989	0.1989	0.1627	**0.6766**	0.2940	0.4724
Y1990	0.1122	**0.6334**	0.5247	0.3031	0.0941
Y1991	0.1396	0.3267	**0.8464**	0.1232	0.1296
Y1992	0.2547	0.2518	**0.7587**	0.2584	-0.0236
Y1993	0.1249	0.3274	**0.8119**	0.0158	0.1052
Y1994	0.2073	0.2790	**0.7899**	0.2537	0.0947
Y1995	-0.0263	-0.3079	**0.7338**	-0.1258	0.1246
Y1996	0.0833	0.3706	0.4089	**0.6923**	0.0825

TABLE 15

BROWN-HEADED COWBIRD FACTOR ANALYSIS IN KENTUCKY WARBLER ROUTES

	Factor 1 late 70s & 90s Epoch	Factor 2 1980s Epoch	Factor 3 early 90s Epoch	Factor 4 early 70s Epoch	Factor 5 1972 Epoch
Y1968	**0.7636**	0.0519	0.1256	0.3196	-0.0251
Y1969	**0.5452**	0.3104	0.1125	0.6131	0.2404
Y1970	0.1565	0.4573	0.3200	**0.6003**	0.2201
Y1971	0.2380	0.1378	0.0894	**0.8534**	0.0986
Y1972	0.0355	0.0906	0.0524	0.1929	**0.9408**
Y1973	0.0250	**0.6932**	0.3396	0.4373	0.0722
Y1974	0.0995	**0.7419**	0.4715	0.3022	-0.1269
Y1975	**0.6355**	0.4231	0.1169	0.2797	0.3493
Y1976	**0.6855**	0.5449	0.3900	0.0531	0.0251
Y1977	**0.7007**	0.4554	0.2086	0.2657	0.1732
Y1978	**0.7860**	0.3903	0.2678	0.0507	0.1454
Y1979	**0.5981**	0.5645	0.2173	0.2782	0.2362
Y1980	**0.6227**	0.5060	0.2558	0.2574	0.0902
Y1981	**0.5593**	0.6105	0.1690	0.1184	0.3709
Y1982	0.2280	**0.7868**	0.2040	0.1400	0.1749
Y1983	**0.5700**	0.5772	0.2818	0.1260	0.3176
Y1984	0.3429	**0.6199**	0.3730	-0.1996	0.2768
Y1985	0.2657	**0.8328**	-0.1644	0.1710	-0.0230
Y1986	0.3859	**0.5780**	0.5372	0.0344	0.2748
Y1987	0.3941	**0.5530**	0.4235	0.1009	0.0128
Y1988	**0.5328**	0.3808	0.6694	0.0956	0.1454
Y1989	0.5307	**0.5492**	0.5225	0.1498	0.1971
Y1990	0.4292	0.3023	**0.6187**	0.1710	0.3103
Y1991	0.2042	0.0812	**0.6872**	0.2394	-0.0335
Y1992	**0.8279**	0.0512	0.3448	0.2911	-0.0098
Y1993	**0.6021**	0.2727	0.5260	0.0202	0.3844
Y1994	**0.6103**	0.1853	0.7157	0.0133	0.0481
Y1995	**0.6538**	0.3113	0.3128	-0.2032	0.0048
Y1996	**0.7361**	0.1747	0.4201	0.2718	0.0069

Stratum Analysis

For the stratum analysis, each of the species was examined by looking at the highest loading year. The highest loading year contains the data which best represents the breeding distribution of the bird being examined. The highest loading year for each species of Warbler was compared to the highest loading year of the competitor species in the same routes. The empirical findings are discussed below:

The Black-and-white Warbler's Competitors

The highest loading years for the Black-and-white Warblers and its competitors during the survey are: Brown-headed Cowbird 1978, American Crow 1990, Black-and-white Warbler 1994, and Blue Jay 1979. Over the twenty-nine years of the survey data, a total of eight strata are used for these four species.

When the species were examined by the eight strata in the selection, it was found that in strata four, twelve, thirteen and twenty-four there are an extremely low number of Black-and-white Warblers. In each of these strata, there is an average number of Brown-headed Cowbirds and Blue Jays, and a very high number of American Crows, particularly in stratum thirteen (Figure 3).

The Pine Warbler's Competitors

The Pine Warbler data emphasized the trend of having high American Crow counts present with low Warbler counts. In each stratum, there is a very large number of American Crow sightings, and by comparison quite a small number of Pine Warblers (Figure 4).

FIGURE 3

BLACK-AND-WHITE WARBLER AND COMPETITOR SPECIES DISTRIBUTION BY STRATA

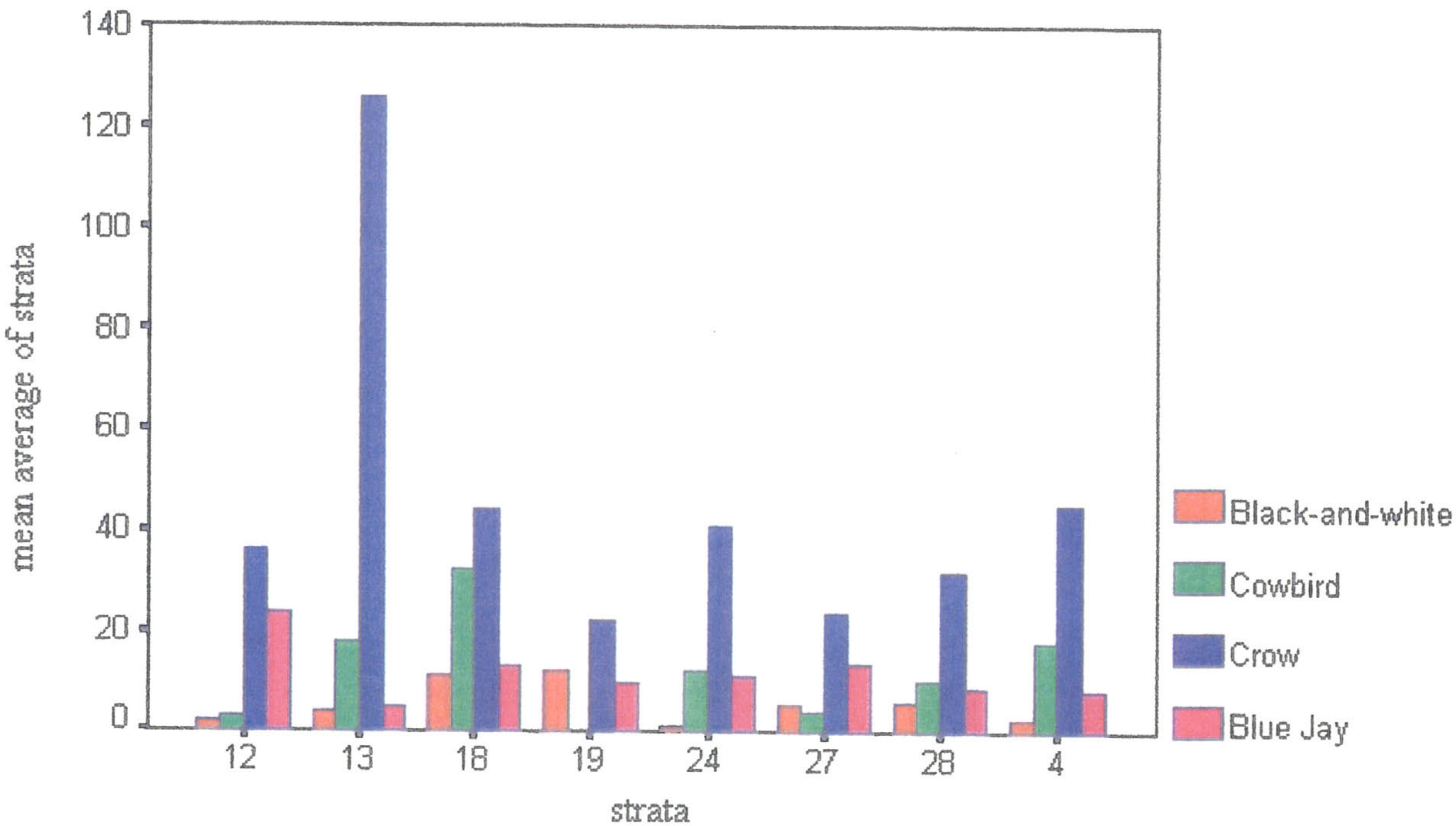
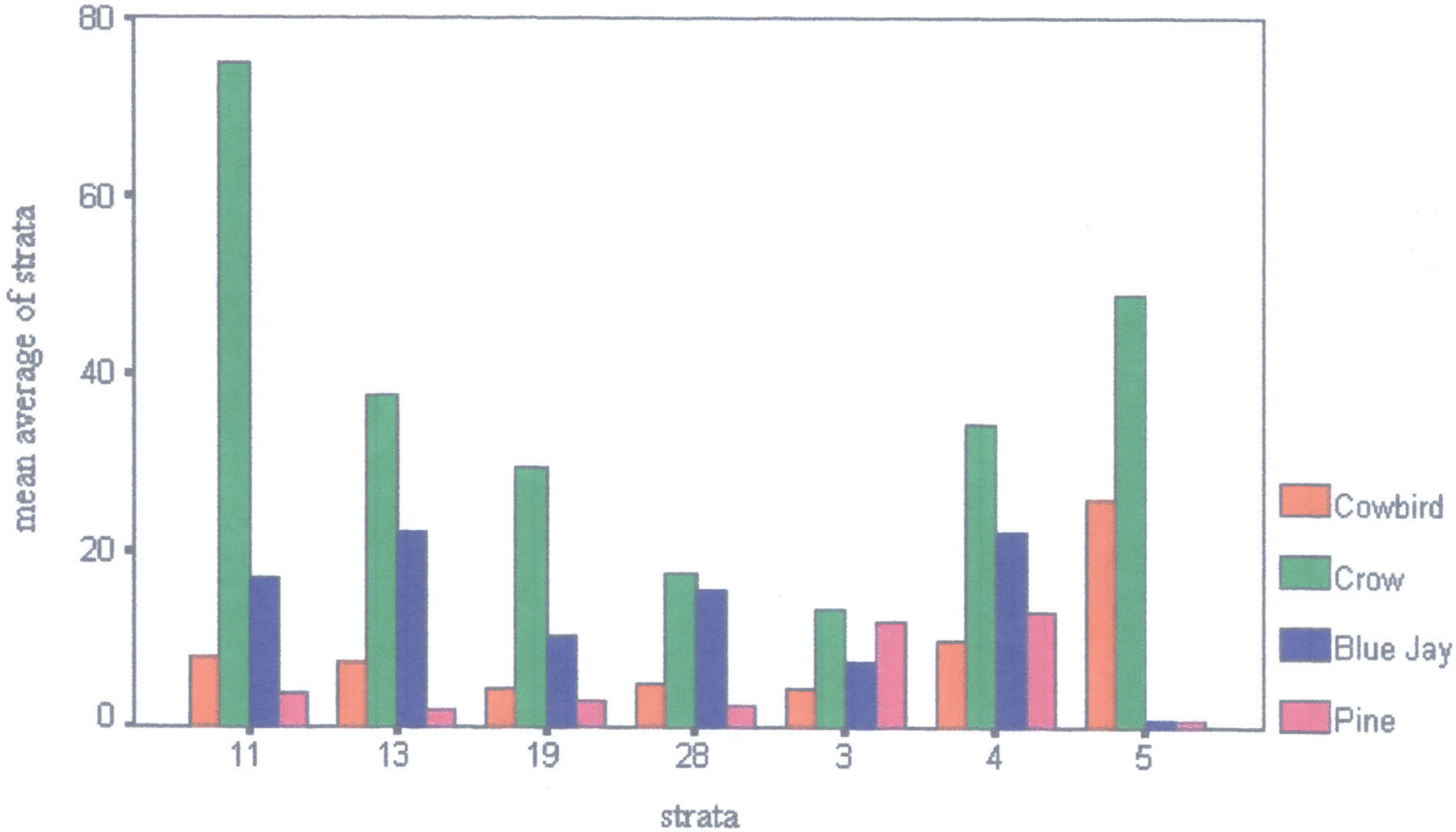


FIGURE 4

PINE WARBLER AND COMPETITOR SPECIES DISTRIBUTION BY STRATA



The Kentucky Warbler's Competitors

The Kentucky Warbler data includes five strata. The Kentucky data closely resembles the Black-and-white Warbler data. Where the American Crow populations are particularly prolific, the Kentucky Warbler numbers appear quite low. This is especially evident in stratum fifteen (Figure 5).

GEOGRAPHIC AREAS ANALYSIS

Black-and-white Warbler

Geographic areas that show a low number of Black-and-white Warblers and higher numbers of American Crows and Blue Jays are Connecticut, Massachusetts, New Hampshire, Nova Scotia, Ontario, and Pennsylvania. These states are located in the northeastern states of America, and the southeastern provinces of Canada (Figure 6).

Pine Warblers

The comparison of Pine Warblers and competitor species by state shows three states in which the Warbler numbers were very low: Arkansas and Alabama. In these states, there were also high populations of American Crows. In Maryland, there is a very high number of Warblers and American Crows. Texas and Virginia have extremely high populations of American Crows, and moderate numbers of Pine Warblers (Figure 7).

Kentucky Warbler

Low populations of Kentucky Warblers were found in the states of Alabama, Arkansas, Kentucky, Maryland, and Tennessee. With the exception of Maryland, all of these states are found in southern United States. In each of these observations, there are high populations of Blue Jays and at least moderately high populations of Brown-headed

FIGURE 5

KENTUCKY WARBLER AND COMPETITOR SPECIES DISTRIBUTION BY STRATA

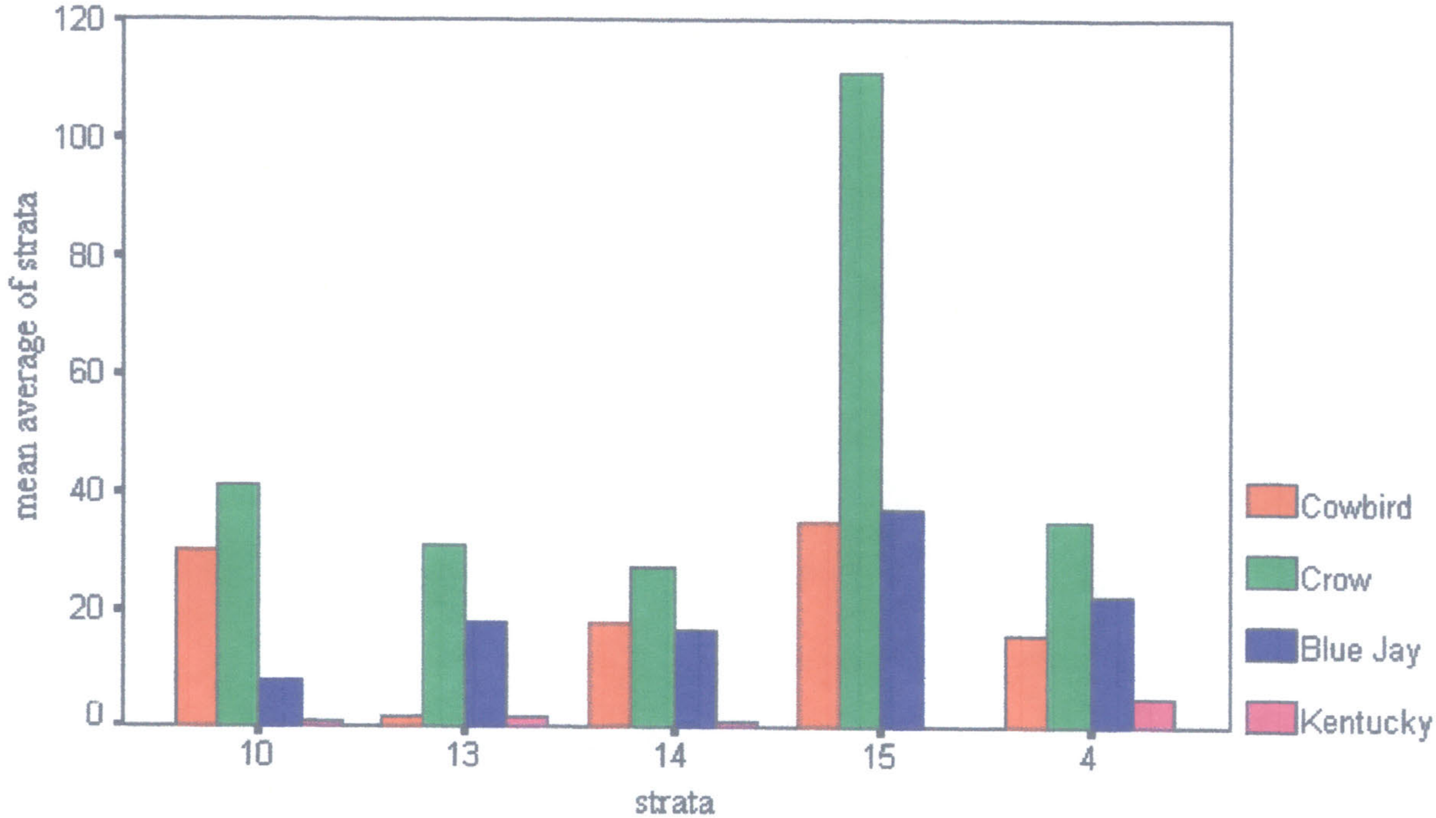
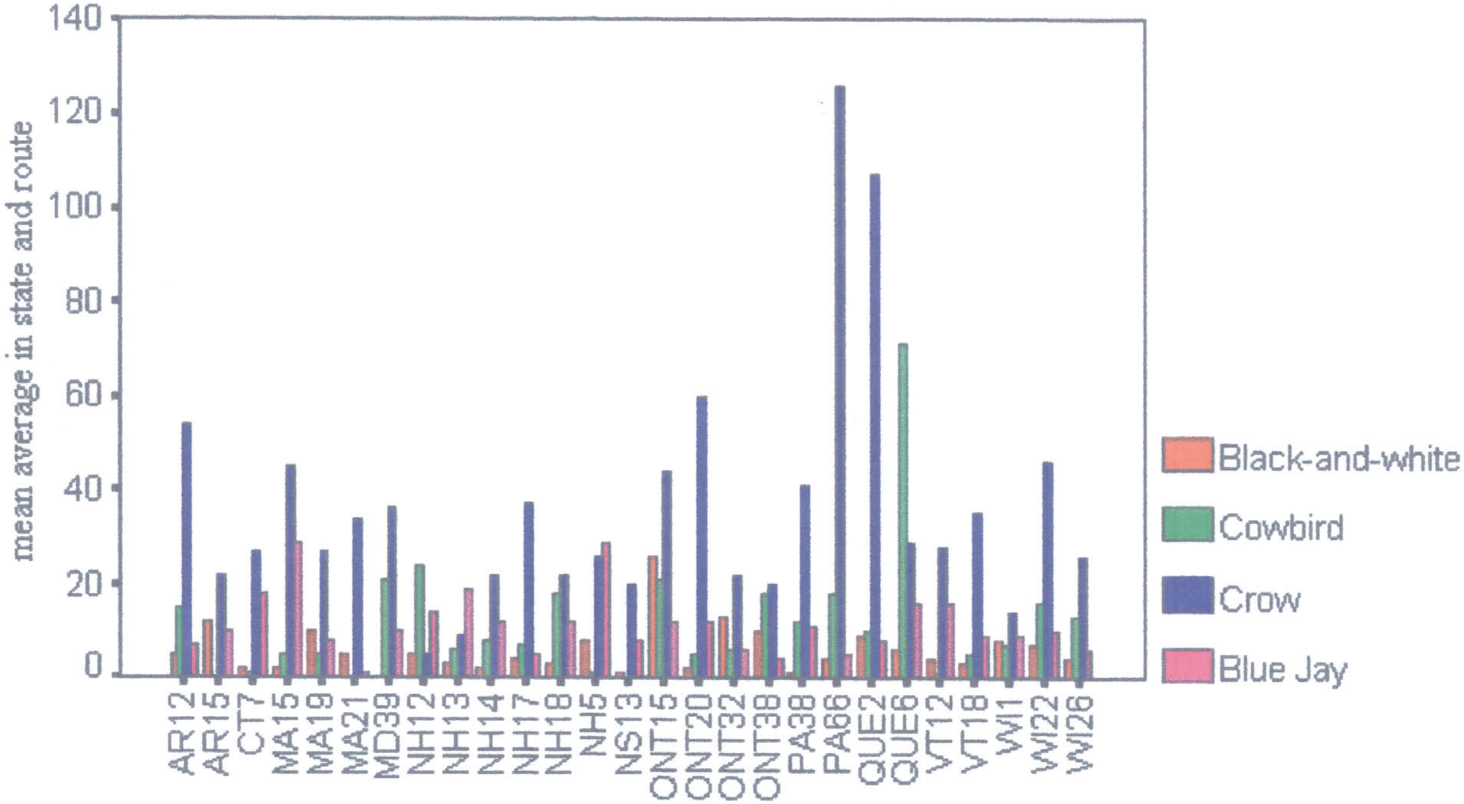


FIGURE 6

BLACK-AND-WHITE WARBLER AND COMPETITOR SPECIES DISTRIBUTION BY STATE AND ROUTE



state and route number

FIGURE 7

PINE WARBLER AND COMPETITOR SPECIES DISTRIBUTION BY STATE AND ROUTE

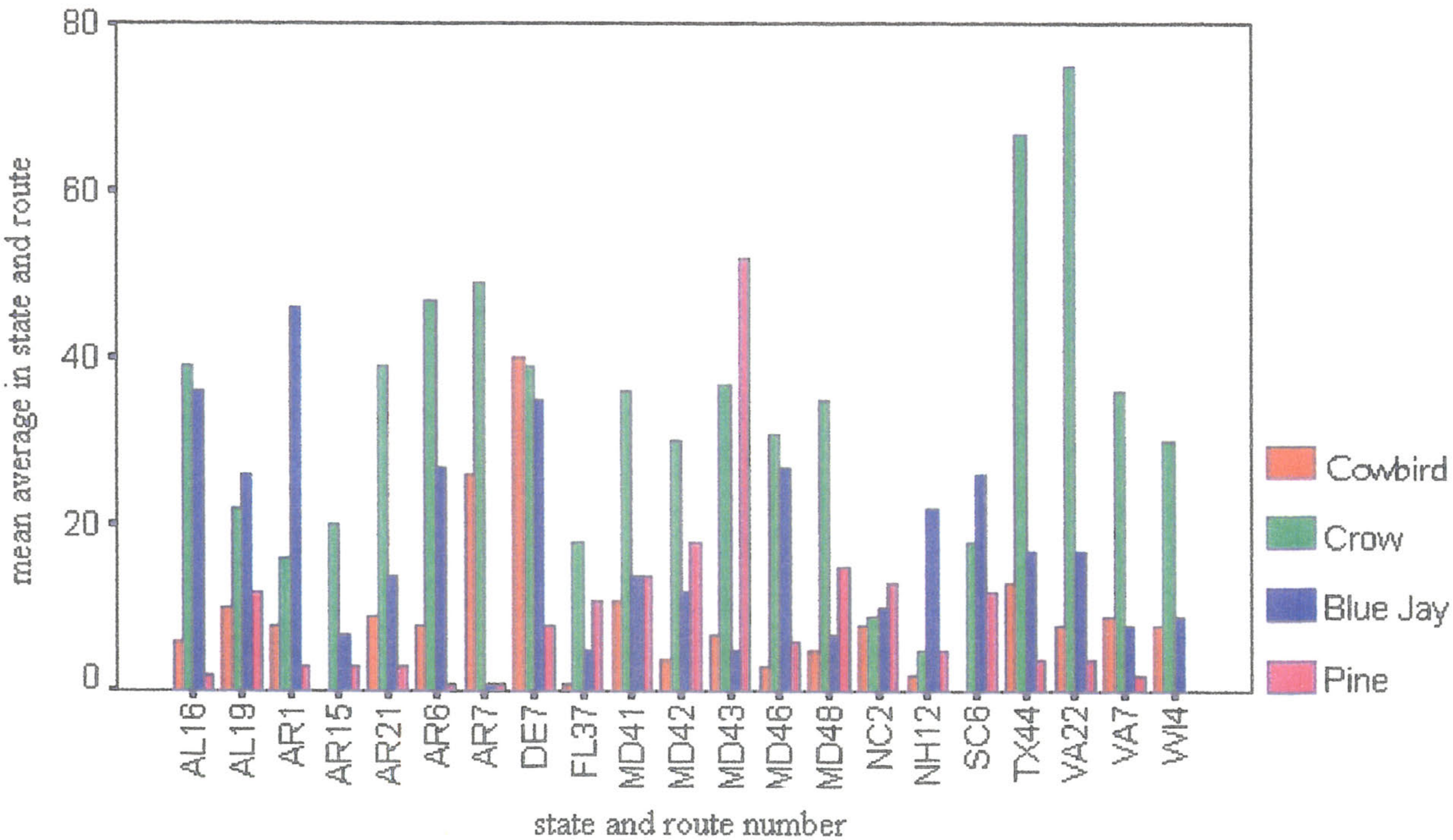
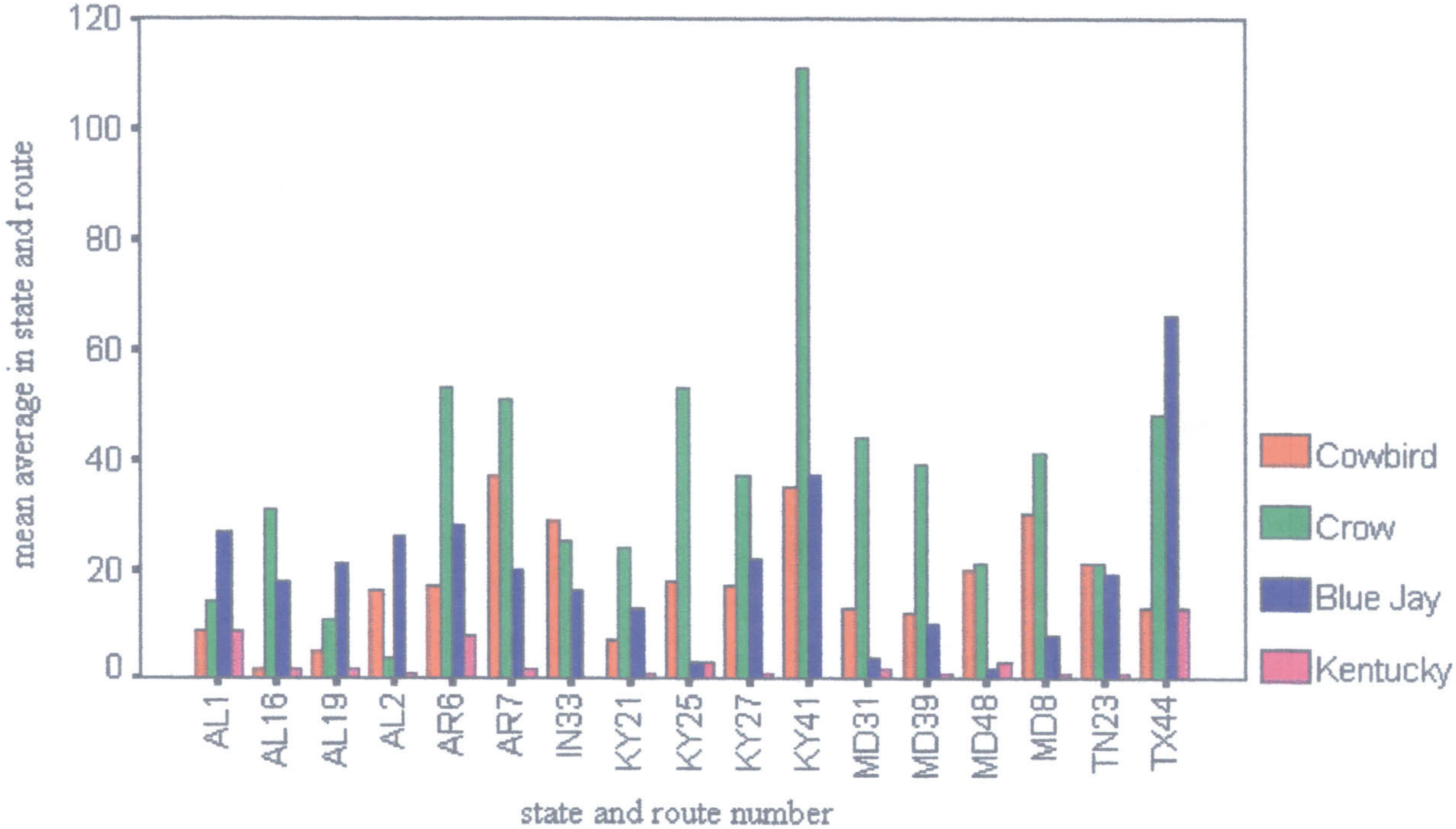


FIGURE 8

KENTUCKY WARBLER AND COMPETITOR SPECIES DISTRIBUTION BY STATE AND ROUTE



Cowbirds (Figure 8).

In the time-mode factor analysis, the Black-and-white Warbler showed a distinctive trend from the 1970s through the early 1980s; during the 1990s, and during the mid-1980s. The Pine Warbler had strong associations in the 1990s, the late 1960s through the mid-1970s, and from the late 1980s through the early 1990s. The Kentucky Warbler did not show particularly marked groupings of time. The highest loading factors were scattered through the 1970s through the 1990s. There is a strong clustering in the late 1980s and early 1990s; the mid-1990s, and the early 1980s, but these seem to reflect the occasional movement away from the factor one year, rather than show a strong movement in the data.

While many man made or naturally occurring phenomenon may be affecting the songbird's choice of nesting sites, only one variable, interspecific competition was analyzed.

Interspecific species were compared in both time and space. In the time-mode analysis the comparison between the Warbler species and the competitor species yielded several time epochs with similarities. In the time-mode factor analysis, the Black-and-white Warbler exhibited changes in their distribution patterns in the years of 1983 and 1989 which corresponded with the mid-1980s change in the Brown-headed Cowbird data. The Pine Warbler showed changes in their distribution patterns during the years of 1976, 1978 and 1993, which coincides with changes in the distribution of the Brown-headed Cowbird during the years of 1975, 1979, and 1994. The Kentucky Warbler had changes in their distribution during the years of 1980 and 1989, which were similar to the changes of the American Crow, which had a shift in distribution in 1990, and the Blue Jay, which changed its breeding patterns in 1980.

The space-mode factor analysis did not yield as strong as results as did the time-mode analysis. Each of the species was analyzed through principal components analysis, and the average numbers per loading on each stratum were calculated. Findings show that the Black-and-white Warbler had a strong proclivity to strata four, twelve, thirteen, eighteen and nineteen. And low propensity to strata four, twenty-seven, and twenty-eight. Strata twenty-two and twenty-six were not included due to the singular site included. The Pine Warbler showed a strong preference for strata four, thirteen, and nineteen, and a low preference for strata three, thirteen, and twenty-eight. Strata five and twenty-one were not included due to the singular site included. The Kentucky Warbler only had one strong region, stratum four. There was low association to the strata ten, thirteen, fourteen, nineteen, twenty-one and twenty-two. Strata fifteen was not included due to the singular site included.

For the space-mode strata analysis, the Black-and-white Warbler tended to be low in the strata that had increased numbers of Brown-headed Cowbirds and Blue Jays, and high populations of American Crows. The disparity between Black-and-white Warblers and American Crows was particularly evident in stratum thirteen. Like the Black-and-white Warbler, the Kentucky Warbler populations were lower in areas that had increased numbers of the competitor species, this was especially true in stratum fifteen where the American Crow was high in number. While the Brown-headed Cowbird and Blue Jay populations did not seem to vary greatly from the Pine Warbler data, the American Crow counts were higher in all areas.

In the space-mode state analysis, the Black-and-white Warblers tended to have low numbers in comparison to the American Crow and Blue Jay in New England and southeastern Canada. Arkansas and Alabama had high populations of American Crows, and low populations of Pine Warblers. In the southern states, low populations of Kentucky Warblers and high populations of Blue Jays were the trend.

While the space-mode data of the Brown-headed Cowbird and Blue Jay distributions did appear to have some correlation to the Warbler distribution data, the American Crow was the species that seemed to have the greatest correlation to the Warblers. This work does not attempt to make conclusive statements regarding the relationship between the competitor species and the Warblers, it is only intended to recognize changes in distributional patterns that may lead to investigation with regard to the cause of these changes.

CHAPTER 6

CONCLUSION

The purpose of this study was to test a procedure to be used to identify changes in nesting bird distributions. As such, the study was successful. The procedure can identify strong correlations in the time-mode analysis, showing specific periods during which distributional changes occurred. Although the findings in the space-mode analysis were not as strongly delineated, that portion of the study did yield some moderately strong results.

Based on the findings of the analysis, this study leaves room for future research. As the time-mode analysis only indicated periods during which the distribution of breeding Warblers experienced change, the next logical step would be to look at possible changes during those times. The same is true for the space-mode analysis. Shifts in fidelity to site selection offer ample opportunity to research changes in breeding sites. The years and regions where shifts occur should be investigated fully to determine what possible human-induced or natural changes have occurred to induce such change.

Time and space-mode factor analysis performed by using principal components analysis has shown to be a useful tool in the study of bird distribution changes. If further research builds upon this study, the procedure can be used as an early detection system to recognize bird species whose distributional changes may be early warning signs of species population decline.

REFERENCES

American Ornithologists' Union. 1983. *Check-list of North American birds, 6th edition. Kansas, U.S.A.*

Annand E M. and F. R. Thompson III. 1997. Forest bird response to regeneration practices in central hardwood forests. *Journal of Wildlife Management* 61(1): 159-171.

Bart, J. and J.D. Schoultz. 1984. Reliability of singing bird surveys: changes in observer efficiency with avian density. *The Auk* 101: 307-318.

________, Matthias Hofschen, and Bruce G. Peterjohn. 1995. Reliability of the Breeding Bird Survey: Effects of Restricting Surveys to Roads. *The Auk* 112(3): 758-761.

Böhning-Gaese, Katrin, Mark L. Taper and James H. Brown. 1993. Are declines in North American insectivorous songbirds due to causes on the breeding range? *Conservation Biology* 7(1): 76-86.

Collias, Nicholas E. and Elsie C. Collias. 1984. *Nest Building and Bird Behavior.* Princeton University Press, Princeton, N.J.

Cooper, J. E. 1995. The role of birds in sustainable food production. *Biodiversity and Conservation* 4(3): 266-280.

Curnutt, John, L., Stuart L. Pimm and Brian A. Maurer. 1996. Population variability of sparrows in space and time. *Oikos* 76: 131-144.

DeGraaf, Richard M. and John H. Rappole. 1995. *Neotropical migratory birds : natural history, distribution, and population change*. Ithaca, N.Y. : Comstock Publishing Associates, a division of Cornell University Press.

Droege, Sam. 1990. The North American Breeding Bird Survey. Pages 1-2 in *J.R. Sauer and S. Survey designs and statistical methods for the estimation of avian population trends.* Biological report 90(1). Fish and Wildlife Service, Washington, D.C.

Erskine, A. J. 1978. The first ten years of the cooperative breeding bird study in Canada. *Canadian Wildlife Service Report Series* 41: 1-61.

Evans D R. and J. E. Gates.1997. Cowbird selection of breeding areas: The role of habitat and bird species abundance. *Wilson Bulletin* 109(3): 470-480.

Faanes, C.A. and D. Bystrak. 1981. The role of observer bias in the North American Breeding Bird Survey. Pages 353-359 in C.J. Ralph and J.M. Scott, eds. Estimating numbers of terrestrial birds. *Studies in Avian Biology* 6.

Gorenzel W. P. and T. P. Salmon. Characteristics of American Crow urban roosts in California. *Journal of Wildlife Management* 59(4): 638-645.

Harrison, Hal H. 1975. *A field guide to birds' nests of 285 species found breeding in the United States east of the Mississippi River*. Houghton Mifflin Company: Boston.

Herkert, James R. 1994. An analysis of Midwestern breeding bird population trends: 1966-1993. *American Midland Naturalist* 134:41-50.

Hernandez A. 1993. The role of birds and mammals in the dispersal ecology of *Rhamnus-alpinus rhamnaceae* in the Cantabrian Mountains. *Folia Zoologica* 42 (2): 105-109.

Houston C S. and M. I. Houston. 1997. Saskatchewan bird species which increased with settlement. *Blue Jay* 55(2): 90-96.

Hutto, Richard L. 1992. Habitat distributions of migratory landbird species in western Mexico. Pages 211-239 in J. M. Hagan and D.W. Johnston, editors. *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press: Washington, D.C.

James, Frances C., Charles E. McCulloch, and David A. Wiedenfeld. 1996. New Approaches to the analysis of population trends in land birds. *Ecology* 77(1): 13-27.

Kaufman, Kenn. 1996. *Lives of North American Birds*. Houghton Mifflin Company: Boston/New York.

Kendall, William L., Bruce G. Peterjohn, and John R. Sauer. 1996. First-time observer effects in the North American Breeding Bird Survey. *The Auk* 113(4):823-829.

Knutson M A. and E. E. Klaas. 1997. Declines in abundance and species richness of birds following a major flood on the Upper Mississippi River. *The Auk* 114(3): 367-380.

________ and E. E. Klaas. 1997. Declines in abundance and species richness of birds following a major flood on the Upper Mississippi River. *The Auk* 114(3): 367-380.

Kollmann J. and B. Schneider. 1997. Effects of landscape structure on seed dispersal of fleshy-fruited species along forest edges. *Bulletin of the Geobotanical Institute* 6(3):

77-86.

Kusunoki M., Y. Kawabe, T. Ikeda and K. Aoshima. 1997. Role of birds in dissemination of the thread blight disease caused by *Cylindrobasidium argenteum*. *Mycoscience* 38(1): 1-5.

Litwin, Thomas S, and Charles R. Smith. 1992. Factors influencing the decline of Neotropical migrants in a northeastern forest fragment: Isolation, fragmentation, or mosaic effects? Pages 483-496 in J. M. Hagan and D.W. Johnston, editors. *Ecology and conservation of Neotropical migrant landbirds.* Smithsonian Institution Press: Washington, D.C.

Lynch, James F. 1992. Distribution of overwintering Nearctic migrants in the Yucatan Peninsula, II: Use of native and human-modified vegetation. Pages 178-196 in J. M. Hagan and D.W. Johnston, editors. *Ecology and conservation of Neotropical migrant landbirds.* Smithsonian Institution Press: Washington, D.C.

Marion L., P. Clergeau, L. Brient L. and G. Bertru G. 1994. The importance of avian-contributed nitrogen (N) and phosphorus (P) to Lake Grand-Lieu, France. *Hydrobiologia* 279-280: 133-147.

Mark, D. and B. J. Stuchbury. 1994. Response of a forest-interior songbird to the threat of cowbird parasitism. *Animal Behaviour* 47 (2): 275-280.

McClanahan T. R. and R.W. Wolfe. 1993. Accelerating forest succession in a fragmented landscape the role of birds and perches. *Conservation Biology* 7 (2): 279-288.

McShea, William J., M. Victoria McDonald, Eugene S. Morton, Rose Meier, and John H. Rappole. 1995. Long-term trends in habitat selection by Kentucky Warblers.

O'Conner, R. J. and J. Faaborg. 1992. The relative abundance of the Brown-headed Cowbird Molothrus-ater in relation to exterior and interior edges in forests of Missouri. *Transactions of the Missouri Academy of Science* 26: 1-9.

Parasharya, B. M., J. F. Dodia, K. L. Mathew and D. N. Yadav. 1996. The role of birds in the natural regulation of *Helicoverpa armigera Hubner* in wheat. *Pavo* 34(1-2): 33-38.

Peterjohn, Bruce. G. 1998. <Bruce_Peterjohn@usgs.gov>. 4 March. RE: Stratum descriptions [Email to kathie.martel@tpwd.state.tx.us].

________, John R. Sauer, and Chandler S. Robbins. 1995. Population trends from the North American Breeding Bird Survey. Pages 3-39 in *T.E. Martin and D.M. Finch, editors. Ecology and management of Neotropical migratory birds.* Oxford University

Press: New York.

Petit, Daniel R., Lisa J. Petit, and Kimberly G. Smith. 1992. Habitat associations of migratory birds overwintering in Belize, Central America. Pages 247-256 in J. M. Hagan and D.W. Johnston, editors. *Ecology and conservation of Neotropical migrant landbirds.* Smithsonian Institution Press: Washington, D.C.

Reed, J. Michael. 1992. A system for ranking conservation priorities for Neotropical migrant birds based on relative susceptibility to extinction. Pages 524-536 in J. M. Hagan and D.W. Johnston, editors. *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press: Washington, D.C.

Robbins, Chandler S., John R. Sauer, Russell S. Greenberg, and Sam Droege. 1989. Population declines in North American birds that migrate to the neotropics. *Proceedings of the National Academy of Sciences* 89:7658-7662.

________, D. Bystrak, and P.H. Geissler. 1986. The Breeding Birds Survey: its first fifteen years, 1965-1979. *U.S. Fish and Wildlife Service Resource Publication 157*: 1-196. Washington, D.C.

Robinson, Scott K. Robinson, Frank R. Thompson III. 1995. Regional forest fragmentation and the nesting success of migratory birds. *Science* 267(5206): 1987-91.

Sauer, John R., Bruce G. Peterjohn, and William A. Link. 1994. Observer differences in the North American Breeding bird Survey. *The Auk* 111(1):50-62.

________, Grey W. Pendleton, and Bruce G. Peterjohn. 1996. Evaluating Causes of Population change in North American insectivorous songbirds. *Conservation Biology* 10(2): 465-478.

Shelley, Fred, Clark Archer, Fiona Davidson, and Stanley Brunn. 1996. *Political Geography of the United States*: Guilford: New York.

Sheppard, J.M. 1996. Nestling Kentucky Warblers and Cowbird attacked by Brown-headed Cowbirds. *Journal of Field Ornithology* 67(3):384-386.

Sherry, Thomas W. and Richard T. Holmes. 1992. Population fluctuations in a long-distance Neotropical migrant: Demographic evidence for the importance of breeding season events in the American Redstart. Pages 524-536 in J. M. Hagan and D.W. Johnston, editors. *Ecology and conservation of Neotropical migrant landbirds.* Smithsonian Institution Press: Washington, D.C.

Snow, David W. 1976. *The web of adaptation: bird studies in the American tropics.*

Cornell University Press: Ithica and London.

Sodhi, N.S. and C. A. Paszkowski. The paring success of male Black-and-white Warblers *(Mniotilta varia)* in forest fragments and a continuous forest. Canadian Field *Naturalist* 111(3):457-458.

Strausberger B M. and M. V. Ashley. 1997. Community-wide patterns of parasitism of a host "generalist" brood-parasitic Cowbird. *Oecologia* 112(2): 254-262.

Thomas, Len. 1996. Monitoring long-term population change: Why are there so many analysis methods? *Ecology* 77(1):49-58.

________, and Kathy Martin. 1995. The importance of analysis method for Breeding Bird Survey population trend estimates. *Conservation Biology* 10(2): 479-490.

Vale, Thomas R., Albert J. Parker, and Kathleen C. Parker. 1982. Bird communities and vegetation structure in the United States. *Annals of the Association of American Geographers* 72(1) :120-130.

Villard, Marc-André and Brian A. Maurer. 1996. Geostatistics as a tool for examining hypothesized declines in migratory songbirds. *Ecology* 77(1): 59-68.

Ward C. and B. S. Low. 1997. Predictors of vigilance for American Crows foraging in an urban environment. *Wilson Bulletin* 109(3): 481-489.