Bird Counts in Minnesota Habitats: A Review

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INTRODUCTION

Literature on bird communities is a valuable resource. Ecologists and land managers draw on the literature to identify ways in which natural events (such as fire) and land management practices (eg. logging) affect bird populations over space and time. Bird community studies of a range of habitats can be used to characterize the response of individual species to gradients in habitat structure (Bond 1957; James 1971; Niemi and Pfannmuller 1979; James et al. 1984). Habitat preference during secondary succession (Engstrom et al. 1984) and interactions among species (James and Boecklen 1984) can be gleaned from long-term studies of communities. Good quantitative data for many species in a variety of habitats is prudent because it is impossible to anticipate all of the environmental changes that occur over time. While the use of such data may not permit strong inference of causal mechanisms permitted in experimental studies (Temple and Wiens 1989), some environmental effects defy experimentation (DeSante and Geupel 1987).

Progress has been made by the Minnesota Natural Areas Inventory to define and locate the best representations of natural plant communities in the state. Since the structure and composition of plant communities strongly affects bird populations (James 1971), a habitat inventory is essential for any conservation plan for bird populations. Rapid advances in the use of satellite images of terrestrial habitats (LANDSAT) permit biologists to identify major habitat types over large

scales. Information from quantitative studies of bird communities may make it possible to locate preferred habitat available for particular species or groups of species. Habitat preserves of a given size and configuration can be designed to maintain populations of many organisms (Florida Game and Fresh Water Fish Commission 1989). This study is a first attempt to summarize quantitative studies of birds in Minnesota.

The body of knowledge of the bird populations of Minnesota is a mixture of short-term studies and ongoing monitoring efforts. Many studies have been published in state and national ornithological and ecological journals, but some research, especially graduate theses, are unpublished. Ornithological research on Minnesota bird populations ranges from simple species lists for a locality or a region to standardized counts in specific habitats. Line transect, spot map, and point counts are the methods most frequently used to obtain estimates of relative abundance or density of birds for a specific area or habitat. The relative strengths and weaknesses of these methods have an ample literature (Ralph and Scott 1981). Comparisons can be made among results of counts that have been conducted with similar methods, but more often than not, researchers modify methods to suit particular research questions or for practical considerations. This makes comparison among counts difficult.

Even when methodology is standardized, comparison of results is complicated by variation in effort, observer competence, and plot size. All of these factors must be minimized to better

understand causes of variation in the numbers of birds over time and among habitats.

Data for Minnesota bird populations turn up in national monitoring and research programs, including the Breeding Bird Survey, the Christmas Bird Count, the Breeding Bird Census and Winter Bird Population Study. Data from these programs are not retrieved and analysed annually for Minnesota, except by individual researchers.

The objectives of this study are to review the literature on Minnesota bird communities, identify habitats for which the bird communities are poorly documented, and to obtain estimates of bird species richness in the habitats of Minnesota by using the statistical technique, rarefaction.

DATA AND METHODS

Literature search

I started the search by going through back issues of Flicker and Loon. I also searched Dissertation Abstracts International using keywords: birds, ecology, Minnesota, and community from 1951 to the present. Unfortunately, Minnesota did not participate in Masters Abstracts International until 1985. In addition, I placed a request for information in the newsletter of the Minnesota Ornithological Society. Finally, I wrote to ornithologists who have conducted research in Minnesota (Appendix I) for comments on and additions to my initial list of references.

Breeding Bird Census and Winter Bird Population Study

The Breeding Bird Census (BBC), started by the National Audubon Society in 1937, is one of the oldest continuous programs to measure bird populations in North America. A few BBC plots have been studied for 40 or more years. The objectives of the BBC are: (1) to determine the species and density of breeding birds found in each habitat type throughout North America; (2) to measure the effects of various land-use practices on breeding-bird populations; (3) to quantify the amount of yearly variation in densities of breeding birds occupying various habitat types; and (4) to establish the nesting requirements for each species of bird throughout its range (Stewart 1949). The National Audubon Society created the Winter Bird Population Study (WBPS), the winter analogue of the BBC, in 1948.

BBCs and WBPSs are conducted by experienced volunteers mostly in the United States and Canada. BBC participants use the "spot mapping method" (Williams 1936) to count the number of territorial birds on a measured plot of land (Hall 1964; Anon. 1970). A modified spot map method is used in the WBPS, but relative abundance is measured as the number of individuals detected per trip instead of the number of territorial individuals (Kolb 1965). Spot mapping is the most precise technique for estimating numbers of birds in most terrestrial habitats short of mark-recapture, but it is not appropriate for colonial species.

A method of quantitative habitat description was recommended for forested habitats to accompany the BBC and WBPS bird counts (James and Shugart 1970). Briefly, the abundance and size class distribution of all species of trees within 0.1-acre circular samples are summarized in the method. The combined results of randomly placed samples within a forest provides a quantitative description of the study plot. The 'James-Shugart' method has been widely adopted by BBC and WBPS participants, thus providing a standard technique of describing vegetation structure. This standard technique permits comparison of a variety of habitats (James and Wamer 1982).

Until 1984 the National Audubon Society published the BBC and WBPS in various journals. The data are now published annually in a supplement to the Journal of Field Ornithology. Many of the BBCs from 1937 to present are stored in a

computerized database at the Cornell Laboratory of Ornithology, but the WBPS computerized database only contains the 1989 counts. BBC and WBPS data for Minnesota are dispersed throughout National Audubon Society publications over the past 50 and 40 years. All BBCs and WBPSs from Minnesota are listed in Appendices II and III respectively.

Rarefaction

Perhaps because it is an obvious aspect of a habitat, ecologists frequently measure species richness and relative abundance of taxa of different habitats (MacArthur and MacArthur 1961; James and Wamer 1982). Species richness can be measured for samples of area, time, or individuals. Estimates of the number of species for an area are most commonly made.

A difficulty faced by researchers who wish to compare species richness among different communities, is that sampling methods and sample size vary among studies. In terrestrial bird communities, this frequently means that studies are made on plots of many different sizes. The observation that the number of species varies with area (the species-area effect) is one of the oldest in ecology (Arrhenius 1921); however, the relationship between species richness and area is non-linear (Connor and McCoy 1979). For this reason, it is not possible to estimate species richness directly from area.

Rarefaction is a statistical technique in which species richness is estimated for subsamples drawn randomly without replacement from the individuals of a given sample (Sanders 1968;

Hurlbert 1971; Fager 1972; Simberloff 1972, 1978). Given the number of individuals in each species of a sample, it is possible to use rarefaction to estimate the species richness [E(S)] and the variance (Heck et al. 1975) of a subsample smaller than the original sample. In this way species richness of the two samples of different size can be compared.

In the Elm-Ash-Birch Forest (Appendix II; number 37) the census resulted in a total of 29 species and 102 territorial males. The distribution of the number of territories is:

21 19 11 7 4 3 3 2 2 2 2 2 2 2 2 2 2 1.5 1.5 1 1 1 1 1 1 1 1 1

As in the example above, it is possible to have half territories in BBC results if a territory straddles a plot boundary (see above example); however, rarefaction can be used only if the number of individuals in each species is an integer. Therefore, the two counts of 1.5 territories were rounded upward to 2 territories, which increases the total number of territories to 103. In this analysis, all half territories were rounded upward and species that had less than a half territory on the study plot ('+') were excluded.

Rarefaction can be used to estimate the species richness for a sample smaller than the total sample. Given the distribution of 103 individuals among 29 species in the example above, the expected number of species for a subsample of 30 individuals would be 15.1 species with a variance of 3.7. I used rarefaction

to obtain estimates of species richness for a standard number of individuals (30) for all BBCs and WBPSs in Minnesota that had a sample of at least 30 individuals.

To obtain an estimate of the number of species for a standard plot size of 8.1 ha, I estimated the number of individuals on 8.1 ha by linear interpolation. In the example of the Elm-Ash-Birch Forest above, the plot size was 8.7 ha. The number of territories estimated on this 8.1-ha plot is 95 (103 teritories x 8.1 ha / 8.7 ha). I then used rarefaction to estimate species richness for 95 territorial individuals. The assumption that the number of individuals increases linearly with increasing area is weak if the habitat is heterogeneous.

The Breeding Bird Census and Winter Bird Population Study were the only two sources of data that I used in the rarefaction analysis. Almost all other bird counts in Minnesota were either conducted with a different method than spot-mapping or the plot size used was too small. Only plots of 8.1 ha or greater were used in the comparison of species richness, because density tends to be overestimated on small plots (Engstrom 1981; Engstrom and James 1981; Verner 1985). For some BBC plots researchers chose to enlarge or reduce the size of the study site in different years. In these cases, I treated each different plot size as an independent site.

WBPS results can be analyzed directly with the rarefaction program because the average number of individuals seen on each trip is rounded to the nearest integer. Species that were

encountered on less than half of the trips (designated with a '+' in the published results) were not included in the analysis.

Habitat classification

There are many different habitat classification schemes available for Minnesota. The Society of American Foresters (1980) classifies present-day forests in Minnesota into seven types: white-red-jack pine, spruce-fir, oak-hickory, elm-ash-cottonwood, maple-beech-birch, and aspen-birch. The Minnesota Natural Heritage Program (undated) classifies the vegetation types of Minnesota before European settlement into five broad categories: forest, savannah and parkland, prairie, wetland, and primary communities, such as cliffs. These general categories are subdivided into finer habitat types in the Minnesota Natural Heritage Program (Table 1). For example, 'Prairie' is classified into 16 different subtypes. In addition to all the natural habitats, man has created new habitats (eg. agricultural, urban, suburban) and greatly modified the composition, size, and continuity of habitats that occurred naturally by timber cutting and altering the frequency of fire.

For the purposes of this study, I classified all BBCs and WBPSs under four broad headings according to the plot title and habitat description: forest, prairie, wetland, and miscellaneous modified habitats. For example, White Cedar Bog Forest (reference numbers 5-8 in Appendix II) was classified as 'Forested Bog' under the heading of wetlands (Table 2). Man-made habitats (eg. agricultural shelterbelts) and highly altered

habitats (eg. aspen clearcuts) were placed in the miscellaneous modified category.

RESULTS

Breeding Bird Censuses and Winter Bird Population Studies

The BBC is the largest source of standardized plot-based counts of birds conducted in North America. In the last 51 years over 4100 BBCs have been conducted in the United States and Canada. Of these counts, 95 were made in Minnesota on 51 different sites (Appendix II). Thirty-one sites were censused for only 1 year, 2 sites for 2 years, 15 sites for 3 years, 2 sites for 4 years, and 1 for 7 years (Table 3). Although the earliest BBC in Minnesota was conducted in 1939, the majority of counts (60) were made between 1979 and 1982.

BBCs were concentrated around Duluth, Minneapolis/St.Paul, and in north-central Minnesota around Clearwater and Itasca counties (Figure 1). BBCs have been conducted in only 17 of 87 counties in Minnesota. WBPSs were concentrated around the central part of the state (Figure 2).

Censuses were conducted most often in forests (33) followed by wetlands (22), and prairie (2) (Table 2). Thirty-eight counts were made in habitats that were highly modified by humans, such as clearcuts, city fields, and agricultural shelterbelts. Ten counts were made of the avian communities in seral stages of secondary succession following logging of aspen forests. The

effects of fire on bird communities were studied in prairie and jack pine forest (2 counts each).

The WBPS is a much smaller program than the BBC. Only slightly more than 2000 WBPSs have been conducted since 1947. Most of the 29 Minnesota winter counts were conducted by R.H. Yahner in agricultural shelterbelts (numbers 9-29 in Appendix III), but upland coniferous plantation, upland oak-poplar forest, jack pine forest and floodplain deciduous forest were also studied. Small plot size of the 7 shelterbelts, all less than 1 ha, makes comparisons of species richness and abundance from these small plots to counts conducted on larger plots unreliable.

Species richness

Of 95 BBCs in Minnesota, 62 were done on plots of 8.1 ha (20 acres) or greater. I estimated species richness for a sample of individuals standardized to 8.1 ha for each of these plots. The number of species estimated for 8.1 ha ranges from 3.5 in open fen to 28.2 in elm-birch-ash forest (Table 3; Figure 3). Within a single plot, the number of species varied considerably among years. For example, species richness in the 'Upland Oak Forest' plot ranged from 9.8 in 1949 to 15.4 species in 1952 (Table 3; Figure 3).

The estimated species richness for samples of 30 individuals was highly correlated with the species richness for a standardized sample for 8.1 ha (Spearman's rho (x 100) = 84.5). For this reason I only used E(S) for 8.1 ha.

Of the 8 WBPSs that were conducted on plots $\geq$ 8.1 ha,

conifer stands (standardized to 8.1-ha, median E(S) = 7; median number individuals = 30) had more species and individuals than deciduous stands (median E(S) = 1; median number of individuals = 3); however, the sample size (3) is very small for both habitats.

Bird community composition

Neotropical migrants make up a significant proportion of the number of species and the number of territorial individuals in some Minnesota habitats. In general the proportion of migrants (classified according to the list in Terborgh (1989): pgs. 80-81) was greatest in deciduous woods and lowest in the structurally simple wetlands with pines in between (Table 5). The birds that are found in the BBCs of Minnesota are listed in Appendix IV.

Independent studies

Studies of bird communities in Minnesota other than BBCs and WBPSs have been conducted with a variety of methods for diverse purposes. Of 23 studies, 12 used spot mapping methods, 5 used line transect methods, 2 used counts from automobiles, 2 were surveys of well-defined areas (no estimates of abundance), and 1 employed modified point counts (Table 6). The studies were mostly conducted in the northern part of the state (Figure 4).

Most frequently, these studies were conducted to describe the effects of specific changes in the environment (Niemi 1976). The effects of logging (3 studies) and fire (4) are discussed below.

Logging

Back (1982) conducted territory mapping studies (spot-map)

on 18 sites in the Mille Lacs Wildlife Management Area. His treatments were divided into 3 classes: five 4-ha plots of 2-4 year-old clear cuts, 11 plots of 0.3-0.5 ha in 5-10 year-old aspen regeneration, and two 4.4-4.8 ha plots of 60-year old aspen. Although Back found that bird species diversity (H') was greater on clearcuts 2-5 years old, the extremely small plot sizes made the small study plots little more than light gaps. Light gaps and small openings are frequently used both by species that need thick understory and species from the neighboring older canopy forest.

In the Superior National Forest, Niemi and Hanowski (1984) established eight 4-6 ha plots in logged areas. The vegetation was composed of a mixture of Quaking Aspen, pines, Black Spruce, alder and willow. The authors used a principal components analysis on quantitative measurements of the bird community and vegetation structure. They concluded that greater "habitat complexity" in the logged areas enhanced bird abundance. "Habitat complexity" was correlated with the number and basal area of snags and shrub height. The chestnut-sided warbler, mourning warbler and white-throated sparrow were the most abundant birds on the plots.

Fire

Tester and Marshall (1961) studied the effects of different fire regimes, grazing, and mowing on only the three most abundant bird species, savannah sparrow, LeConte's sparrow, and bobolinks at the Waubun Prairies Research Area. Although spot-mapping was

used, the plots were small (4 ha). In general fire reduced bird numbers.

The data for the study of a jack pine forest in Bergstedt and Niemi (1974) following the Little Sioux fire is also presented as a BBC (Appendix II; no. 3). Niemi (1978) lists birds associated with burning regimes. For a 6.25-ha plot of jack pine-black spruce, Apfelbaum and Haney (1981) found that the number of bird species increased even though the density of birds decreased one year after a wildfire.

Haney and Apfelbaum (1984) conducted a study of bird communities in the Superior National Forest and Quetico Provencial Park. The study plots were located along age gradients in upland sites that that had been burned, logged, and planted in pines. Ages of trees in 13 burned sites ranged from 1 to 370 years old; the trees in 7 logged sites were 1 to 50 years old; and 4 pine plantations ranged from 3 to 67 years old. Spot-mapping was used to count birds and all study plots were 250 x 250 m (6.25-ha) study plots. The overall result of their study was that bird species richness and density was lowest for the pine plantations, then the logged habitats, and the plots post-fire succession were the most species rich. The authors attributed the greater numbers of birds to greater patchiness and variation in structure in the burned habitats. They concluded that using land for logging or pine plantations will reduce the numbers of birds in the region.

Micellaneous topics

G.J. Niemi, director of the Center for Water and the Environment of the Natural Resources Research Institute, has conducted a large number of studies of bird communities in Minnesota. Niemi authored or coauthored 27 BBCs (Appendix II) and used these data in a variety of studies.

Niemi and Hanowski (1984) used both territorial mapping and transect counts to determine the effects of a transmission line on bird populations in 6 habitats. The results of the territorial mapping studies were also published as BBCs. (See numbers 23-32 and 38-42 in Appendix II.) Although the authors had carefully selected control and treatment study sites for similarity and proximity to each other, most of the differences in the results could be explained by differences in habitat structure. They concluded that the transmission line had no clear negative impact on bird populations.

Niemi has also studied birds in wetlands before phosphate mining (Hanowski and Niemi 1985; Hanowski and Niemi 1987), birds in a conservation area (Niemi 1987), and extensive studies of birds in peatlands (Niemi 1983; Niemi et al. 1983; Niemi 1985). Using data from peatlands in Finland and Minnesota, Niemi studied convergence in morphology of birds within genera.

Pfanmuller (1979) conducted an extensive study of the bird communities in a region of potential copper-nickel development. She used both transects and spot-mapping of small plots to sample the birds in winter and during the breeding season. Pfanmuller employed a combination of ordination and cluster analysis to

define nine bird communities for the following habitats: recent clearcut, aspen regeneration, young plantation, disturbed shrub, mature deciduous uplands (aspen-birch and aspen-birch-fir), mature coniferous uplands, mature lowland coniferous (open and closed bogs), alder and grassland. Doran and Todd (1976); (1977) also conducted bird surveys on sites of potential mining sites.

Svedarsky et al. (1983) studied the birds on small plots in cottonwood savannah, willow swamp, cottonwood lowland, and willow marsh using spot-mapping.

The bird communities of deciduous forests in a transect from the wooded to the prairie regions of northwestern Minnesota were subjects of research by Kelleher (1967). The 24 study plots in 13 forest stands, selected for structural homogeneity, ranged in size from < 1 to 8.4 ha. Although most of the plots of this study were too small to be used in the BBC analysis, I estimated species richness for 18 plots (5 prairie; 13 forest region) using rarefaction. To standardize all plots, I used the number of individuals estimated for a plot size of 4.0 ha. Species richness of the prairie deciduous forests was almost significantly greater than species richness in the plots in the forest region (P=0.0546; Mann-Whitney test).

Several counts have been done for a region across a variety of habitats (LaFond 1979; Hickey 1956; Kendeigh 1956; Seabloom 1960; Longley 1958). Several studies have been made of bird communities on islands (Rusterholtz 1973; Howe 1977; Rusterholtz and Howe 1979; Wilson and Berlin 1983; Wiens 1984), but the data

are not easily compared.

Very few studies of Minnesota bird communities in the winter have been published. O'Brien (1972) and Schmnitz and Bremer (1959) did not use standardized methods, but do provide basic lists of the occurrence of birds within regions.

DISCUSSION

Species Richness

At a broad level species richness among Minnesota BBCs is lowest in simple habitats -- prairies, fens, and bogs -- and highest in forests. Patterns of species richness among forests is more difficult to discern (Figure 3). Comparing species richness among BBCs at a large geographical scale, James and Wamer (1982) found coniferous forests to have fewer species than deciduous forests. Wiens (1975) also found relatively low species richness in coniferous forests. Species richness of coniferous forests in Minnesota was not clearly lower than deciduous forests; however, coniferous-deciduous forests had more species than either of the more uniform habitat types.

A detailed examination of patterns of species richness among forest habitats in Minnesota is beyond the scope of this study. Listing habitats according to species richness (Figure 3) is just a start. Quantitative habitat data for BBC plots instead of defining a priori habitat types is essential. Multivariate statistics, such as principal components analysis, can be used to

examine correlated aspects of the structure and composition of habitats in relation to species richness. For example, the relative proportion or heights of hardwoods in pine dominated forests would have a strong influence on the number and types of bird species.

Species richness can be used as a criterion for evaluating a habitat or parcel of land for conservation purposes (Fuller 1980; Niemi 1987; Usher 1986). If the number of species in an area is of interest, rarefaction has many advantages over diversity indices (James and Rathbun 1981; Back 1982). Although species richness may be of interest, species composition is also obviously very important. As Pfanmuller (1979, pg. 122) noted, "The prime consideration should be the uniqueness of the fauna and its ability to adapt to habitat alterations. All species do not demonstrate the same adaptive flexibility". The list of the proportions of neotropical migrants in the various habitats of Minnesota ranks the importance of these habitats to a broad group of species (Table 6).

Avian community research in Minnesota

Research on bird communities in Minnesota is not well-distributed geographically (Figures 1, 2, and 5) nor have all habitats been studied. In particular, little quantitative data has been collected for the bird communities of floodplain forest (mainly elm-ash-cottonwood forests in the southeastern part of the state), savannas, or prairies. It's also important to note that the numbers of BBCs in different habitats (Table 2) include

studies of the same plot over time. For example, seven BBCs have been conducted on a single plot of oak forest (Table 3). Studies of prairies would be especially valuable because 7 bird species that occur in prairies are listed on the Checklist of Endangered and Threatened Animal and Plant Species of Minnesota (Minn. Dept. Nat. Res. 1986).[1]

Of habitats most affected by human disturbance, only logged aspen forests are relatively well-studied. The affects of agriculture and urbanization are poorly documented. Counts of birds in agricultural, suburban, and urban areas would be useful additions to Minnesota ornithology. Loggerhead Shrike (Lanius ludovicianus), Henslow's Sparrow (Ammodramus henslowii), and Upland Sandpiper (Bartramia longicauda) are listed in Minnesota (Minn. Dept. Nat. Res. 1986) and all occur in agricultural areas. These species deserve autecological research and annual monitoring, but the natural communities of the species should also be documented.

The main programs in North America to monitor changes in numbers of birds over time and space are the Breeding Bird Survey (BBS) and the Christmas Bird Count (CBC) (Robbins, et al. 1986; Butcher in press). Two strengths of the BBS and CBC are that they are geographically extensive and the number of samples of the environment is large. Both of these programs provide

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[1] Sprague's Pipit (Anthus spragueii), Baird's Sparrow (Ammodramus bairdii), Burrowing Owl (Athene cunicularia), Chestnut-collared Longspur (Calcarius ornatus), Short-eared Owl (Asio flammeus), Sharp-tailed Sparrow (Ammospiza caudacutus), and Marbled Godwit (Limosa fedoa).

data on the numbers and distributions of birds in Minnesota, but they don't have information on numbers of birds in specific habitats.

The BBC (not BBS) has been used to monitor local populations. Occasionally, local changes are viewed within the context of larger-scale phenonema. For example, the decline of neotropical migrant species on some long-term BBC study plots has opened a controversy over whether local declines are part of widespread trends and what are the possible causes (Robbins 1979; Hall 1984; Johnston and Winings 1987; Terborgh 1989). In some cases, population trends from intensive and extensive studies can be compared (Holmes and Sherry 1988). This could be done more often with the BBC and BBS or the CBC and WBPS.

A strength of the BBC and WBPS is that estimates of density or at least relative abundance of bird species are provided for specific habitats. This is extremely valuable, because availability and quality of habitat are essential for the long-term preservation of birds, as well as all other animals. Data provided by these plot based counts can be used easily with a habitat inventory in Minnesota. If enough counts were made in a variety of habitats, it might be possible to constuct models of habitat preference for a large number of bird species in the state.

A number of aspects of the BBC have been criticised. One criticism is that interpretation of clusters of registrations used to indicate the location of territorial individuals is too

variable among observers (Enemar et al. 1978). In Great Britain, the field maps for the Common Bird Count are interpreted by experienced staff at the British Trust for Ornithology. This would be very difficult to do for the BBC, but the instructions for map interpretation could be strengthened. The procedure for interpretation of partial territories should be applied consistently. This would have a bearing on estimates of species richness. BBC methods also can be strengthened by emphasizing the need to record simultaneous registrations (Tomialojc 1980), making plot size fairly large (Engstrom 1981), and maintaining consistent standards of effort over time and among plots (Engstrom and James 1984).

The strengths and value of the BBC and WBPS far outweigh the weaknesses. To date these databases represent the most extensive collection of information on the bird populations in specific habitats in Minnesota. Independent studies, including theses, dissertations, and published papers, are highly diverse. Comparing results among these studies directly would be difficult and risky. Expanding and improving the BBC and WBPS would be an inexpensive way to provide good data on the bird communities of Minnesota.

Some recommendations for improvement include:

(1) Encourage researchers to contribute to the BBC or WBPS if spot-mapping can be used in independent studies. G.J. Niemi and R.H. Yahner accomplished this.

(2) Work with the Natural Areas Inventory to locate the best

representations of habitat in the state. Nature Conservancy preserves, state parks, national forests, and university research areas are logical sites for long-term bird studies. Students at the Lake Itasca Biological Station have conducted many BBCs over the years.

(3) Encourage particular bird clubs or individuals to take on responsibility for research on a study site and possibly even provide small grants for travel money. Perhaps the Minnesota Ornithological Society could take on the responsibility to organize an "Ornithological Survey of the Habitats of Minnesota". The state could provide the leadership to define what is needed.

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Table 1. Natural communities of Minnesota (Minnesota Natural Heritage Program [undated]).

Forest Communities

Aspen - Birch Forest
Black Spruce - Feather Moss Forest
Floodplain Forest
Great Lakes Pine Forest
Maple - Basswood Forest (4 regions)
Mixed Oak Forest
Northern Hardwood - Conifer Forest
Spruce - Fir Forest
Upland White Cedar Forest
Jack Pine Forest

Savanna and Parkland Communities

Aspen Parkland Complex
Dry Sand Savanna (Jack Pine and oak subtypes)
Mesic Blacksoil Savanna

Prairie Communities

Bluff Prairie
Dolomite Prairie
Dry Sand Prairie
Glacial Till Hill Prairie
Gravel Prairie
Mesic Blacksoil Prairie (7 subtypes)
Wet Blacksoil Prairie (4 subtypes)

Wetland Communities

Calcareous Fen
Conifer Swamp
Emergent Marsh
Floating-leaved Marsh
Forested Bog
Hardwood Swamp
Open Bog
Patterned Peatland Complex
Poor Fen
Rich Fen
Sedge Meadow
Shrub Swamp
Submergent Marsh

Primary Communities

10 types including beaches, talus slope, and cliffs

Table 2. The number of Breeding Bird Censuses by habitat type. The numbers in parentheses refer to the reference number to Appendix II.

Habitats	Total
Forest Communities	
Deciduous	
Aspen-Birch (20,57,65)	3
Aspen (56)	1
Mixed Oak (9-14,36)	7
Mixed Deciduous (2,21,37,55,60,64)	6
Coniferous/Deciduous (68,35,74,43-45,49)	7
Coniferous	
Red Pine (71)	1
Jack Pine (3,46,47,51,52,70)	5
Conifer Plantation (62,72)	2
Prairie	
Prairie (34,33)	2
Wetlands	
Forested Bog (5-8)	4
Closed Black Spruce Bog (23,28,38)	3
Open Black Spruce Bog (24,29 39)	3
Fen (27,32,42)	3
Open Bog (26,31,41)	3
Shrub Swamp (25,30,40)	3
Emergent Wetland (53,54)	2
Modified Habitats	
Open Field (4,17-19)	4
Shelterbelt (76-95)	21
Disturbed Aspen (22,48,50,58,59,61,63,66,67,69)	10
Coniferous/Deciduous (1,15,16,73)	4

Table 3. Breeding Bird Censuses in Minnesota (in alphabetical order by cour
beside the habitat name.

County	Habitat (Type)	Plot Size	ID #	Year	Ind per 40 ha
Anoka	White Cedar Bog Forest	9.11	5	1948	162
			6	1949	201
			7	1950	302
			8	1951	180
Beltrami	Open Fen	15.01	42	1980	117
			27	1981	189
			32	1982	119
Carlton	Aspen-Birch Forest	20.48	20	1977	101
		14.00	57	1978	188
Cass	Mature Aspen-Northern Hardwoods Forest	17.00	21	1977	108
		12.51	60	1979	159
		13.84	64	1981	199
Cass	Aspen Forest (19-year)	7.08	59	1979	124
Cass	Red Pine Plantation	11.53	62	1979	156
Cass	Mature Aspen-Fir	11.17	68	1981	78
Clay	Burned Prairie	13.31	33	1972	63
Clay	Unburned Prairie	16.23	34	1972	78
Clearwater	Northern Conifer, Alder Edge and Bog	10.12	16	1958	272
Clearwater	Birch-Elm-Ash Forest	8.70	55	1979	616
Clearwater	Elm-Ash-Birch Forest	8.70	2	1980	395
			37	1981	473

Table 3. (contd.)

County	Habitat (Type)	Plot Size	ID #	Year	Inc 40
Clearwater	Mature Pine-Fir-Birch	12.75	35	1980	3(
Clearwater	Mixed Successional Aspen-Oak-Conifer Forest	8.93	1	1980	3:
			15	1981	3:
			73	1982	4(
Crow Wing	Jack Pine-Deciduous	16.19	74	1955	!
Dakota	Mature (1946) Four-Row Belt	0.69	75	1979	13
			82	1980	2(
			89	1981	4(
Dakota	Mature (1948) Five-Row Belt	0.69	76	1979	40(
			83	1980	8(
			90	1981	7:
Dakota	Mature (1949) Eight-Row Belt	0.36	77	1979	37
			84	1980	6
			91	1981	16
Dakota	Mature (1951) Three-Row Belt	0.32	78	1979	11
			85	1980	2
			92	1981	6
Dakota	Immature (1961) Nine-Row Belt	0.79	79	1979	13
			86	1980	10
			93	1981	10
Dakota	Immature (1966) Four-Row Belt	0.28	80	1979	31
			87	1980	31
			94	1981	34
Dakota	Immature (1974) Three-Row Belt	0.20	81	1979	11
			88	1980	39
			95	1981	43

Table 3. (contd.)

County	Habitat (Type)	Plot Size	ID #	Year	Ind 40
Lake of the Woods	Open Black Spruce Bog	5.02	29	1980	6
			39	1981	1(
			24	1982	11
Lake of the Woods	Shrub Swamp	12.51	40	1980	31
			25	1981	32
			30	1982	25
Lake of the Woods	Open Bog	10.00	41	1980	19
			26	1981	3(
			31	1982	18
Ramsey	Open City Field	7.28	18	1939	1:
			17	1940	1!
			19	1941	1!
St. Louis	Balsam Fir-Birch Forest	12.25	43	1972	2(
			44	1973	3!
			45	1974	2!
			49	1975	2:
St. Louis	Aspen Clear-Cut	7.50	48	1974	1:
			50	1975	2:
St. Louis	Mature Jack Pine Forest	12.02	47	1974	1
St. Louis	Burned Jack Pine Ridge	13.50	3	1973	1
			46	1974	1
St. Louis	Burned Jack Pine Ridge I	9.00	51	1975	1
St. Louis	Burned Jack Pine Ridge II	18.00	52	1974	2
St. Louis	Sedge-Cat-tail Wetland	1.00	53	1979	4
St. Louis	Sedge-Potentilla Wetland II	1.00	54	1979	2
Watonwan	Grass Fields	21.37	4	1980	1

Table 4. Winter Bird Population Studies in Minnesota (in alphabet per count on average is included in parentheses under the number

County	Habitat	Plot Size (ha)	Ref. #	Year
Clay	Floodplain Deciduous Forest	10	8	1965
Crow Wing	Jack Pine Forest	16.19	7	1952
Dakota	Mature (1946) Four-Row Belt	0.69	9	1979
			16	1980
			23	1981
Dakota	Mature (1948) Five-Row Belt	0.69	10	1979
			17	1980
			24	1981
Dakota	Mature (1949) Eight-Row Belt	0.36	11	1979
			18	1980
			25	1981
Dakota	Mature (1951) Three-Row Belt	0.32	12	1979
			19	1980
			26	1981
Dakota	Immature (1961) Nine-Row Belt	0.79	13	1979
			20	1980
			27	1981
Dakota	Immature (1966) Four-Row Belt	0.28	14	1979
			21	1980
			28	1981
Dakota	Immature (1974) Three-Row Belt	0.20	15	1979
			22	1980
			29	1981

Table 4. (contd.)

County	Habitat	Plot Size (ha)	Ref. #	Year
Morrison	Upland Oak-Poplar Forest	32.4	4	1967
			5	1968
			6	1969
Stearns	Upland Coniferous Plantation	10	1	1966
			2	1968
			3	1969

Table 3. Breeding Bird Censuses in Minnesota (in alphabetical order by county). The habitat category is in parentheses beside the habitat name.

County	Habitat (Type)	Plot Size	ID #	Year	Ind per 40 ha	S	E(S30)	Var. E(S30)	N 8.1ha	E(S8.1ha)	Var. E(S8.1ha)
Anoka	White Cedar Bog Forest	9.11	5	1948	162	14	13.0	0.7	32	13.3	0.5
			6	1949	201	14	12.0	1.2	40	13.3	0.5
			7	1950	302	22	15.8	2.3	61	21.1	0.7
			8	1951	180	19	16.0	1.6	36	17.7	0.9
Beltrami	Open Fen	15.01	42	1980	117	4	3.7	0.2	23	3.5	0.3
			27	1981	189	4	3.4	0.2	38	3.5	0.2
			32	1982	119	4	3.7	0.2	24	3.5	0.3
Carlton	Aspen-Birch Forest	20.48	20	1977	101	16	12.0	1.9	20	9.7	1.9
		14.00	57	1978	188	18	12.5	2.2	38	14.0	2.0
Cass	Mature Aspen-Northern Hardwoods Forest	17.00	21	1977	108	13	10.3	1.5	21	8.4	1.8
		12.51	60	1979	159	9	6.9	1.1	32	7.2	1.1
		13.84	64	1981	199	16	9.8	2.3	40	11.6	2.2
Cass	Aspen Forest (19-year)	7.08	59	1979	124	8	-	-	-	-	-
Cass	Red Pine Plantation	11.53	62	1979	156	14	11.3	1.5	31	11.5	1.4
Cass	Mature Aspen-Fir	11.17	68	1981	78	10	-	-	15	8.0	1.0
Clay	Burned Prairie	13.31	33	1972	63	6	-	-	12	4.5	0.7
Clay	Unburned Prairie	16.23	34	1972	78	8	7.8	0.2	15	5.3	1.1
Clearwater	Northern Conifer, Alder Edge and Bog	10.12	16	1958	272	18	13.9	1.9	55	17.3	0.6
Clearwater	Birch-Elm-Ash Forest	8.70	55	1979	616	22	13.9	2.7	124	21.8	0.2
Clearwater	Elm-Ash-Birch Forest	8.70	2	1980	395	23	14.8	2.8	80	22.6	0.4
			37	1981	473	29	15.1	3.7	95	28.2	0.6

Table 3. (contd.)

County	Habitat (Type)	Plot Size	ID #	Year	Ind per 40 ha	S	E(S30)	Var. E(S30)	N 8.1ha	E(S8.1ha)	Var. E(S8.1ha)
Clearwater	Mature Pine-Fir-Birch	12.75	35	1980	360	26	14.7	3.1	73	22.2	2.3
Clearwater	Mixed Successional Aspen-Oak-Conifer Forest	8.93	1	1980	326	20	13.6	2.4	66	19.2	0.6
			15	1981	331	16	11.3	1.9	67	15.4	0.5
			73	1982	488	25	15.9	2.7	98	24.4	0.6
Crow Wing	Jack Pine-Deciduous	16.19	74	1955	91	21	18.4	1.3	18	12.9	1.9
Dakota	Mature (1946) Four-Row Belt	0.69	75	1979	1340	8	-	-	-	-	-
			82	1980	289	4	-	-	-	-	-
			89	1981	405	4	-	-	-	-	-
Dakota	Mature (1948) Five-Row Belt	0.69	76	1979	4000	7	-	-	-	-	-
			83	1980	869	4	-	-	-	-	-
			90	1981	753	6	-	-	-	-	-
Dakota	Mature (1949) Eight-Row Belt	0.36	77	1979	3777	3	-	-	-	-	-
			84	1980	666	5	-	-	-	-	-
			91	1981	1666	10	-	-	-	-	-
Dakota	Mature (1951) Three-Row Belt	0.32	78	1979	1125	4	-	-	-	-	-
			85	1980	250	2	-	-	-	-	-
			92	1981	625	3	-	-	-	-	-
Dakota	Immature (1961) Nine-Row Belt	0.79	79	1979	1367	4	-	-	-	-	-
			86	1980	1012	6	-	-	-	-	-
			93	1981	1063	12	-	-	-	-	-
Dakota	Immature (1966) Four-Row Belt	0.28	80	1979	3142	6	-	-	-	-	-
			87	1980	3142	7	-	-	-	-	-
			94	1981	3428	8	-	-	-	-	-
Dakota	Immature (1974) Three-Row Belt	0.20	81	1979	1199	2	-	-	-	-	-
			88	1980	3999	10	-	-	-	-	-
			95	1981	4399	12	-	-	-	-	-

Table 3. (contd.)

County	Habitat (Type)	Plot Size	ID #	Year	Ind per 40 ha	S	E(S30)	Var. E(S30)	N 8.1ha	E(S8.1ha)	Var. E(S8.1ha)
Lake of the Woods	Open Black Spruce Bog	5.02	29	1980	63	4	-	-	-	-	-
			39	1981	103	6	-	-	-	-	-
			24	1982	119	6	-	-	-	-	-
Lake of the Woods	Shrub Swamp	12.51	40	1980	319	12	7.5	1.5	64	10.0	1.2
			25	1981	326	13	8.9	1.5	66	11.5	1.0
			30	1982	258	11	8.3	1.3	52	10.0	0.7
Lake of the Woods	Open Bog	10.00	41	1980	196	8	7.1	0.6	39	7.6	0.4
			26	1981	300	6	5.9	0.1	60	6	0
			31	1982	180	6	5.9	0.1	36	6	0
Ramsey	Open City Field	7.28	18	1939	120	16	-	-	-	-	-
			17	1940	153	17	-	-	-	-	-
			19	1941	153	12	-	-	-	-	-
St. Louis	Balsam Fir-Birch Forest	12.25	43	1972	267	23	13.3	3.0	54	18.6	2.5
			44	1973	352	22	12.4	2.9	71	18.8	2.0
			45	1974	257	22	13.0	3.0	52	18.0	2.3
			49	1975	238	23	13.1	3.1	48	17.7	2.7
St. Louis	Aspen Clear-Cut	7.50	48	1974	133	8	-	-	-	-	-
			50	1975	213	11	-	-	-	-	-
St. Louis	Mature Jack Pine Forest	12.02	47	1974	166	14	11.4	1.4	33	11.9	1.3
St. Louis	Burned Jack Pine Ridge	13.50	3	1973	162	9	7.8	0.7	33	8.0	0.6
			46	1974	142	18	12.6	2.4	28	12.0	2.5
St. Louis	Burned Jack Pine Ridge I	9.00	51	1975	160	12	10.8	0.8	32	11.2	0.6
St. Louis	Burned Jack Pine Ridge II	18.00	52	1974	228	13	9.7	1.6	46	11.2	1.2
St. Louis	Sedge-Cat-tail Wetland	1.00	53	1979	440	4	-	-	-	-	-
St. Louis	Sedge-Potentilla Wetland II	1.00	54	1979	240	2	-	-	-	-	-
Watonwan	Grass Fields	21.37	4	1980	121	15	11.9	1.5	24	10.9	1.6

Table 4. Winter Bird Population Studies in Minnesota (in alphabetical order by county). The number of species seen at least o per count on average is included in parentheses under the number of species.

County	Habitat	Plot Size (ha)	Ref. #	Year	Ind.per 40 ha	S	E(S50)	Var. E(S50)	N 8.1ha	E(S8.1ha)	Var. E(S8.1ha)
Clay	Floodplain Deciduous Forest	10	8	1965	92	7(3)	-	-	18	3.0	.04
Crow Wing	Jack Pine Forest	16.19	7	1952	90	(13)	-	-	18	9.3	1.45
Dakota	Mature (1946) Four-Row Belt	0.69	9	1979	291	8(3)	-	-		-	-
			16	1980	406	8(4)	-	-		-	-
			23	1981	2035	12(7)	-	-		-	-
Dakota	Mature (1948) Five-Row Belt	0.69	10	1979	2989	6(3)	-	-		-	-
			17	1980	1663	6(4)	-	-		-	-
			24	1981	517	8(3)	-	-		-	-
Dakota	Mature (1949) Eight-Row Belt	0.36	11	1979	0	3(0)	-	-		-	-
			18	1980	108	4(0)	-	-		-	-
			25	1981	549	7(1)	-	-	-	-	-
Dakota	Mature (1951) Three-Row Belt	0.32	12	1979	125	5(1)	-	-	-	-	-
			19	1980	1247	5(4)	-	-	-	-	-
			26	1981	125	6(1)	-	-	-	-	-
Dakota	Immature (1961) Nine-Row Belt	0.79	13	1979	309	7(2)	-	-	-	-	-
			20	1980	51	9(1)	-	-	-	-	-
			27	1981	155	4(2)	-	-	-	-	-
Dakota	Immature (1966) Four-Row Belt	0.28	14	1979	136	3(1)	-	-	-	-	-
			21	1980	137	5(1)	-	-	-	-	-
			28	1981	272	4(2)	-	-	-	-	-
Dakota	Immature (1974) Three-Row Belt	0.20	15	1979	0	1(0)	-	-	-	-	-
			22	1980	195	1(1)	-	-	-	-	-
			29	1981	0	2(0)	-	-	-	-	-

Table 4. (contd.)

County	Habitat	Plot Size (ha)	Ref. #	Year	Ind.per 40 ha	S	E(S50)	Var. E(S50)	N 8.1ha	E(S8.1ha)	Var. E(S8.1ha)
Morrison	Upland Oak-Poplar Forest	32.4	4	1967	5	5(3)	-	-	1	1	0
			5	1968	11	8(5)	-	-	2		
			6	1969	24	6(8)	-	-	4		
Stearns	Upland Coniferous Plantation	10	1	1966	203	15(8)	7.2	0.58	41	6.6	0.91
			2	1968	224	12(8)	7.7	0.29	45	7.4	0.49
			3	1969	92	9(4)	-	-	18	3.3	0.46

Table 5. Relative importance of neotropical migrants in Minnesota habitats. "% migrant spp." is the number of migrant species divided by the total number of species. "% migrant terr." is the number of territories held by neotropical migrants divided by the total number of territories.

Habitat	N	% migrant spp. median	(range)	% migrant terr. median	(range)
Shelterbelt	21	0	(0-17)	0	(0-22)
Open field	3	0	(0- 7)	0	(0- 5)
Open fen	3	0		0	
Open bog	3	0		0	
Emergent wetland	3	0		0	
Prairie	2	7	(0-13)	1	(0- 2)
Closed spruce bog	3	21	(18-21)	25	(24-33)
Shrub swamp	3	23	(17-27)	7	(4-11)
Open spruce bog	3	25	(20-29)	13	(12-15)
White cedar bog forest	4	36	(30-36)	30	(20-36)
Pine	9	43	(32-56)	58	(36-80)
Coniferous-deciduous	7	50	(35-57)	78	(54-83)
Aspen-birch	3	56	(53-65)	89	(85-90)
Mixed deciduous	6	58	(53-70)	81	(53-97)
Oak	7	62	(56-67)	73	(64-74)

Table 6. Summary of published bird counts in Minnesota (not including Breeding Bird Censuses and Winter Bird Population Studies).

County	Citation	Count Method	Habitat Type	Year(s)
Anoka	LaFond (1979)	Auto count	Mixed	1978
Becker Clearwater Mahnomen Norman	Kelleher (1967)	Spot map	deciduous woods	1964-66
Beltrami	Niemi and Hanowski (1984)	Line transect Spot map	Closed spruce Tamarack Open spruce Low shrub High shrub Sedge fen	1980-82
Clearwater	Hickey (1956)	Auto count	Mixed	1954
Clearwater	Kendeigh (1956)	Line transect	Mixed	1955
Clearwater	Lefebvre (1959)	Survey	Bog	1959
Clearwater	Seabloom (1960)	Line transect	Mixed	1959
Cook	Wilson and Berlin (1983)	Point count	Black spruce Balsam fir Paper birch	1981
Cook	Apfelbaum and Haney (1981)	Spot map	Jack pine-black spruce	1976
Cook	Haney and Apfelbaum (1984)	Spot map	Jack pine-black spruce	1984 (?)

Table 6 (contd.)

County	Citation	Count Method	Habitat Type	Year(s)
Cook	Niemi (1987)	Line transect	Spruce-fir Northern hardwoods-fir Wetlands	1983
Kanabec Mil Lacs	Back (1982)	Spot map	Aspen woods and clearcuts	1978-79
Lake	Niemi and Hanowski (1984)	Spot map	Mixed aspen-birch Fir-pine and spruce logged habitats	1978
Polk	Svedarsky, et al. (1983)	Spot map	Cottonwood savanna Willow swamp Cottonwood lowland Willow marsh	1976-80
St. Louis	Bergstedt and Niemi (1974)	Spot map	Jack pine Aspen	1973
St. Louis	Rusterholtz (1974)		Island	
St. Louis	Doran and Todd (1976)	Modified spot map	Jack pine clearcut Aspen clearcut (10-yr) Jack pine (10-20 ft.) Mature lowland conifer Upland deciduous	1975
St. Louis	Howe (1977)		Island	
St. Louis	Hanowski and Niemi (1985)	Line transect	wetlands	1985
Wabasha	Longley (1958)	Survey	Mixed	1951-55

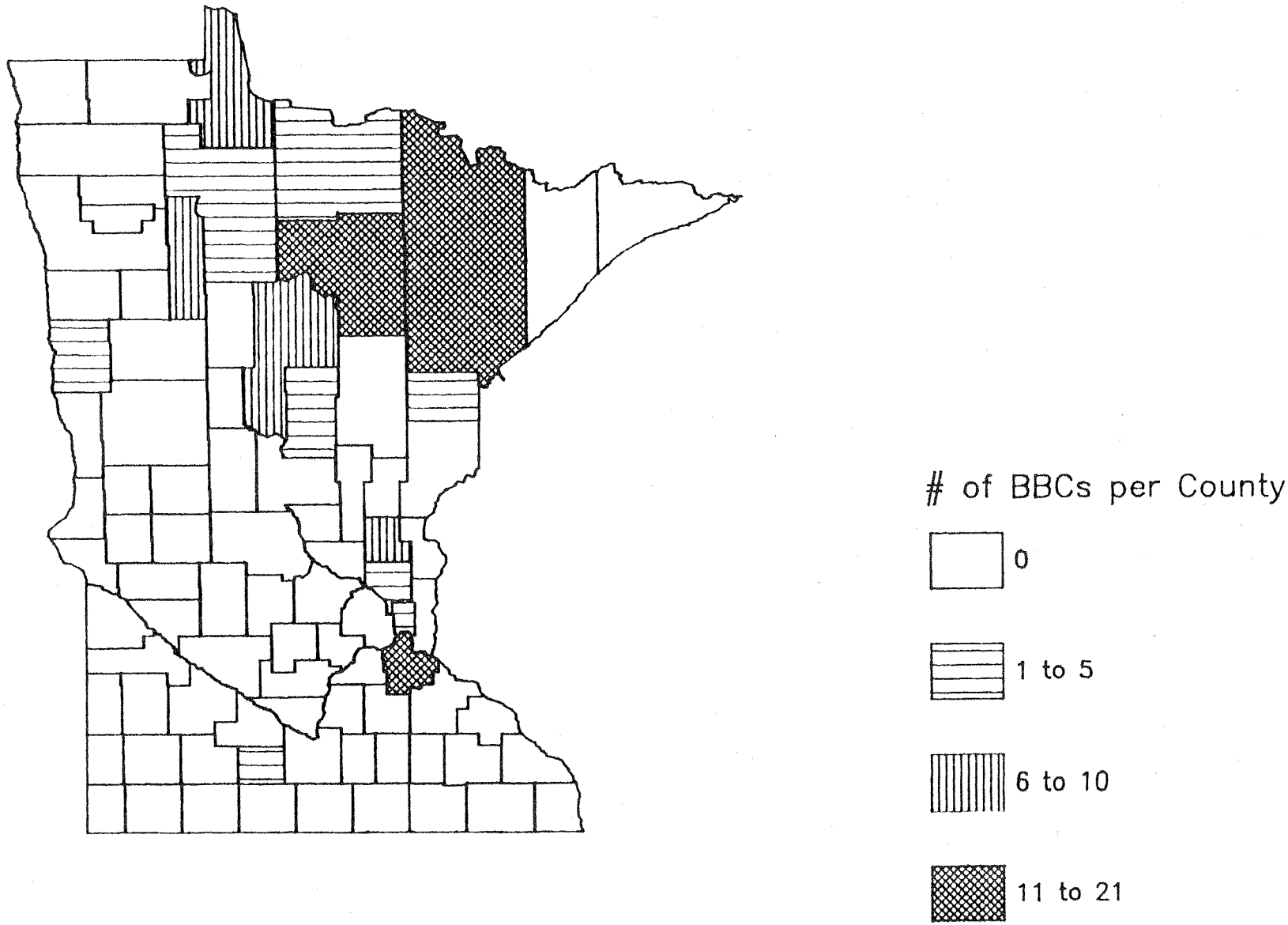
Figure 1. Counties in which Breeding Bird Censuses were conducted in Minnesota.

Figure 2. Counties in which Winter Bird Population Studies were conducted in Minnesota.

Figure 3. Habitats listed in order of increasing estimated species richness [E(S)] standardized to a plot size of 8.1 ha for all BBCs conducted in Minnesota.

Figure 4. Habitats listed in order of increasing estimated species richness [E(S)] standardized to a plot size of 8.1 ha for all WBPSs conducted in Minnesota.

Figure 5. Counties in which independent studies of bird communities were conducted in Minnesota.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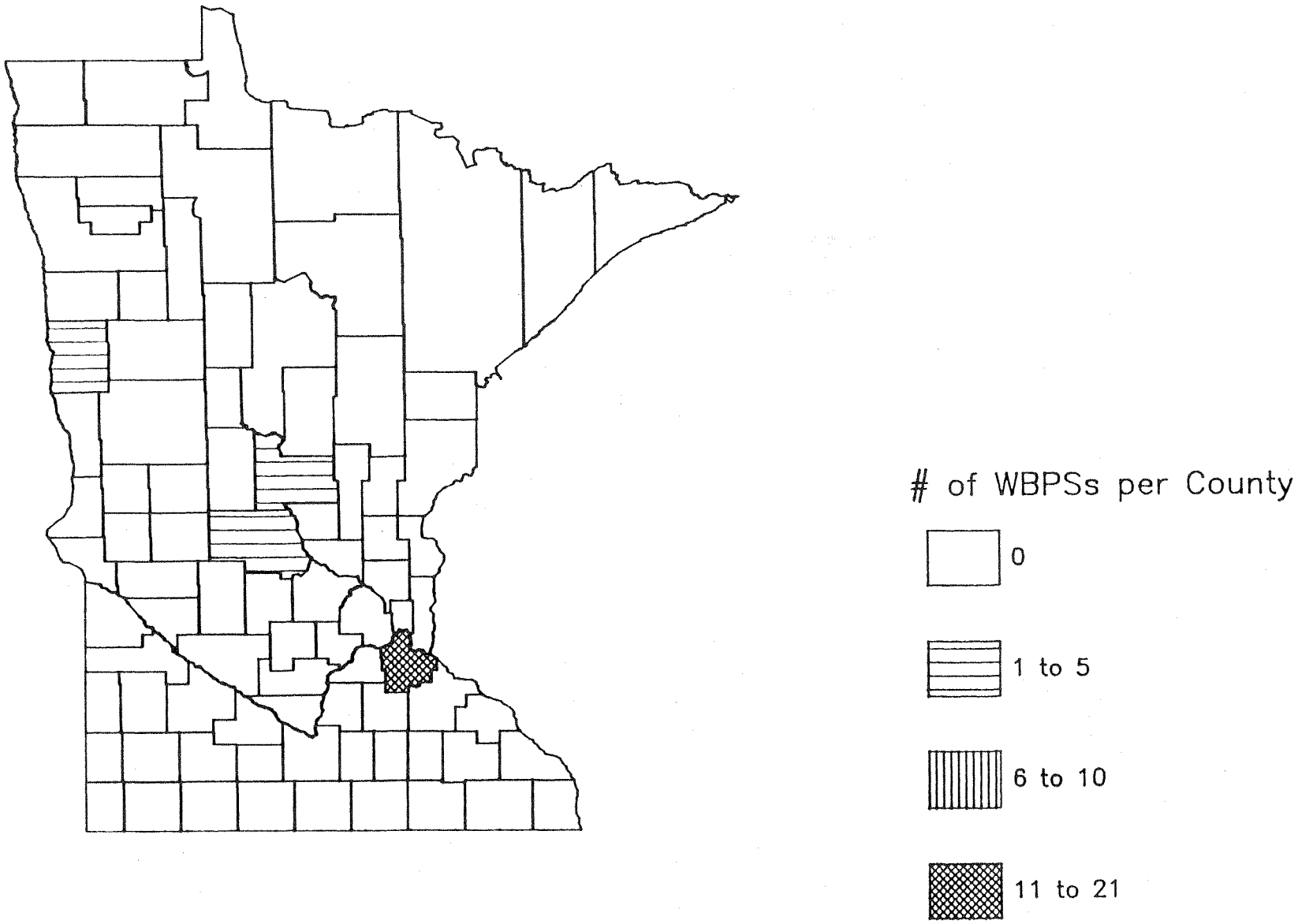
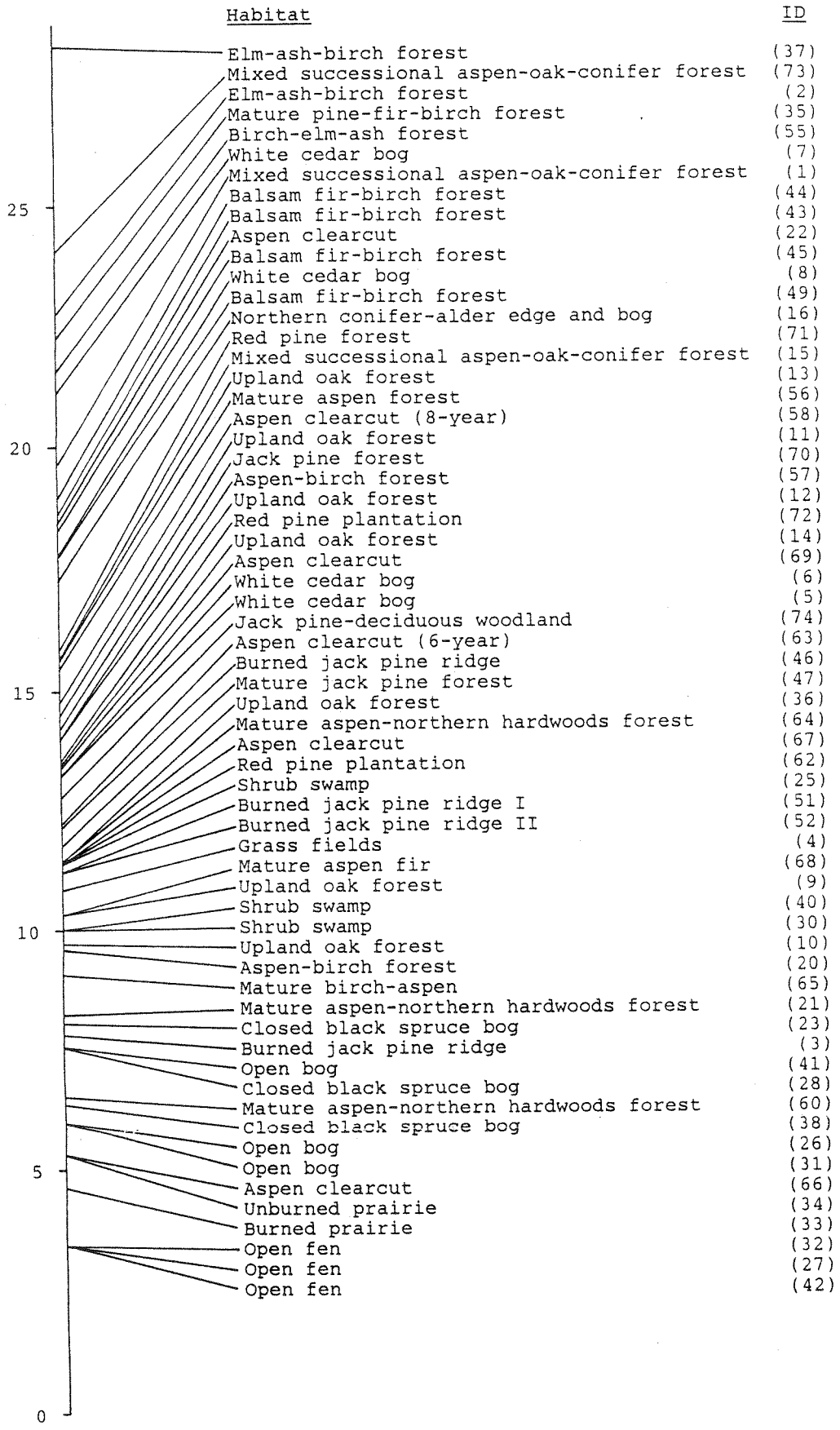
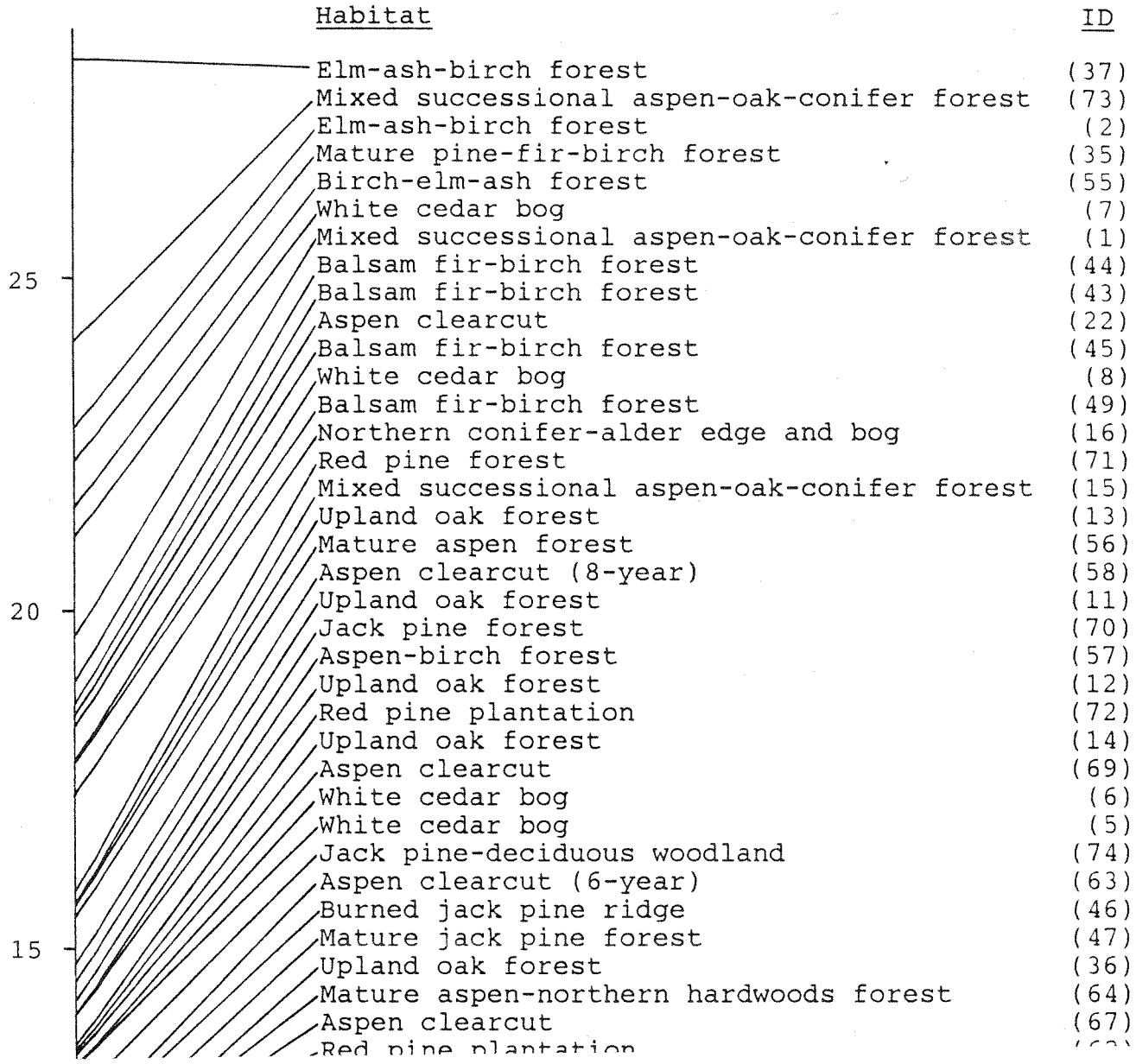
1 to 5
6 to 10
11 to 21


# of WBPSs per County
0
1 to 5
6 to 10
11 to 21

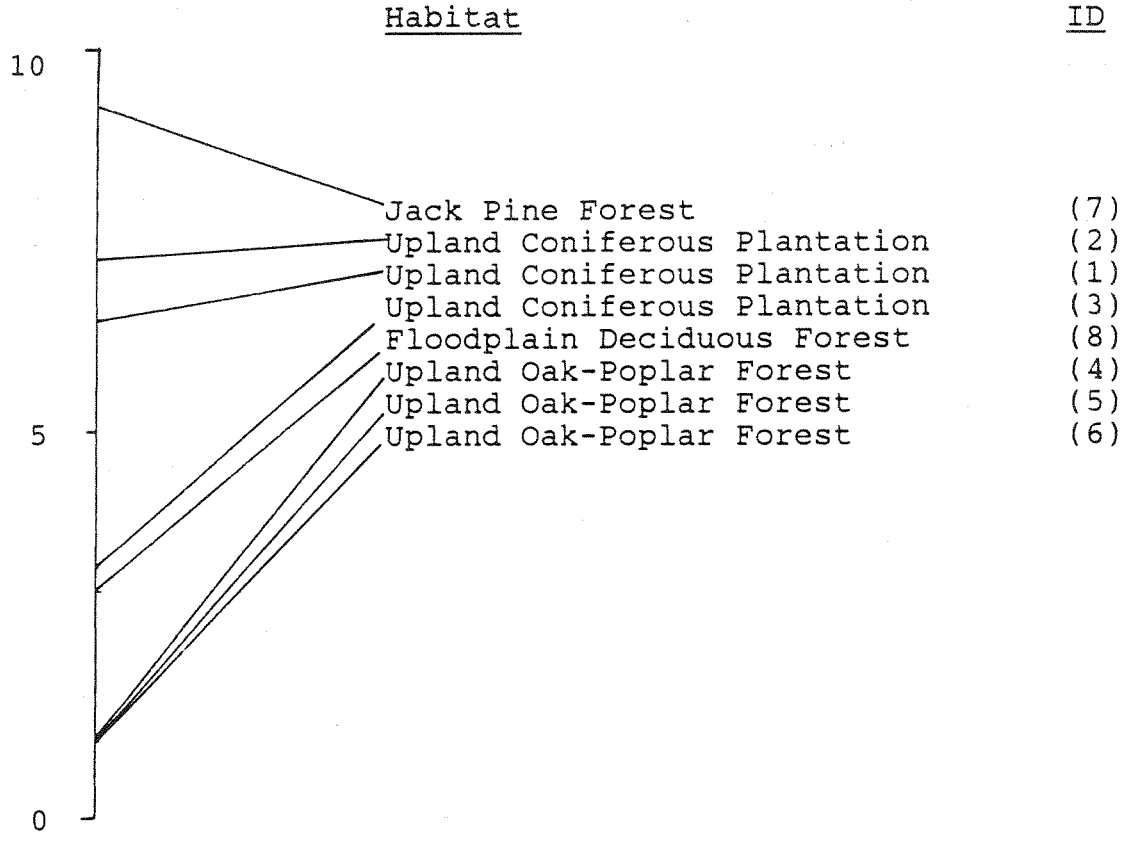
E(S) 8.1 ha

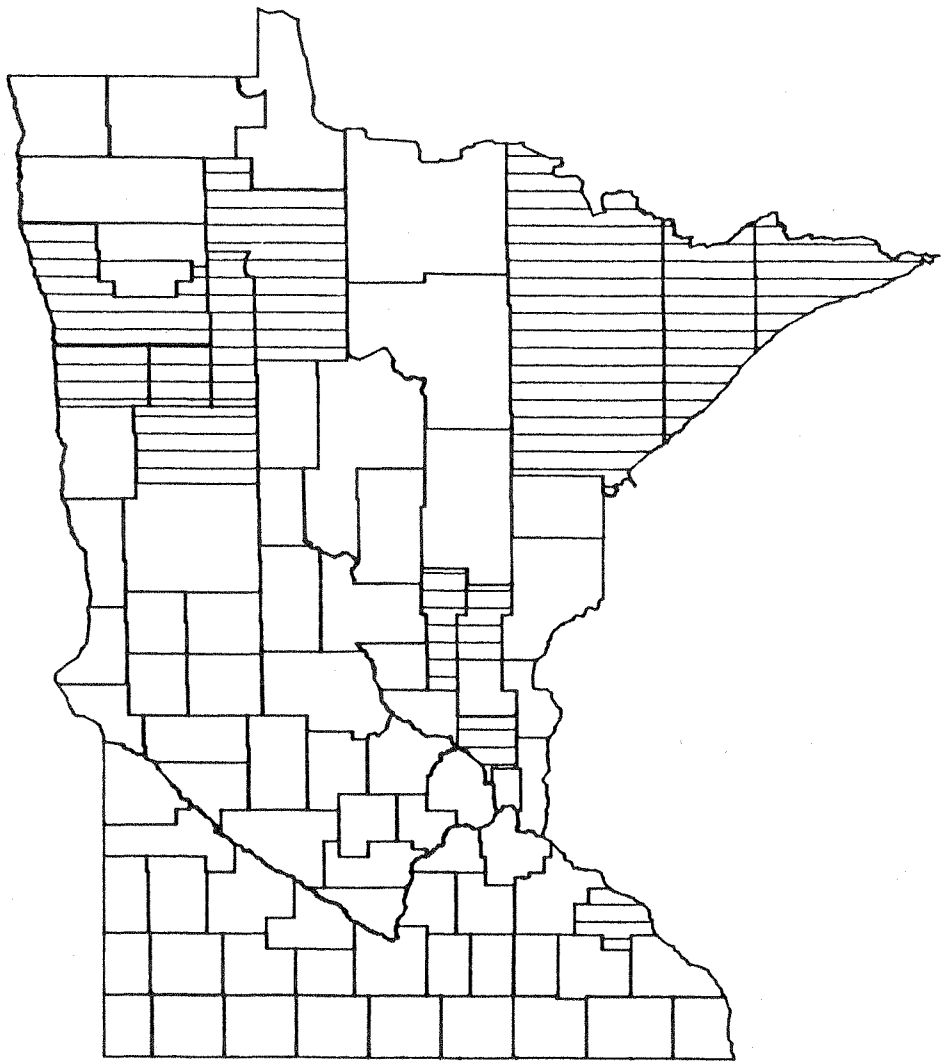

Habitat
ID
Elm-ash-birch forest (37)
Mixed successional aspen-oak-conifer forest (73)
Elm-ash-birch forest (2)
Mature pine-fir-birch forest (35)
Birch-elm-ash forest (55)
White cedar bog (7)
Mixed successional aspen-oak-conifer forest (1)
Balsam fir-birch forest (44)
Balsam fir-birch forest (43)
Aspen clearcut (22)
Balsam fir-birch forest (45)
White cedar bog (8)
Balsam fir-birch forest (49)
Northern conifer-alder edge and bog (16)
Red pine forest (71)
Mixed successional aspen-oak-conifer forest (15)
Upland oak forest (13)
Mature aspen forest (56)
Aspen clearcut (8-year) (58)
Upland oak forest (11)
Jack pine forest (70)
Aspen-birch forest (57)
Upland oak forest (12)
Red pine plantation (72)
Upland oak forest (14)
Aspen clearcut (69)
White cedar bog (6)
White cedar bog (5)
Jack pine-deciduous woodland (74)
Aspen clearcut (6-year) (63)
Burned jack pine ridge (46)
Mature jack pine forest (47)
Upland oak forest (36)
Mature aspen-northern hardwoods forest (64)
Aspen clearcut (67)
Red pine plantation (62)
Shrub swamp (25)
Burned jack pine ridge I (51)
Burned jack pine ridge II (52)
Grass fields (4)
Mature aspen fir (68)
Upland oak forest (9)
Shrub swamp (40)
Shrub swamp (30)
Upland oak forest (10)
Aspen-birch forest (20)
Mature birch-aspen (65)
Mature aspen-northern hardwoods forest (21)
Closed black spruce bog (23)
Burned jack pine ridge (3)
Open bog (41)
Closed black spruce bog (28)
Mature aspen-northern hardwoods forest (60)
Closed black spruce bog (38)
Open bog (26)
Open bog (31)
Aspen clearcut (66)
Unburned prairie (34)
Burned prairie (33)
Open fen (32)
Open fen (27)
Open fen (42)
25
20
15
10
5
0

E(S) 8.1 ha


Habitat
ID
Elm-ash-birch forest (37)
Mixed successional aspen-oak-conifer forest (73)
Elm-ash-birch forest (2)
Mature pine-fir-birch forest (35)
Birch-elm-ash forest (55)
White cedar bog (7)
Mixed successional aspen-oak-conifer forest (1)
Balsam fir-birch forest (44)
Balsam fir-birch forest (43)
Aspen clearcut (22)
Balsam fir-birch forest (45)
White cedar bog (8)
Balsam fir-birch forest (49)
Northern conifer-alder edge and bog (16)
Red pine forest (71)
Mixed successional aspen-oak-conifer forest (15)
Upland oak forest (13)
Mature aspen forest (56)
Aspen clearcut (8-year) (58)
Upland oak forest (11)
Jack pine forest (70)
Aspen-birch forest (57)
Upland oak forest (12)
Red pine plantation (72)
Upland oak forest (14)
Aspen clearcut (69)
White cedar bog (6)
White cedar bog (5)
Jack pine-deciduous woodland (74)
Aspen clearcut (6-year) (63)
Burned jack pine ridge (46)
Mature jack pine forest (47)
Upland oak forest (36)
Mature aspen-northern hardwoods forest (64)
Aspen clearcut (67)
Red pine plantation
25
20
15

E(S) 8.1 ha


Habitat
ID
10
5
0
Jack Pine Forest (7)
Upland Coniferous Plantation (2)
Upland Coniferous Plantation (1)
Upland Coniferous Plantation (3)
Floodplain Deciduous Forest (8)
Upland Oak-Poplar Forest (4)
Upland Oak-Poplar Forest (5)
Upland Oak-Poplar Forest (6)



# of Miscellaneous Studies per County

0

1 to 5

6 to 10

11 to 21

Appendix I. Researchers who were asked for comments on the list of community studies of birds of Minnesota. Asterisks identify those individuals who responded to my letter.

* Dr. Robert A. Askins
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St. Paul, Minnesota 55108

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Warner Nature Center
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Duluth, Minnesota 55812

Dr. Steve Wilson
Minnesota Department of Natural Resources
Star Route 2 Box 3710
Ely, Minnesota 55731

Appendix II. List of Breeding Bird Censuses that were conducted in Minnesota.

1. Barzen, J. 1981. BBC 71. Mixed Successional Aspen-Oak-Conifer Forest. Amer. Birds 35:66-67.

2. Bell, B. and M. Candee. 1981. BBC 34. Elm-Ash-Birch Forest. Amer. Birds 35:58-59.

3. Bergstedt, B.V. 1973. BBC 62. Burned Jack Pine Ridge. Amer. Birds 27:987-988.

4. Braband, L. 1981. BBC 218. Grass Fields. Amer. Birds 35:103,106.

5. Breckenridge, W.J. 1955. BBC 1 (1948). White Cedar Bog. Aud. Field Notes 9:408-412.

6. _____. 1955. BBC 1 (1949). White Cedar Bog. Aud. Field Notes 9:408-412.

7. _____. 1955. BBC 1 (1950). White Cedar Bog. Aud. Field Notes 9:408-412.

8. _____. 1955. BBC 1 (1951). White Cedar Bog. Aud. Field Notes 9:408-412.

9. _____. 1955. BBC 1 (1948). Upland Oak Forest. Aud. Field Notes 9:408-412.

10. _____. 1955. BBC 1 (1949). Upland Oak Forest. Aud. Field Notes 9:408-412.

11. _____. 1955. BBC 1 (1950). Upland Oak Forest. Aud. Field Notes 9:408-412.

12. _____. 1955. BBC 1 (1951). Upland Oak Forest. Aud. Field Notes 9:408-412.

13. _____. 1955. BBC 1 (1952). Upland Oak Forest. Aud. Field Notes 9:408-412.

14. _____. 1955. BBC 1 (1954). Upland Oak Forest. Aud. Field Notes 9:408-412.

15. Buek, R.J. and L.C. Mueller. 1982. BBC 70. Mixed Successional Aspen-Oak-Conifer Forest. Amer. Birds 36:70.

16. Rosenwinkel, E.R. and J. Carlson. 1958. BBC 33. Northern Conifer - Alder Edge and Bog. Aud. Field Notes 12:460.

17. Cummings, W.M. 1940. BBC 9. Open City Field. Bird Lore 42 (supplement):478.

18. _____. 1941. BBC 14 (1939). Open City Field. Audubon 43 (supplement):486.

19. _____. 1941. BBC 14 (1941). Open City Field. Audubon 43 (supplement):486.

20. Dawson, D.K. and J.R. Probst. 1978. BBC 34. Aspen-Birch Forest. Amer. Birds 32:65.

21. _____. 1978. BBC 35. Mature Aspen-Northern Hardwoods Forest. Amer. Birds 32:65-66.

22. _____. 1978. BBC 77. Aspen Clearcut. Amer. Birds 32:79.

23. Hanowski, J., M. Nevers, and G.J. Niemi. 1982. BBC 189. Closed Black Spruce Bog. Amer. Birds 36:100.

24. _____. 1982. BBC 190. Open Black Spruce Bog. Amer. Birds 36:100-101.

25. _____. 1982. BBC 191. Shrub Swamp. Amer. Birds 36:100-101.

26. _____. 1982. BBC 192. Open Bog. Amer. Birds 36:100-101.

27. _____. 1982. BBC 193. Open Fen. Amer. Birds 36:100-101.

28. Hanowski, J. and G.J. Niemi 1983. BBC 178. Closed Black Spruce Bog. Amer. Birds 37:100.

29. _____. 1983. BBC 179. Open Black Spruce Bog. Amer. Birds 37:100.

30. _____. 1983. BBC 180. Shrub Swamp. Amer. Birds 37:101.

31. _____. 1983. BBC 181. Open Bog. Amer. Birds 37:101.

32. _____. 1983. BBC 182. Open Fen. Amer. Birds 37:101.

33. Hibbard, E.A. 1972. BBC 97. Burned Prairie. Amer.Birds 26:1004-1005.

34. _____. 1972. BBC 98. Unburned Prairie. Amer.Birds 26:1005.

35. Mills, P.J. 1981. BBC 70. Mature Pine-Fir-Birch Forest. Amer. Birds 35:66.

36. Mitchell, M.J. 1960. BBC 1. Upland Oak Forest. Aud.

Field Notes 14:488-489.

37. Nagel, M. and S. Madsen. 1982. BBC 35. Elm-Ash Birch Forest. Amer. Birds 36:62.

38. Nevers, M., J. Hanowski, and G.J. Niemi. 1981. BBC 201. Closed Black Spruce Bog. Amer. Birds 35:100.

39. _____. 1981. BBC 202. Open Black Spruce Bog. Amer. Birds 35:100.

40. _____. 1981. BBC 203. Shrub Swamp. Amer. Birds 35:100.

41. _____. 1981. BBC 204. Open Bog. Amer. Birds 35:100.

42. _____. 1981. BBC 205. Open Fen. Amer. Birds 35:100.

43. Niemi, G.J. 1972. BBC 29. Balsam Fir-Birch Forest. Amer. Birds 26:956.

44. _____. 1973. BBC 35. Balsam Fir-Birch Forest. Aud. Field Notes 27:974.

45. _____. 1974. BBC 49. Balsam Fir-Birch Forest. Amer. Birds 28:1011-1012.

46. _____. 1974. BBC 60. Burned Jack Pine Ridge. Amer. Birds 28:1016.

47. _____. 1974. BBC 61. Mature Jack Pine Forest. Amer. Birds 28:1016-1017.

48. _____. 1974. BBC 69. Aspen Clear-cut. Amer. Birds 28:1021.

49. _____. 1975. BBC 44. Balsam Fir-Birch Forest. Amer. Birds 29:1099.

50. _____. 1975. BBC 64. Aspen Clear-cut. Amer. Birds 29:1106.

51. _____. 1975. BBC 65. Burned Jack Pine Ridge I. Amer. Birds 29:1106.

52. _____. 1975. BBC 66. Burned Jack Pine Ridge II. Amer. Birds 29:1107.

53. _____. 1980. BBC 194. Sedge-Cat-tail Wetland. Amer. Birds 34:98.

54. _____. 1980. BBC 197. Sedge-Potentilla Wetland. Amer. Birds 34:99.

55. Ponto, S. and E. Loeffler. 1980. BBC 28. Birch-Elm-Ash Forest. Amer. Birds 34:51-52.

56. Rakstad, D. and J.R. Probst. 1979. BBC 27. Mature Aspen Forest. Amer. Birds 33:63.

57. _____. 1979. BBC 28. Aspen-Birch Forest. Amer. Birds 33:63-64.

58. _____. 1979. BBC 78. Aspen Clearcut (8-year). Amer. Birds 33:77.

59. _____. 1980. BBC 27. Aspen Forest (19-year). Amer. Birds 34:51.

60. _____. 1980. BBC 29. Mature Aspen-Northern Hardwoods Forest. Amer. Birds 34:52.

61. _____. 1980. BBC 30. Young Aspen Forest. Amer. Birds 34:52.

62. _____. 1980. BBC 68. Red Pine Plantation. Amer. Birds 34:62.

63. _____. 1980. BBC 88. Aspen Clearcut (6-year). Amer. Birds 34:67.

64. _____. 1982. BBC 36. Mature Aspen-Northern Hardwoods Forest. Amer. Birds 36:62.

65. _____. 1982. BBC 37. Mature Birch-Aspen. Amer. Birds 36:62.

66. _____. 1982. BBC 39. Aspen Clearcut. Amer. Birds 36:62-63.

67. _____. 1982. BBC 40. Aspen Clearcut. Amer. Birds 36:63.

68. _____. 1982. BBC 69. Mature Aspen-Fir. Amer. Birds 36:70.

69. _____. 1983. BBC 43. Aspen Clearcut. Amer. Birds 37:66.

70. _____. 1983. BBC 67. Jack Pine Forest. Amer. Birds 37:72.

71. _____. 1983. BBC 68. Red Pine Forest. Amer. Birds 37:72.

72. _____. 1983. BBC 69. Red Pine Plantation. Amer. Birds 37:72.

73. Tillotson, L. and K. Horgan. 1983. BBC 212. Mixed Succesional Aspen-Oak-Conifer Forest. Amer. Birds 37:108.

74. Wass, M. 1955. BBC 16. Jack Pine-Deciduous Woodland. Aud. Field Notes 9:419.

75. Yahner, R.H. 1980. BBC 111. Mature (1946) Four-row Shelterbelt. Amer. Birds 34:71.

76. _____. 1980. BBC 112. Mature (1948) Five-row Shelterbelt. Amer. Birds 34:71.

77. _____. 1980. BBC 113. Mature (1949) Eight-row Shelterbelt. Amer. Birds 34:71.

78. _____. 1980. BBC 114. Mature (1951) Three-row Shelterbelt. Amer. Birds 34:72.

79. _____. 1980. BBC 115. Immature (1961) Nine-row Shelterbelt. Amer. Birds 34:72.

80. _____. 1980. BBC 116. Immature (1966) Four-row Shelterbelt. Amer. Birds 34:72.

81. _____. 1980. BBC 117. Immature (1974) Three-row Shelterbelt. Amer. Birds 34:72.

82. _____. 1981. BBC 151. Mature (1946) Four-row Shelterbelt. Amer. Birds 35:84.

83. _____. 1981. BBC 150. Mature (1948) Five-row Shelterbelt. Amer. Birds 35:84.

84. _____. 1981. BBC 149. Mature (1949) Eight-row Shelterbelt. Amer. Birds 35:85.

85. _____. 1981. BBC 148. Mature (1951) Three-row Shelterbelt. Amer. Birds 35:85.

86. _____. 1981. BBC 147. Immature (1961) Nine-row Shelterbelt. Amer. Birds 35:85.

87. _____. 1981. BBC 146. Immature (1966) Four-row Shelterbelt. Amer. Birds 35:85.

88. _____. 1981. BBC 145. Immature (1974) Three-row Shelterbelt. Amer. Birds 35:85.

89. _____. 1982. BBC 125. Mature (1946) Four-row Shelterbelt. Amer. Birds 36:82.

90. _____. 1982. BBC 124. Mature (1948) Five-row Shelterbelt. Amer. Birds 36:81-82

91. _____. 1982. BBC 123. Mature (1949) Eight-row Shelterbelt. Amer. Birds 36:81.

92. _____. 1982. BBC 122. Mature (1951) Three-row Shelterbelt. Amer. Birds 36:81.

93. _____. 1982. BBC 121. Immature (1961) Nine-row Shelterbelt. Amer. Birds 36:81.

94. _____. 1982. BBC 120. Immature (1966) Four-row Shelterbelt. Amer. Birds 36:81.

95. _____. 1982. BBC 119. Immature (1974) Three-row Shelterbelt. Amer. Birds 36:81.

Appendix III. List of Winter Bird Population Studies that were conducted in Minnesota.

1. Eckert, K., R.P. Russell. 1966. WBPS 14. Upland Coniferous Plantation. Aud. Field Notes 20:469.

2. Eckert, K.R. 1968. WBPS 20. Upland Coniferous Plantation. Aud. Field Notes 22:489-490.

3. Ford, N.L. 1969. WBPS 21. Upland Coniferous Plantation. Aud. Field Notes 23:536.

4. Ryan, L.S. 1967. WBPS 18. Upland Oak-Poplar Forest. Aud. Field Notes 21:468-469.

5. _____ 1968. WBPS 19. Upland Oak-Poplar Forest. Aud. Field Notes 22:489.

6. _____ 1969. WBPS 20. Upland Oak-Poplar Forest. Aud. Field Notes 23:536.

7. Wass, M. 1952. WBPS 28. Jack Pine Forest. Aud. Field Notes 6:226.

8. Welter, L. 1965. WBPS 13. Floodplain Deciduous Forest. Aud. Field Notes 19:424.

9. Yahner, R.H. 1980. WBPS 52. Mature Four-row Shelterbelt. Amer. Birds 34:38.

10. _____ 1980. WBPS 53. Mature Five-row Shelterbelt. Amer. Birds 34:38.

11. _____ 1980. WBPS 54. Mature Eight-row Shelterbelt. Amer. Birds 34:38.

12. _____ 1980. WBPS 55. Mature Three-row Shelterbelt. Amer. Birds 34:38.

13. _____ 1980. WBPS 56. Immature Nine-row Shelterbelt. Amer. Birds 34:39.

14. _____ 1980. WBPS 57. Immature Four-row Shelterbelt. Amer. Birds 34:39.

15. _____ 1980. WBPS 58. Immature Three-row Shelterbelt. Amer. Birds 34:39.

16. _____1981. WBPS 65. Mature Four-row Shelterbelt. Amer. Birds 35:39.

17. _____1981. WBPS 66. Mature Five-row Shelterbelt. Amer. Birds 35:39.

18. _____1981. WBPS 67. Mature Eight-row Shelterbelt. Amer. Birds 35:39.

19. _____1981. WBPS 68. Mature Three-row Shelterbelt. Amer. Birds 35:39.

20. _____1981. WBPS 69. Immature Nine-row Shelterbelt. Amer. Birds 35:39.

21. _____1981. WBPS 70. Immature Four-row Shelterbelt. Amer. Birds 35:39.

22. _____1981. WBPS 71. Immature Three-row Shelterbelt. Amer. Birds 35:39.

23. _____1982. WBPS 62. Mature Four-row Shelterbelt. Amer. Birds 36:44.

24. _____1982. WBPS 63. Mature Five-row Shelterbelt. Amer. Birds 36:44.

25. _____1982. WBPS 64. Mature Eight-row Shelterbelt. Amer. Birds 36:44.

26. _____1982. WBPS 65. Mature Three-row Shelterbelt. Amer. Birds 36:44.

27. _____1982. WBPS 66. Immature Nine-row Shelterbelt. Amer. Birds 36:45.

28. _____1982. WBPS 67. Immature Four-row Shelterbelt. Amer. Birds 36:45.

29. _____1982. WBPS 68. Immature Three-row Shelterbelt. Amer. Birds 36:45.

18. _____1981. WBPS 67. Mature Eight-row Shelterbelt. Amer. Birds 35:39.

19. _____1981. WBPS 68. Mature Three-row Shelterbelt. Amer. Birds 35:39.

20. _____1981. WBPS 69. Immature Nine-row Shelterbelt. Amer. Birds 35:39.

21. _____1981. WBPS 70. Immature Four-row Shelterbelt. Amer. Birds 35:39.

22. _____1981. WBPS 71. Immature Three-row Shelterbelt. Amer. Birds 35:39.

23. _____1982. WBPS 62. Mature Four-row Shelterbelt. Amer. Birds 36:44.

24. _____1982. WBPS 63. Mature Five-row Shelterbelt. Amer. Birds 36:44.

25. _____1982. WBPS 64. Mature Eight-row Shelterbelt. Amer. Birds 36:44.

26. _____1982. WBPS 65. Mature Three-row Shelterbelt. Amer. Birds 36:44.

27. _____1982. WBPS 66. Immature Nine-row Shelterbelt. Amer. Birds 36:45.

28. _____1982. WBPS 67. Immature Four-row Shelterbelt. Amer. Birds 36:45.

29. _____1982. WBPS 68. Immature Three-row Shelterbelt. Amer. Birds 36:45.