REGIONAL COPPER-NICKEL STUDY

SONG BIRDS OF THE STUDY AREA

July 5, 1978

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Minnesota Environmental Quality Board

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INTRODUCTION

Birds are an integral part of all ecosystems. Their complex patterns of distribution and abundance provide the biologist with an important tool for evaluating environmental conditions. During the breeding season, when many species have specific horizontal and vertical niche requirements (MacArthur 1958, Cody 1974), the composition of the avian community reflects upon the structure and diversity of the vegetation (Probst 1976, MacArthur and MacArthur 1961, Willson 1974, Anderson and Shugart 1974). During the winter, when birds must survive amidst extremely low temperatures and scarce food resources (Kricher 1975), the pattern of habitat utilization reflects upon the ability of different habitats to provide the necessary requirements for survival.

Because the composition of the avifauna directly reflects biotic and abiotic features of the environment, it quickly responds to any natural or artifical habitat alteration. Following forest fires, the open canopy and the abundance of burned snags and stubs may attract cavity nesting species such as the eastern bluebird (*Sialia sialis*) (Bergstedt and Niemi 1974). Likewise, following timber harvest, many insectivorous forest species that depended on the canopy layers of the forest for food, are replaced by granivorous species than can exploit the seed crops of the young herbaceous cover (Hagar 1960). Before biologists can predict the potential impacts of habitat alterations upon animal communities, they must first characterize the communities and assess the influence of various habitat features upon their composition.

The primary objective of the Regional Copper-Nickel Bird Study was to identify and describe the major bird communities within the RCNSA. Characterizing these communities and defining the influence of the vegetation upon their composition is a necessary prerequisite to predicting the potential impacts of environmental changes related to copper-nickel mining.

DESCRIPTION OF THE STUDY AREA

The Regional Copper-Nickel Study Area (Study Area) encompasses approximately 2000 square miles of land in two northeastern Minnesota counties, Lake County and St. Louis County (Figure 1). Extending from the western arm of Vermillion Lake east to Snowbank Lake, and from the north arm of Burntside Lake south to Bassett Lake, over half of the land is currently in government ownership. Terrestial studies concentrated in a region northeast and south of the Giant's Range.

The Giant's Range is the only predominant bedrock feature in the RCNSA. Rising approximately 200-400 feet above the surrounding terrain, it extends from Grand Rapids, Minnesota, east-northeast to Babbitt, Minnesota. A band of copper-nickel mineralization lies adjacent to its southern edge. Glacial features, such as glacial lake beds, end moraines, and an extensive drumlin field, are primarily responsible for the physiography of the remainder of the Study Area (Olcott and Siegel 1978).

The original vegetation of the area was a mosaic of mature red and white pine forests (*Pinus resinosa* and *Pinus strobus*), jack pine forests (*Pinus banksiana*), conifer bogs, and aspen-birch forests (*Populus tremuloides* and Betula papyrifera) (Marschner 1930). When the area was surveyed and settlement began in the 1880's, the red and white pine forests, concentrated primarily in the St. Louis watershed, were the first to be harvested. At present, virgin timber is virtually absent from the RCNSA. The little that remains in the northern watersheds is currently being harvested.

The vegetation cover of the area today is generally very disturbed and patchy in extent. Throughout the region, the effects of logging, burning, and various other forest management practices are apparent. Natural pine stands have now been replaced primarily by managed jack pine and red pine plantations. Because jack pine is harvested at 50-70 years of age, and red pine at 120-180 years of age, succession to the more mature red pine-white pine forest and the spruce-fir (Picea sp. and Abies balsamea) climax of the area is no longer likely. White pine succession has also been seriously halted by the species susceptibility to white pine blister rust.

All stages of plantation development are present throughout the Study Area, ranging from stands that have been recently clearcut to stands supporting mature forests. During the early stages of development, the young pine seedlings are likely to be quickly overtopped by a dense growth of young aspen suckers. Management techniques, such as hand-release and herbicide, are used to remove the faster growing aspen.

Aspen-birch forests are present throughout the Study Area but are best developed in the St. Louis watershed and along moraines near the Stony River. If left undisturbed these pioneer forests are likely to be replaced by shade-tolerant conifers such as red pine or balsam fir. Well-stocked stands however, are generally harvested before succession proceeds to a more coniferous composition. The thin-soiled, bedrock-exposed landscape in the northern watersheds supports a more mixed deciduous-coniferous forest with such species as aspen, birch, balsam fir and black spruce (*Picea mariana*). Some of the larger stands in this community type are presently being harvested and restocked with jack pine or red pine.

Conifer bogs are also well-distributed throughout the area in old glacial lake beds and along major streams. The most extensive conifer lowlands are located in the eastern half of the St. Louis watershed (Figure 1). Further south, in the lowlands of the Toimi Drumlin field, conifer bogs are replaced by more nutrient-rich alder carrs (*Alnus rugosa*).

METHODS

Background to Community Analysis - For the biologist, one of the first steps in data analysis is the attempt to identify natural groupings of organisms, or communities. Communities can be distinquished by any of a wide variety of classification criteria. The criteria range from the more subjective techniques, such as a visual examination of the data, to the more objective mathematical techniques, such as numerical classification (Mueller-Dombois and Ellenberg 1974). Regardless of the technique, the purpose of classification is to combine sets of data with similar attributes. It allows the biologist to make generalizations about the relationships among organisms and to generate predictive models about their distribution in the natural environment.

The Regional Copper-Nickel Study implemented both the techniques of numerical classification and ordination in their attempt to recognize and describe natural communities of birds. The specific techniques of agglomerative heirarchial cluster analysis and multi-group discriminant analysis where chosen (Boesch 1977). Previous avian studies have dealt primarily with techniques of ordination at the species level (Cody 1968, James 1971, Anderson and Shugart 1974, Conner and Adkisson 1976, Niemi 1976, and Smith 1977), wherein the distribution of individual species was related to various parameters of the vegetation. The classification of avian communities has generally been subjective and descriptive in nature (e.g. Kendeigh 1948 and Martin 1960) with most avian ecologists assuming that the "boundaries" of avian communities directly reflect the "boundaries" of vegetation communities. Compared with the numerous studies that have dealt with rigorous mathematical approaches to plant community classification (e.g. Grigal and Ohman 1975 and Nobles, et al. 1977), few studies have dealt with such an approach to avian community classification.

Cluster analysis is a numerical classification technique that combines sets of data, or entities, on the basis of their similarity. The degree of similarity, or distance between entities, may be determined by any of several established algorithms, applicable to either quantitive or qualitative data (Boesch 1977). An agglomerative heirarchial (Pielou 1977) method of clustering was chosen. It is agglomerative as a result of combining the original entities (such as sample sites) to form successively more inclusive groups. Combination of the groups is generally determined on the basis of their overall similarity, rather than on the presence or absence of a single attribute. The clustering process can be graphically represented by a dendrogram which illustrates the heirarchial arrangement of the entities (e.g. see Figure 10). The cluster of pairs are joined together at successively lower levels of similarity as one proceeds from the left side of the figure to the right side.

The results of numerical classification are not to be interpreted as definitive; the technique is best employed as an aid to classification rather than as a classification per se. An important way of utilizing the technique is to generate several dendrograms by varying: 1) the distance and similarity measures that calculate the similarity matrix (i.e. the measures of similarity between all possible pairs); 2) the measurements of species composition that are used in the similarity measures (e.g. the species relative density or absolute density); and 3) the clustering algorithms for grouping similar entities or groups into clusters. If the resulting dendrograms are similar, the biologist is able to discuss and analyze stable and discrete communities.

Numerical classification operates under the assumption that the sample units naturally fall into discrete and recognizable communities. The validity of this assumption however, has been challenged by ecologists who allege that discrete discontinuities between communities are not realistic (e.g. Gleason 1926 and Curtis 1959). Those ecologists who maintain that species are geographically distributed independently of one another, favor the use of ordination techniques that graphically portray the relationships among sample stands. Ordination arranges the stands within a uni-dimensional or multi-dimensional coordinate frame so that the relative continuity or discontinuity in their distribution is illustrated (e.g. see Figure 13).

Although ordination and numerical classification reflect two different concepts in ecology, the continuum concept and the community concept, the techniques may also augment one another (Boesch 1977). Following cluster analysis, when recognizable communities have been defined, ordination can illustrate the relationships among the communities by plotting their centroids (e.g. see Figure 13). The ordination technique commonly used for this purpose is discriminant analysis. Discriminant analysis operates by defining linear combinations of the components of each stand (e.g. species) so that, within a coordinate frame, the distances between communities are maximized. The number of linear combinations, or functions, needed to explain all the variance within the data set is one less than the number of communities that have been recognized. The variance however, is not equally accounted for by all functions; the function that is derived first accounts for the greatest proportion of the variance, the second function accounts for the greatest proportion of the remaining variance, and so on. As a result, most of the discrimination among communities can be depicted by the first two or three functions, each representing one axis in the coordinate frame.

Discriminant analysis may be used to reduce the original number of variables in numerical classification to the minimum number necessary for recognizing discrete communities. Species whose distribution and abundance provide the least amount of information for distinguishing communities can be discarded. Species whose distribution and abundance provide the biologist with valuable information for distinguishing communities are retained and recognized as the discriminant variables.

Two additional operations are also possible with discriminant analysis. First, given certain assumptions (Boesch 1977, Pielou 1977), the biologist may test the significance of the community classification. The mean (centroid) and variance within each community are calculated and the familiar F-ratio is used to test whether the distances between centroids are significant. Second, the biologist may also classify similar data obtained from other sources into the community framework he has established. The coordinates of the unclassified data are determined by calculating the discriminant scores along each axis. The final location within the coordinate frame suggests the appropriate community classification.

Methods-Field Techniques

Summer - Territory mapping (Williams 1936) was the field technique selected for characterizing the breeding bird communities within the Study Area. The validity of several assumptions inherent in the technique, such as equal species detectability, have been discussed by various authors (e.g. Kendeigh 1944 and Emlen 1971). Despite these potential problems, the most important advantage of territory mapping is that the method has been standardized by an international congress (Robbins 1970) and has been widely applied. It should be emphasized that it is an estimation of the breeding members of the population and may not accurately account for the nonbreeding, or floating, members of the population.

Territory mapping may be implemented along a trail or transect (Kendeigh 1956) or on a grid within the habitat (Robbins 1970). The former approach was applied during the 1976 field season. Thirty-five census transects were established along improved gravel roads or logging trails (Figure 2).

An additional transect was established along an E-W line through the middle of a recent clearcut (site #34). The map coordinates and vegetation cover type for all 36 sites are listed in Appendix I. Thirty-four of the transects were each 500 m in length; the remaining two (B35 and B36) were 250 m in length. Fifty meter intervals along each transect were marked with plastic flagging.

All bird sounds and sightings within 100 m of either side of the transect were recorded on a data sheet which divided the transect into a 50 m X 50 m grid. Appropriate markings were used to indicate whether the bird was sighted and/or heard singing or calling. To calculate population densities only those observations within 50 m of either side of the transect were used, resulting in an effective sampling area of 5 ha.

The 1976 census period ran from June 8 to August 1. Each site was visited four to five times during the month of June, including one evening census, and two to three times during July. Population densities were generally derived from only the first five weeks of sampling. Morning census periods began at sunrise and ran four to five hours. Heavy rain or high winds were the only weather conditions preventing censusing. Two separate transects were run simultaneously by two researchers, Gerald J. Niemi and Lee A. Pfannmuller. Forty minutes were spent at each site; 20 minutes walking each leg of the transect. Eight to ten transects were sampled each morning. Their order for each morning was systematically rotated to avoid bias due to timing of the census period relative to sunrise.

The transects were selected to represent as many habitat types as possible. Because the vegetation is naturally quite variable, and often highly disturbed from the effects of logging, the vegetation cover in fewer than one-third of the transects was homogeneous throughout the entire 10 ha.

The variability in vegetation cover along the 1976 breeding bird transects complicated the attempt to characterize bird communities associated with distinct vegetation types. As a result, the original sampling approach was modified for the 1977 field season; censuses were conducted on a plot within a single habitat rather than along transects that often traversed several habitats. Thirty-nine plots were established within homogeneous stands throughout the Study Area. When the stands were large enough, plots were 105 m X 105 m in size, with plastic flagging marking 15 m intervals along each edge. When the size and shape of the stand did not permit a square grid, its shape was modified to reflect the shape of the stand, the only criteria being that approximately the same area, 1 ha, be enclosed.

In stands where the understory vegetation was extremely dense there was concern that the census results might be adversely affected from the disturbance caused by an observer walking through the stand. Logging trails were available in six potential sampling sites where this was a concern. Transects, ranging from 250 m to 500 m in length were therefore established and censused as in 1976. In addition, two of the census transects sampled in 1976, B01 and B04, were also sampled in 1977. Finally, in an attempt to compare results from the two sampling techniques, plot censusing and transect sampling, four transects were established at four sampling sites where plots had already been laid, although logging trails had also been available. The locations of all 51 sites (39 plots and 12 transects) are shown in Figure 3 and their map coordinates and vegetation cover are listed in Appendix I.

The plots were censused by walking along the perimeter and recording all bird sounds and sightings within the plot and 50 m outside of each edge of the plot. To determine population densities the boundaries of the plot were theoretically expanded to include as much of the area outside the boundaries (up to 45 m along each edge) as possible, as long as the vegetation cover remained homogeneous.

The 1977 census period ran from May 23 to July 7. Each site was visited four to six times during this period. As in 1976, two separate sites were censused simultaneously by two researchers, Lee A. Pfannmuller and Nancy E. Piragis. Other census techniques were similar to those implemented during the 1976 field season.

During the 1976 and 1977 field seasons quantitative vegetation data were collected on all transects and plots where breeding birds were censused. A detailed discussion of the methods used in vegetation sampling can be found in the Regional Copper-Nickel Study Field Operations Manual. The data collected during 1977 were used by the author to assess the influence of the vegetation upon the bird community composition (see Methods-Regression Analysis).

Winter - Sixteen plots, including all major vegetation cover types, were established for the 1977 winter bird study (Figure 4, Appendix 1). Because of the availability of snow-plowed roads, the plots were concentrated in the northern half of the Study Area. One hectare in size, the perimeter of each plot was marked with plastic flagging at 25 m intervals. Sampling was conducted during the months of January and February; each site was censused two to three times per week. Approximately 50 minutes were spent walking along the perimeter of each plot and all birds heard and/or observed within the plot were recorded; bird observations outside the plot were also recorded together with their approximate distance from the perimeter. The plot observations were also supplemented by all observations gathered while either walking or driving in the Study Area. Participants in this aspect of the winter bird study were Miriam Axelrod, David Bruce, and Lee Pfannmuller. Peter Doran and Tom Hargy, from the Minnamax project in Babbitt, also contributed to the winter bird study.

Another aspect to the winter study involved the distribution of tabulation sheets to several residents and institutions in the area with bird feeders. Participants were asked to put a checkmark by each day that a particular species was observed. All eleven participants contributed information for the months of January and February.

Methods-Analysis Techniques

Cluster Analysis - The breeding bird data were examined using cluster analysis in two ways. The first, referred to as normal analysis, grouped together plots on the basis of their overall similarity in species composition. The second, referred to as inverse analysis, grouped together species with similar plot distributions. Various combinations of distance and similarity measures, clustering algorithms, and species measures (variate scores) were attempted. The similarity of the resulting dendrograms reflects upon the stability of the clusters.

The following combinations were used in normal analysis. For variate scores:

1) The importance value of each species defined as the sum of the species relative density, relative frequency and relative biomass;

2) The importance value of each species defined as the sum of the species relative density, relative frequency and relative consuming biomass (Schoener 1969);

3) The relative density of each species; and

4) The absolute density of each species (no. of breeding pairs per km^2).

For distance and similarity measures:

1) The standard distance method (Orloci 1967);

2) The absolute distance method (ibid); and

3) The Czekanowski index of similarity (Field 1971).

For clustering algorithms:

1) Minimum dispersion (Orloci 1967); and

2) Minimum average distance (Anderberg 1973).

The following combinations were used in inverse analysis. For variate scores:

1) The importance value of each species defined as the sum of the species relative density, relative frequency and relative biomass; and

2) The absolute density of each species.

For distance and similarity measures:

1) The Dice index of similarity (Boesch 1977); and
2) The Jaccard index of similarity (ibid).

For clustering algorithms:

1) Minimum average distance (Anderberg 1973).

Following a few initial runs, species that were present on only one or two plots were eliminated if it was judged that their presence on a plot was not critical for classification purposes. The original number of species used in the analysis (78) was cut down to 56 without altering the stability of the clusters.

Computer programs incorporating the standard and absolute distance measures and clustered by the minimum dispersion method were written by Edward Cushing (Dept. of Ecology and Behavioral Biology, University of Minnesota) and George Burnett (Regional Copper-Nickel Study). Computer programs incorporating the Czekanowski index of similarity and clustered by the minimum average distance method were written by George Burnett and Jeff Boesch (University of Minnesota) and are available through the Universty Computer Center.

The results of inverse and normal analysis were interrelated by a process termed nodal analysis. The objective of nodal analysis was to illustrate the relative distribution of the species associations over the stand associations. Standard procedures for nodal analysis are not well-established so the procedure used by the Copper-Nickel Study will be described in detail.

Nodal analysis began by assigning an index value to each species on a plot on the basis of its importance value (relative frequency plus relative density plus relative biomass). Ranging from zero to six, the scale for the index value was as follows:

Importance Value	Score
0	0
.001 - .250	1
.251 - .500	2
.501 - .750	3
.751 - 1.000	4
1.001 - 1.250	5
greater than 1.250	6

Next, the scores for each square in an n X n matrix (n species associations X n bird communities) were calculated by summing the scores for all species in the community. The total was then expressed as an importance index per unit area by dividing the total score by the number of species in the species association times the number of sample plots in the bird communities. These indices were then converted to a scale from zero to one by dividing all scores by the maximum. The final score is the importance index for each species association in each habitat.

Discriminant Analysis - Once major bird communities were recognized and defined, discriminant analysis was implemented to reduce the original number of discriminating variables, to ordinate the communities, to test group significance and to classify the 1976 breeding bird transects from homogeneous vegetation cover types. The SPSS computer program for discriminant analysis, available through the University of Minnesota Computer Center, was used. A species absolute density and its importance value were used as input on different occasions to test which parameter resulted in a more reasonable list of discriminating variables. Mahler's distance measure was the discriminating technique employed.

Functional Groups - The species that comprise the avifauna of a community all depend upon different features of the habitat. Some species, for example, may confine all their activities to the forest floor, others may depend upon the forest floor for nesting cover, while they forage in the subcanopy. Although each species occupies a unique position, or niche, in the community, broad behavioral categories can be defined. Often referred to as guilds, the categories depict different ecological strategies, such as foraging strategies or nesting strategies. Documentation of the presence and abundance of different functional guilds aids the biologist in studying the ecological structure of the community.

Breeding birds observed on the Study Area sites were classified into various foraging and nesting guilds. Strategical categories defined as foraging guilds include: 1) pickers and gleaners; 2) timber feeders; 3) pursuers (sallying flycatchers and aerial feeders); 4) ground feeders; 5) vertebrate predators; 6) specialized feeders; and 7) generalist species that feed both in the foliage and on the ground. Strategical categories defined as the nesting guilds included: 1) ground nesters (on the ground or a few inches above); 2) shrub nesters (shrub or small tree nester, generally $\leq$ 3 m in height); 3) cavity nester; 4) tree nester; and 5) specialized nester. Numerous literature sources were explored in order to correctly classify each species. However, classification of some species may be successfully argued as inappropriate for two reasons. First, for a few species the classification was not consistent from one source to the next. Second, sufficient information is lacking for many species, particularly with regard to foraging strategies. In spite of these limitations the final classification will be useful in the community analysis.

Regression Analysis - The influence of the structure and composition of the vegetation on the composition of bird communities was studied using regression analysis. Various parameters characterizing the vegetation were correlated with parameters characterizing the bird communities.

The MULTREG statistical package (version 3.2.) available through the University of Minnesota, was used for the analysis. Three data files were established and correlations tested within each:

1) Wetland conifer plots; G02, G03, G06, G31, G43, G45
2) Upland conifer plots; G01, G11, G13, G16, G17, G19, G20, G21, G22, G23, G24, G25, G26, G28, G30, G34, G35, G36 and
3) Upland deciduous plots; G04, G05, G07, G08, G09, G10, G12, G14, G15, G32, G33, G37, G38, G39, G40, G41, G42, G47

RESULTS

Breeding Birds

Nearly 10,000 bird observations, registering a total of 104 different species (Appendix 2), were tallied on plots and transects during the 1976 and 1977 breeding seasons. The primary summer habitat for 41 of these species, accounting for approximately 34 percent of all observations, is in the northern coniferous forests of Minnesota (Green and Janssen 1975).

Most of the remaining species are distributed throughout the state. A few species however (e.g. chestnut-sided warbler, Dendroica pensylvanica, and ovenbird, Seierus aurocapillus), do not breed in the western prairie region. The regional distribution of the species, together with a summary of the number observed per year, is presented in Appendix 2.

Common Birds - Wood warblers of the family Parulidae are the major component of the summer avian fauna (Figure 5), contributing an average of 50 percent of all observations. The five most common members of the family are the ovenbird, chestnut-sided warbler, Nashville warbler (Vermivora ruficapilla), mourning warbler (Oporornis philadelphia), and common yellowthroat (Geothlypis trichas). When the species are listed in decreasing order of abundance (Table 1), these five warbler species are shown to contribute approximately 40 percent of all observations. The family Fringillidae (grosbeaks, finches, sparrows, and buntings) is second in importance, contributing nearly 15 percent of the observations. The white-throated sparrow (Zonotrichia albicollis) is the most abundant member of this family.

Several of the common species are notably abundant in areas that have been recently disturbed by logging and/or burning. As pointed out previously, such disturbance is found throughout the Study Area. Three species, the chestnut-sided warbler, mourning warbler, and white-throated sparrow, were found to be ubiquitous and abundant on study plots located within the 1971 Little Sioux burn and a recent aspen clearcut, both in northeastern Minnesota (Niemi 1976). These species were also abundant on the young disturbed plots of the Study Area. In both deciduous and coniferous upland stands the density of the species decreased significantly as the age of the stand increased (Figure 6).

The most abundant bird encountered both summers was the ovenbird. Unlike the species discussed above, the ovenbird was associated with more mature coniferous and deciduous habitats. It was consistently absent from stands that were less than 25 years in age and whose canopy closure was less than 50 percent. In stands that supported an ovenbird population, the species was likely to be one of the most abundant members of the avian community. The species absence from the early successional stages of mature broad-leafed forests and conifer plantations has also been noted by other authors (e.g. Erskine 1977, Anderson and Shugart 1974, and Niemi 1976).

The relative abundance of birds within the Study Area was compared to the relative abundance of birds over the entire State of Minnesota. Statewide abundance of species was determined from results of the North American Breeding Bird Survey conducted in Minnesota during the years 1976 and 1977. Conducted once each year, the survey censuses breeding birds along established routes located throughout the state. Of the 52 established routes in Minnesota, approximately 27 are sampled each year.

As illustrated in Figure 7, the relative abundance of the major passerine bird families over the entire State of Minnesota is significantly different from that observed within the mineral resource zone. The Icteridae, or blackbird family, was the most abundant passerine family in the state. Two members of the family, the red-winged blackbird (Agelaius phoeniceus) and common grackle (Quiscalus quiscula), were the top two ranking species both years; together they accounted for approximately 20 percent of all observations.

Members of the blackbird family are most commonly associated with the open agricultural habitats where they can often be an economic pest. Because of the lack of available habitat in the mineral resource zone, blackbirds were relatively unimportant, contributing only two percent of the total observations. In the area west-southwest of the zone of mineralization, tillable land is more abundant and blackbirds are likely to be more important.

The most abundant passerine family in the Study Area, the Parulidae, was only third in abundance in the state, contributing approximatley ten percent of all observations. Statewide, the three most common warblers were the ovenbird, common yellowthroat, and chestnut-sided warbler; species that were also important in the Study Area. East of the prairie, the young successional habitats and broad-leafed forests that support these species are widely available. As a result, they are important members of the avifauna throughout most of the state.

Rare and Unique Birds - Thirty of the 104 species observed during the breeding bird surveys have been recognized as rare or very rare birds within the Superior National Forest (Green 1971); 29 are recognized as uncommon. During the two summer field seasons these 59 species contributed approximately 12 percent of all observations. The abundance status of all 104 species in the Superior National Forest is listed in Appendix 2.

One species, the golden-winged warbler (*Vermivora chrysoptera*) has yet to be officially recorded as a breeding bird within the forest. During the summer of 1976 the warbler was observed on nine occasions; during the summer of 1977, 54 observations were recorded. All records have been confined to upland and lowland habitats that lacked a tree canopy but supported a very dense growth of shrubs or saplings. The most northern observation of the golden-winged warbler was on plot G11, near the U.S. Steel open pit (Section 1, T59N, R13W). The species was not observed in similar habitats located north of this township. Not far from G11, biologists from the Minnamax project have also reported several observations of the species (Doran and Todd 1975). Although positive nesting evidence is still lacking to officially establish the golden-winged warbler as a breeding bird of the Superior National Forest, the numerous observations suggest that it is indeed a member of the avian fauna as far north as Babbitt, Minnesota.

Several of the species observed during the study have been officially designated as Blue List Species by the National Audubon Society. The Blue List, established in 1971, serves as an "early warning system" to focus attention on species undergoing local or widespread population declines. Four of the 58 species on the 1978 Blue List (Arib 1977) were observed during the breeding bird survey, they include: american bittern (Botarus lentiginosus), sharp-shinned hawk (Accipiter striatus), osprey (Pandion haliaetus), and yellow warbler (Dendroica petechia). An additional species, the marsh hawk (Circus cyaneus), was also observed in the area, although not during the breeding bird survey.

A few additional species also deserve mention. Two warblers, the Tennessee warbler (Vermivora peregrina), and Cape May warbler (Dendroica tigrina) have been recognized by the State of Minnesota as species "meriting special concern" (Moyle 1975). Both species, along with 37 additional species, have been recognized as potentially critical, unique or indigeneous species dependent upon habitats found in northeastern Minnesota (Table 2) (Niemi, unpublished).

Breeding Season Phenology - Eighty-six of the 104 species recorded during the two summer field seasons are summer residents (Appendix 2). Many of the species spend the winter months in the tropics or subtropics; others winter along the west coast of North America (Erskine 1977). Spending an average of only 3 to 5 months on their breeding range these species began to arrive in the Study Area in late March and early April. Many of the early migrants, such as sparrows and thrushes, only passed through the area on their way to breeding grounds further north. One of the most conspicuous spring migrants in the Study Area during the spring of 1977 was the tree sparrow (*Spizella arborea*).

Because the majority of summer residents are insectivorous, they did not begin to arrive until early May when insects became more abundant. By the end of May most breeding species had arrived and their territories were established. Singing activity peaked and remained high throughout the first few weeks of June. However, by the first week in July, singing had reduced considerably and many of the young had already fledged. Many of the insectivorous warblers began to migrate south again in early August and by late September most summer residents were gone.

Although migration accounts for a very large flux of individuals into and then out of an ecosystem in a period of less than six months, it does not upset the established patterns of energy flow and nutrient cycling (Sturges, et al. 1974). As consumers, birds are near the top of the food chain and their temporary, periodic removal is less likely to affect energy turnover. Occasionally, however, their removal does significantly affect the turnover of some essential elements in the ecosystem. Sturges, et al. (1974) demonstrated that bird migration accounted for 16 percent of the net phosphorus loss from the Hubbard Brook Watershed.

Winter Birds

Compared to the total of 104 species observed during the breeding bird survey, only 20 species were observed during the 1977 winter field study (Appendix 2). Throughout two months of intensive field work, fewer than 10 observations were recorded for 11 of the 20 species. The two most commonly observed species were the common raven (*Corvus corvax*) and black-capped chickadee (*Parus atricapilus*). Together with numerous observations of the boreal chickadee (*Parus hudsonicus*), the chickadee family (Paridae) was the most abundant bird family. Second in importance was the woodpecker family (Picidae) which registered numerous observations of the downy woodpecker (*Dendrocopus pubescens*), hairy woodpecker (*Dendrocupus villosus*), and pileated woodpecker (*Dryocopus pileatus*). There were also several observations of the northern three-toed woodpecker (*Picoides tridactylus*), which has been reported as a rare winter visitant to northeastern Minnesota (Green and Janssen 1975).

The feeder study reported a total of 27 different species, including 12 which were not reported in the field study (Appendix 2). One of the more unusual observations was that of a black-billed magpie (*Pica pica*), commonly reported at a feeder along Highway 21, between Ely and Babbitt. The black-billed magpie is a very rare winter visitant to northeastern

Minnesota (Green and Janssen 1975). Figure 8 compares the relative composition of feeder observations to the relative composition of field observations. In both studies woodpeckers and chickadees were the most abundant winter birds.

The most conspicuous aspect of the winter bird study was the paucity of observations. During the entire two month study an average of only six birds were observed for every five hours spent in the field. Numerous observers in the area had also commented on the conspicuous absence of many of the common finch species, such as the common redpoll (*Acanthis flammea*) and pine grosbeak (*Pinicola enucleator*).

Winter birds, primarily finches, have long been recognized for their enormous yearly fluctuations in numbers. These fluctuations are readily apparent when their abundance, as recorded by the Audubon Christmas Bird Counts, are plotted for the State of Minnesota (Figure 9). Although the data is influenced to a large extent by variability in the number of observers, census conditions, etc., major fluctuations are still apparent. In Minnesota the abundance of winter finches is primarily dependent upon the presence of redpolls; however, the presence of other finches, such as grosbeaks and crossbills, also contribute to the variations (Figure 9). All of these finch species are seen to have been exceptionally low in abundance during the winter of 1976-1977.

Biologists have long sought explanations for these irruptive patterns of winter bird abundance. Most explanations point to the availability of the major food supply - the seed crops of several boreal tree species (e.g. Lack 1954, Eriksson 1970). Bock and Lepthien (1976) have recently demonstrated "the existence of a circumboreally synchronized pattern of seed crop fluctuations in certain high-latitude tree species and a resulting pattern of southward eruptions of birds dependent upon these foods (p. 569)".

In light of these wide fluctuations in the annual abundance of many winter bird species, characterization of the winter bird fauna should incorporate data from a minimum of two years of study. Nevertheless, data collected during a year of low abundance provides valuable information regarding bird abundance and distribution during a period of extreme stress due to low ambient temperatures and a low food supply.

Comparison of Breeding Bird Census Methods

As mentioned previously, the 1976 and 1977 breeding bird surveys conducted by the Copper-Nickel Study implemented two different methods of sampling. An obvious concern was whether the two methods would yield similar results when conducted in the same stands of vegetation. Four plots where grids had already been established also had suitable logging trails; road transects were therefore established in addition to the grids. Statistics used to compare the results of the two methods are in Table 3.

Few of the statistics illustrate any obvious differences between the two sampling methods. Most important, there was no consistent difference in their total population estimates. Nevertheless, the results do illustrate that the mean number of recorded observations per hectare was slightly higher in three of the plot censuses than the mean number recorded in the transect censuses. A reasonable explanation for the difference is that when the observer walks around the plot he is likely to create more noise moving through the understory than when walking along a cleared logging trail. This disturbance is likely to attract some birds and may arouse them to vocalize, thereby increasing the number of observations.

There was also a slight tendency for species that were unique to the transect census to contribute a greater percentage to the total density than species unique to the plot census. This suggests that species that are rare or infrequent in a habitat may have a greater chance of being recorded during the trail census; suggesting in turn that they are less likely to be observed when there is a noise disturbance. These differences should be further explored in a more extensive comparison of census methods. The only American study that has carried out a similar comparison (Dickinson 1978) demonstrated that a higher population estimate resulted from the plot census (722 breeding pairs/km^2) than from the transect census (574 breeding pairs/km^2). The author proposed that the difference resulted from the greater probability of encountering an individual one or more times when traversing parallel strips through the habitat then when traversing one continuous strip. Only one stand, however, was sampled for the comparison.

RESULTS - COMMUNITY CLASSIFICATION

<u>Results - Numerical Classification</u> - Two of several dendrograms that resulted from normal analysis on the breeding bird data are shown in Figures 10 and 11. Both dendrograms illustrate the high correlation between the predominant vegetation cover at each site and the similarity in their respective bird communities. Although the exact ordering and clustering of the sites varies among these and other dendrograms, the

stability of the clusters is strong enough to suggest a reasonable community classification. Within the mineral resource zone of the Regional Copper-Nickel Study Area, nine breeding bird communities were recognized, they include: 1) the recent clearcut community; 2) the aspen regeneration community; 3) the young plantation community; 4) the disturbed shrub community; 5) the mature deciduous upland community; 6) the mature coniferous upland community; 7) the mature coniferous lowland community; 8) the alder community; and 9) the grassland community (because there was only one sample plot in this community, it is not illustrated in Figures 10 and 11). The results of normal analysis also indicate that there was less variability in the community composition of mature habitats than in the community composition of young habitats. This point will be discussed in further detail later.

The dendrograms that resulted from inverse analysis suggested the classification of nine species-associations. The associations were defined as: 1) the red-eyed vireo (Vireo olivaceus)/ovenbird association; 2) the mourning warbler/chestnut-sided warbler association; 3) the common flicker (Colaptes auratus)/brown-headed cowbird (Molothrus ater) association; 4) the yellow-bellied flycather (Empidonax flaviventris)/Connecticut warbler (Oporornis agilis) association; 5) the hermit thrush (Catharus guttatus)/blackburian warbler (Dendroica fusca) association; 6) the gray catbird (Dumetella carolinensis)/swamp sparrow (Melospiza georgiana) association; 7) the eastern wood pewee (Contopus virens)/scarlet tanager (Piranga olivacea) association; 8) the sparrow hawk (Falco sparuerius)/brown thrasher (Toxostoma rufum) association; and 9) the black-capped chickadee/golden-crowned kinglet (Regulus satrapa) association. Other species that are included in each association are listed in Table 4.

The integration of normal cluster analysis and inverse cluser analysis (i.e. nodal analysis) is shown in Figure 12. The figure illustrates both the relative importance of each species association across all bird communities and the relative importance of all species associations within each individual bird community.

Results-Discriminant Analysis - The spatial relationship among 43 of the 1977 sample plots is illustrated in Figure 13. Although 7 functions were needed to fully explain all the variance among the 8 major bird communities, the first 2 functions alone accounted for 71%. In addition, 10 species were found capable of discriminating among the communities instead of the original 78 that were initially used for numerical classification. The ten species included: 1) the mourning warbler; 2) veery (*Catharus fuscescens*); 3) cedar waxwing (*Bombycilla cedrorum*); 4) Nashville warbler; 5) golden-winged warbler; 6) alder flycatcher (*Empidonax alnorum*); 7) blue jay (*Cyanocitta cristata*); 8) blackburian warbler; 9) dark-eyed junco (*Junco hyemalis*); and 10) yellow-bellied flycatcher. By examining Table 10, it is evident that these ten species also represent the major species associations recognized by numerical classification. When all seven functions were used to classify the 1977 data, information from these 10 species correctly classified 98% of the plots. When only the first 2 functions were used for classification, the species correctly classified 91% of the plots.

The significance of the community classification is presented in the F-matrix of Table 5. The only community distinction that was not significant at the 5% level was the distinction between the aspen regeneration community and the disturbed shrub community. Nevertheless, the distinction was retained for several reasons. For example, sample plots from the disturbed shrub community were always among the first to be clustered together, forming a very distinct and recognizable community; the aspen regeneration plots formed a less distinct and stable community. In addition, the two communities were seldom clustered together before being clustered with other communities.

Application of the F-ratio for testing the significance of the community classification is only valid given the following assumptions: 1) that the species quantitites (i.e. importance values or densities) have a normal distribution; and 2) that the sampling units have been drawn at random from the parent population (Pielou 1977). Because the validity of these assumptions in the present study may be questioned, the F-matrix in Table 5 should not be interpreted as conclusive evidence for the significance of the community classification.

CHARACTERIZATION OF BIRD COMMUNITIES

As discussed above, nine major breeding bird communities were recognized within the mineral resource zone of the Regional Copper-Nickel Study Area. These communities are characterized under three major headings: 1) wetland bird communities; 2) coniferous upland bird communities; and 3) deciduous upland bird communities. Population summaries for all nine communities are presented in Table 6.

The rigorous classification techniques that were applied to the breeding bird data were not applied to the winter bird data. Instead, the sample plots were broadly categorized by general features of the vegetation structure and composition. The resulting communities correspond closely to several of the communities recognized from the breeding bird data and will be characterized under the appropriate headings. Population summaries are presented in Table 7 and illustrated in Figure 14.

WETLAND BIRD COMMUNITIES

Summer - The breeding bird communities of the northern wetlands are among the more unique bird communities found in the State of Minnesota. Two major communities were identified within the RCNSA: 1) the alder bird community; and 2) the mature conifer bird community. Both were consistently recognized by cluster analysis as discrete and stable groups. Two facies of the mature conifer community were also distinquished and will be characterized in the following discussion: 1) the open canopy bog; and 2) the closed canopy bog.

Several characteristics of the wetland breeding bird communities are illustrated in Figures 15 and 16. Figure 15 illustrates the relative contribution of the different nesting and foraging guilds to the total population density. Figure 16 compares the importance value of several of the common species in each wetland community. These will be discussed in detail in the following characterizations.

The Alder Bird Community - As mentioned previously, the alder lowland habitat is common in the Toimi Drumlin field of the St. Louis watershed. The wet, shrubby habitat of this region supports a unique avifauna that was invariably recognized as distinct from all other communities. Two alder plots within the St. Louis watershed were sampled during the summer of 1977, G18 and G48.

The most important species associations in the alder bird community were the mourning warbler/chestnut-sided warbler association and the gray catbird/swamp sparrow association (Figure 12). The latter, which was of greater importance in the alder community than any other community, was more characteristic of the alder avifauna. The mourning warbler/chestnut-sided warbler association was more characteristic of the avifauna in the young plantation and disturbed shrub communities.

Characteristic species that demonstrated a preference for the alder community included the alder flycatcher, gray catbird, veery, golden-winged warbler, common yellowthroat and swamp sparrow. Although none of these species were unique to the community, they all reported their highest population densities and importance values in the alder habitat. The golden-winged warbler and veery were also among the ten species chosen for providing the most information for discriminating among communities. Species unique to the alder community were rare and observed on only one plot; they include the yellow warbler, sora rail (Porzana carolina) and short-billed marsh wren (Cistothorus platensis).

Dominant species are defined as the most abundant species in a population. The dominant species in the alder bird community was the chestnut-sided warbler. Despite its importance to the community, the chestnut-sided warbler was not included in the list of characteristic species. The warbler is more characteristic of the young successional stages of upland bird communities and its presence and importance in the alder does not aid in distinquishing the community as unique.

Although faunistically distinct from other bird communities, the two alder plots differed significantly from one another. The Skibo plot, G18, supported approximately 2400 breeding pairs per km^2, the highest population density reported during the 1977 field study. Twenty-one species were also registered, again the largest number of species on any of the 51 plots. The second alder plot, G48, supported approximately 880 breeding pairs per km^2 which represented only 12 species. In light of these large differences, reporting an average density of 1640 pairs per km^2 is misleading. The discrepancy however, may be explained by noting structural differences in the vegetation of the two plots. The vegetation of the Skibo alder plot, G18, was structurally more diverse than that on G48. Dead standing trees and live paper birch, black ash and white cedar trees were scattered throughout the Skibo alder, providing an additional dimension for habitat utilization (MacArthur and MacArthur 1961, Cody 1968). These trees, for example, provided a nesting platform for such tree nesters as the rose-breasted grosbeak (Pheucticus ludovicianus) and cedar waxwing. They also provided a foraging perch for pursuers, like the great-crested flycatcher (Myiarchus crinitus) and american redstart (Setophaga ruticilla). The structural difference between the two plots was also evident by the relative abundance of the avian functional groups. Fourteen percent of the total avian density in the Skibo alder was composed of tree nesters and nearly 6% was composed of cavity nesters; neither nesting guild was present in G48.

The difference between the two alder plots may be further explained by the familiar ecological principle of the "edge effect". The total acreage of the alder stand in which G18 is located is smaller than that for G48. The ecotone between the Skibo alder and the nearby upland deciduous community provides an additional habitat dimension to the community. Some of the species recorded within the stand may be more closely associated with the vegetational ecotone than with the alder habitat proper (Balda 1975).

The Conifer Bog Bird Community - Conifer bogs are well-developed on poorly drained lowlands throughout the Study Area. Like the alder lowland, conifer bogs support a unique avifanua that was consistently distinguished as a discrete and stable community. Six conifer bogs (G02, G03, G06, G31, G43 and G45) were sampled during the 1977 field season.

The yellow-bellied flycatcher/Connecticut warbler association was the most characteristic species association in the conifer lowland bird community (Figure 12). The mourning warbler/chestnut-sided warbler and hermit thrush/blackburian warbler associations were important representatives of the avifauna but were more characteristic of other communities.

Many of the species reported in the conifer bogs were characteristic of the community, having demonstrated a strong preference for the lowland habitat. Characteristic species included the Nashville warbler (Vermivora ruficapilla), Connecticut warbler (Oporornis agilis), yellow-bellied flycatcher (Empidonax flaviventris), and lincoln's sparrow (Melospiza lincolinii). The Nashville warbler and yellow-bellied flycatcher were among the ten discriminating variables chosen for ordination. Information regarding their presence and abundance is often sufficient for distinguishing the conifer lowland bird community from all others. Five additional species, the ruby-crowned kinglet (Regulus calendula), Tennessee warbler (Vermivora peregrina), Cape May warbler (Dendroica tigrina), gray jay (Perisoreus canadensis), and swainson's thrush (Catharus ustulatus) were not only characteristic species, but were also unique to the community. As discussed above, the Tennessee warbler and Cape May warbler have been recognized by the State of Minnesota as "species meriting special concern".

The Nashville warbler was the dominant species on all but one stand (G45), contributing between 26% and 48% of the total population density. In the open tamarack bog of G45 the common yellowthroat was the dominant species. Because the yellowthroat was more abundant in the alder and young plantation communities, G45 was often classified with sample stands representing those habitats.

Physiognomic features of two of the conifer lowlands (G02 and G45) were significantly different from those of the other four stands. These differences were also reflected in the composition and size of the avian community. The high water table in plots G02 and G45 supported a forest that was characterized by its low shrub density and open tree canopy. The trees, either black spruce or tamarack (Larix larciana), were often stunted and widely spaced. The lower water table in the other stands supported a forest characterized by a higher shrub density and a dense tree canopy. Because these structural differences were reflected in the bird community, two facies of the conifer lowland were recognized; the open canopy bog and the closed canopy bog.

The species composition of the two facies were quite similar (Figure 16). Species that prefer more open, scrubby habitats, such as the common yellowthroat and alder flycatcher, demonstrated higher densitites and importance values in the open bog. This facies however, did not support any species that were not present in the closed canopy bog. The latter, on the other hand, supported approximately six more species than the open bog. Species that were unique to this facie included the winter wren, robin and veery.

The most obvious difference in the two bird communities was their total population density (Figure 15). The open canopy bog supported 448 breeding pairs per km^2 while the closed canopy bog supported nearly twice the density with 855 pairs per km^2. Physiognomic features offer the most reasonable explanation for the difference. As illustrated in Figure 15, approximately 70% of the birds in conifer lowlands are ground nesters. The higher water table in the open bogs may discourage many of the ground nesting species, such as the robin and veery, members of thrush family. Erskine (1977) has also noted the absence of thrushes from the wet and open conifer bogs in Canada. Furthermore, because the majority of ground nesters are pickers and gleaners that depend upon the canopy for food (Figure 15), the lower density of trees in the open bog (hence, the lower availability of food resources) may also be responsible for its lower density and diversity of birds. The low shrub density of the habitat also precludes the abundance of many shrub-nesting species.

The possible influence that vegetational features of a stand may have upon the composition of the bird community were investigated further with regression analysis. Typically composed of sphagnum moss and low ericaeous shrubs, the diversity of the ground cover was found to have significant influence upon the community composition. The total density of ground nesters, which comprised nearly 70% of the population density in all 6 lowland stands, was significantly correlated with ground cover diversity ($p < .05$, $t > 0$, $R^2 = .81$). The correlation suggests that the higher water table in the open bog may reduce the diversity in ground cover and thereby negatively influence the abundance of ground nesters. A positive correlation between the density of shrub nesters and the density of high shrubs in all 6 stands was also significant ($p < .05$, $t > 0$, $R^2 = .81$) and again reflects upon the different community compositions of the open and closed bog habitats.

DISCUSSION - The wetland breeding bird communities comprise the most unique avifauna in the Regional Copper-Nickel Study Area. Regardless of the clustering technique that was attempted, they maintained their stability and were consistently recognized as discrete communities. The alder community, however, differed in several respects from the conifer community. Unlike the dense tree canopy of many conifer bogs, the open tree canopy and dense high shrub cover of the alder bogs supported a fauna that, although unique, more closely resembled the fauna of the young deciduous and coniferous uplands. Species such as the chestnut-sided warbler and black-and-white warbler (*Mniotilta varia*), that were characteristic of the young shrub stages of upland community succession, appear to do equally well in shrubby lowlands.

Another difference between the alder bird communities and the conifer lowland bird communities is the number of species that dominate the population (Figure 14). Both facies of the conifer lowland were dominated by only one or two species, the Nashville warbler and common yellowthroat. The more diverse alder community was dominated by several species, including the veery, chestnut-sided warbler, Nashville warbler, common yellowthroat and swamp sparrow.

On the other hand, the wetland communities were similar in several respects. Two wetland species, the Nashville warbler and common yellowthroat, were common and abundant in both communities. Both communities were also dominated by species that nest upon the ground. Furthermore, the majority of these ground nesting species are dependent upon the shrub and tree canopies for the food resources they provide.

Data characterizing breeding bird communities of alder lowlands outside the RCNSA are scarce. Several of the species recorded in the habitat, such as the alder flycatcher, common yellowthroat, and song sparrow, have been reported as characteristic of the open sedge-willow wetlands in Canada (Erskine 1977).

More literature is available for the breeding bird communities of conifer lowlands (Brewer 1967, Erskine 1977). Characteristic species of the black spruce forest in Canada were similar to those listed for the RCNSA. However, population densities in the Canadian forests (150-450 breeding pairs per km^2), were much lower than in the RCNSA (Erskine 1977). The difference between the Canadian figures and those reported in the Copper-Nickel Study (444-848 breeding pairs per km^2) most likely result from a more stringent interpretation of terriroty maps by the author, A. Erskine.

Erskine's community analog for the open bog is the bog forest "dominated by tamarack, alone or with low black spruce, which in turn grades off into the more open bogs (p. 27)". He notes that the Nashville warbler was the dominant species while the cedar waxwing and common yellowthroat, which are characteristic of edges and low shrubs respectively, were also important.

These species were also characteristic of the open bog community in the present study. Erskine, however, did not report a lower population density in the open bog.

Winter - During the 1977 winter bird study six lowland conifer stands were sampled. As in the breeding bird study, a similar distinction between the open canopy bog and the closed canopy bog was recognized. The average number of observations for both communities is illustrated in Figure 14. Again, the major difference between bird communities of the two facies was their population densities. Expressed as the number of observations per 5 hour period, the closed canopy bog average twice as many observations (7.8) as the open canopy bog (3.6). Maintenance of body heat could be one of the principal factors responsible for this difference. Exposure to high winds and the subsequent loss of body heat could be considerably higher in the open canopy stands. Because of the lower tree density, the available food resources (primarily insect larvae and seeds) may also be much lower.

Characteristic winter birds of the conifer lowland included the gray jay (*Perisoreus canadensis*), northern three-toed woodpecker and boreal chickadee. The boreal chickadee was the only species unique to the conifer lowland. Other species present in the community are listed in Table 7.

A similar winter bird study was conducted during 1976 by biologists at the Minnamax project in Babbitt, Minnesota (Doran, et al. 1977). They reported an average of 22 observations per 5 hour period in their lowland conifer community, a community similar to the closed bog community of the present study, where an average of approximately 8 observations were recorded per 5 hour period. The large number of common redpolls (12 observations/5 hours) and pine grosbeaks (6 observations/5 hours) reported by the Minnamax project is primarily responsible for the discrepancy between the two studies. As mentioned previously, these winter finches demonstrated large annual fluctuations in abundance. It is evident from Figure 9 that they were very abundant during the winter of 1976, but not in 1977.

CONIFEROUS UPLAND BIRD COMMUNITIES

Summer - Although natural pine stands were common in the study area in the late nineteenth century, the majority have since been logged and replaced by managed plantations of jack pine and red pine. During the course of successional changes that proceed from the time a stand is clearcut till it is once again ready to be harvested, three major bird communities were distinguished: 1) the recent clearcut community; 2) the young plantation community; and 3) the mature plantation community.

Characteristics of the composition of the three communities are illustrated in Figures 17 and 18 and will be discussed below.

The Recent Clearcut Bird Community - Stands that have been recently harvested can be found throughout the Study Area. Lacking a tree canopy and a dense shrub canopy, the structural simplicity of the clearcuts supports a community of birds whose species composition was significantly different from that in all other bird communities of the RCNSA.

Six stands that had been recently harvested were sampled during the 1977 field season. Deciduous vegetation had previously been dominant on two of the stands (G37 and G40) while coniferous vegetation had dominated the remaining stands (G11, G13, G19 and G25). Although there were no significant differences in their bird communities, the two groups will be discussed separately. This will permit the full range of successional trends in both the upland coniferous and upland deciduous stands to be characterized.

The mourning warbler/chestnut-sided warbler association was the most important species association in the conifer clearcut community (Figure 12). One of the most common members of the avifauna, the mourning warbler (Figure 17) was one of the discriminating variables chosen for community classification by discriminant analysis.

Species that demonstrated a preference for the conifer clearcut stands included the eastern kingbird (Tyrannus tyrannus), common snipe (Capilla gallinags) and common raven. The snipe and raven were also unique to the clearcut community. Several other large passerines and non-passerines, although rare throughout the Study Area, were often observed in the open habitat of the clearcuts. Included among these species were the sparrow hawk, brown thrasher, brewer's blackbird (Euphagus cyanocephalus), olive-sided flycatcher (Nuttallornis borialis) and evening grosbeak (Hesperiphona vespertina). Three of these species are members of the sparrow hawk/brown thrasher association, the second most important species group in the clearcut community. The preponderance of birds with relatively large body weights in the avifauna of two-dimensional communities has also been noted by Willson (1974).

The chestnut-sided warbler was the dominant species on three of the four clearcuts, while the white-throated sparrow was dominant on the fourth. Together with the mourning warbler, the chestnut-sided warbler and white-throated sparrow were ubiquitous on the conifer clearcut stands. Nevertheless, reporting higher densities and importance values in other communities, none of three species demonstrated a preference for the clearcut community.

The structural simplicity of the clearcut habitat is reflected by both the size and composition of the bird community. Recording an average population density of 467 breeding pairs per km^2, the community was second only to the open facie of the conifer lowland community (448 pairs/km^2) in reporting the lowest breeding density in the RCNSA. The limited availability of resources such as nesting cover, was likely the primary cause of the low population.

As expected, tree nesters and cavity nesters were relatively unimportant to the clearcut bird community, contributing an average of 13% and 3%, respectively, to the total population density. Tree nesters made the largest contribution to the avifauna on stand G13. Because numerous mature red pine trees remained standing after the jack pine had been harvested, the tree basal area on the plot was 5.3 m^2 per ha., compared to an average basal area of .1 m^2 per ha. on the other clearcut plots. Reflecting this difference, 32% of the individuals on G13 were tree nesters, including such characteristic forest species as the eastern wood pewee and the rose-breasted grosbeak.

Ground nesters and shrub nesters were the most important nesting guilds in the clearcut community. The large contribution by shrub nesters may reflect the physiognomic heterogeneity of some clearcut stands. Two stands, for example (G11 and G25), contained small ravines with a dense growth of alder that may have attracted such common shrub nesters as the song sparrow and chestnut-sided warbler. Many shrub nesters may also nest in peripheral areas where more cover is available, but at the same time actively forage and display on the open clearcuts.

The relative contribution of the foraging guilds to the community density also reflects the structural simplicity of the habitat. Timber feeders were completely lacking and pursuers contributed only 3% of the density. Figure 18 further illustrates that pickers and gleaners contribute nearly twice as many individuals and species to the community as ground feeders. This contradicts the results of several studies that report the dominance of ground feeders in the early successional communities (Hagar 1960, Kilgore 1971). The result however is obscured by the large proportion of individuals that were catagorized as feeding both within the foliage and on the ground. Such species are included in the "other" catagory of Figure 18. It is likely that, within the clearcut community, these individuals are primarily feeding on the ground.

The Young Plantation Bird Community - As succession proceeds in the harvested stand the vegetation structure becomes more diverse. A dense growth of aspen may soon overtop the young conifers while the herbaceorus layer becomes more luxuriant. If windrows were present, a dense growth of *Rubus* sp. and young apsen will reside atop the slash. Such changes are reflected in both the size and composition of the bird community. The avifauna on six stands sampled during 1977 (G01, G16, G22, G28, G34 and G35) was significantly different from that on other stands and was designated the young plantation bird community.

The most important species association in the young plantation community is the mourning warbler/chestnut-sided warbler association (Figure 12). Because this species-group is equally important in the disturbed shrub community, information regarding the presence and abundance of other associations is necessary for characterizing the avifauna. From Figure 12 it appears that the importance of both the mourning warbler/chestnut-sided warbler association and the common flicker/brown-headed cowbird association will serve to distinguish the young plantation community.

Characteristic species of the community that were present on all six sample stands included the song sparrow, white-throated sparrow, blue jay and chestnut-sided warbler. Both the white-throated sparrow and the common flicker, which was present on all but one stand, reported their highest population density in this community. The dominant species on each of the sample stands was either the chestnut-sided warbler, white-throated sparrow or song sparrow. The common nighthawk (Chordeiles minor) was the only species unique to the community.

Population densities in the young plantation community ranged from approximately 700 breeding pairs per km^2 to 1640 pairs per km^2. The higher densities were reported in stands where there was considerable diversity in the structure of the vegetation. For example, the stand reporting the highest population density included two windrows, each supporting a dense growth of Rubus sp. and young aspen, a seedling white spruce (Picea glauca) plantation, and a stand of young jack pine, 2-3 m in height. Such diversity, typical of many young conifer stands throughout the Study Area, provides more opportunitites for utilization by birds than stands with less structural diversity.

As shown in Figure 17, the young plantation community supported more than twice as many individuals as the clearcut community. Although their relative contribution to the population density was similar in both communities, the number of individuals in each nesting and foraging guild increased two- and three-fold. Most of the guilds also supported more species than in the clearcut community. Both these changes are likely to have resulted from the increased cover in both the shrub and herbacecus layers. More nesting sites were available for both shrub nesters and ground nesters and more food resources were available for all species.

The Mature Plantation Bird Community - The final bird community in the upland conifer successional scheme is the mature plantation community. Found in mature stands of jack pine, red pine and white spruce, the community is faunistically more unique than any of the younger communities preceeding it. Eight sample stands, including three jack pine stands (G17, G26 and G30), four red pine stands (G20, G21, G23 and G24) and one white spruce stand (G36), were sampled during the summer of 1977.

The important species associations in the community included the red-eyed vireo/ovenbird association and the hermit thrush/blackburian warbler association (Figure 12). Because the latter group was relatively more important to the mature plantation community than to any other, it was more characteristic of the avifauna. Species that demonstrated a preference for the mature plantations included the hermit thrush, eastern wood pewee, yellow-rumped warbler (*Dendroica coronata*), blackburian warbler, golden-crowned kinglet and brown creeper (*Certhia familiaris*). A species unique to the habitat was the red-breasted nuthatch (*Sitta canadensis*). Perhaps the best indicator species for the community was the blackburian warbler, another one of the ten species chosen for its ability to discriminate between the bird communities of the RCNSA.

All eight mature conifer stands shared two species in common, the ovenbird and Nashville warbler. Although this was not the preferred habitat of either species, the ovenbird was the dominant species in five of the stands while the Nashville warbler was second in dominance in four of the stands.

Although the dominant tree species in most mature plantations was either jack pine or red pine, the composition of the avifauna did not reflect this difference. Two stands whose community compositions were recognized as the most similar among all mature conifer uplands (Figure 10) included one mature jack pine stand (G17) and one mature red pine stand (G23). The avifauna of the mature white spruce stand however, did differ in several respects from that of the mature pine stands. The most significant difference was the population density; the mature white spruce supported nearly twice the number of breeding pairs (1107 pairs per km^2) as the mature pine (660 pairs per km^2). White spruce trees may actually attract nesting species. Jackson (1976) reports that in a plantation where white spruce trees contributed about 57% of the total tree density, 79% of the nests in the plantation were in white spruce. The small size of the plantation may also be an important factor. Only 1.3 ha. in size, the stand was bordered on one side by a dirt road and on two other sides by a young aspen forest. The prominent "edge effect" may be attracting a large number of individuals. Although it usually clustered with pine stands the species composition of the white spruce was also somewhat dissimilar. The only characteristic species present was the yellow-rumped warbler. Again, the small size of the stand may be an important factor. Because it was the smallest of all mature plantations sampled, there is a possibility that the stand may not be large enough to support many of the characteristic mature conifer species. On the other hand, because white spruce trees differ structually from pine trees, they may actually discourage nesting by species that prefer pine.

Like the mature white spruce stand, the community composition of a northern jack pine stand (G26) deviated from that of the other stands. The vegetation cover included a 27-year old jack pine plantation broken by patches of a mature black spruce bog and an alder carr. The diversity of the avifauna reflected the diversity of the vegetation. Included among the 17 species reported in the stand were species characteristic of the mature conifer bird community, such as the hermit thrush, yellow-rumped warbler and blackburian warbler, and species characteristic of the early successional communities, such as the mourning warbler and chestnut-sided warbler. Two species that were recorded on only one visit to the stand, the yellow-bellied flycatcher and ruby-crowned kinglet, are characteristic species of the conifer lowland bird community. Because the vegetational diversity and faunal diversity in this stand was considered atypical of the mature conifer plantations in the Study Area, it was not included when the summaries were tabulated for Table 6, and Figures 12, 17, and 18.

Excluding the northern jack pine stand, the average population density in the mature plantation community was approximately 737 breeding pairs per km^2, a substantial decrease from the density of the young plantation community preceeding it. Although decreased in absolute abundance when compared to the young plantation community, ground nesters were the most important nesting guild in the mature plantation. Ground feeders were also very important and their total abundance increased progressively from the clearcut community to the mature plantation community. The high importance of species that nest and/or forage upon the ground in closed plantations has been reported by other authors (Probst 1976, and Haapanen 1965). It is postulated that closure of the tree canopy results in a more open understory that is more favorable for ground-dwelling species than the very dense shrub growth of the young plantations. The results presented in Figure 18 suggest that the dense decidous growth of the young plantation provides more cover for ground nesters than the open understory of the mature plantation but that the more open conditions in the mature habitat are more conducive to species that forage on the ground. An open understory is also reported to improve stand conditions for pursuers (Haapanen 1965). Data from the Copper-Nickel Study supports this contention. Pursuers increased in both density and importance in the progression from clearcut to forest.

Tree nesters were also important to the mature conifer bird community and reported a higher population density than in the younger communities. Because deciduous growth has been controlled since the plantation was quite young and, because the closed canopy further hampers understory development, shrub nesters were relatively unimportant to the community. Cavity nesters were absent on all but two of the stands.

Discussion - The successional changes that follow the harvest of a forest stand are accompanied by significant changes in the composition of the avifauna. Within the RCNSA three major bird communities were recognized that reflect the major successional stages in conifer upland communities. Comparison of these communities illustrates the significant impacts vegetation has upon bird community size and composition.

The recent clearcut community was the smallest breeding bird community in the conifer uplands. Supporting fewer than 500 breeding pairs per km^2, few habitat dimensions were available for exploitation by the avifauna. Lacking trees and shrubs the only resource layer available for utilization was the ground layer. Because of its structural simplicity the clearcut supported fewer species and fewer individuals than the older successional community of the young plantation. Often referred to as a "two-dimensional" habitat, several authors have noted the exceptionally low density and diversity of its songbird population (Karr 1968, and Shugart and James 1973).

The effect that adding a third dimension to the habitat has upon the bird community is dramatically illustrated in Figure 18. Once shrubs become an important component of the vegetation the density of breeding birds increased nearly three-fold. Furthermore, the habitat supported a greater diversity of breeding species (an average of 16 in the young plantation bird community compared with 11 in the clearcut community). It is proposed that the increased cover of the shrub canopy acts to increase nesting cover for both ground nesters and shrub nesters and to increase food resources for foliage-gleaning species. Several authors have noted the increased size and diversity of bird populations in the shrub-stage communities (Odum 1950, and Shugart and James 1973). The data has often been cited as supportive evidence for the general principle that "bird populations tend toward higher levels of diversity as ecological succession progresses" (Curtis and Ripley 1975, p.132).

The principle, however, was not supported by data collected from the next successional stage, the mature plantation bird community. Both the diversity of breeding species (11) and the total population density of the community have decreased. The majority of species that are absent once the tree canopy is fully developed are shrub nesters such as the alder flycatcher, golden-winged warbler, brown thrasher and song sparrow; all were characteristic of open shrubs (Figure 18). However, even the red-eyed vireo, a dominant shrub nester in aspen forests, was not very important in the mature conifer forest. Because the deciduous growth on conifer plantations has often been controlled and because the canopy is often too dense to allow much sunlight to reach the forest floor, the shrub density in mature plantations (.9) is less than half the shrub density in the young plantations. The loss of cover in this structural layer appears to result in the decreased size and diversity of the shrub nesting guild.

In spite of the decreased importance of the shrub layer and its associated bird species, one might predict a large expansion of guilds associated with the tree canopy, particularly tree nesters. Although tree nesters nearly doubled in numbers from those observed in the young plantation community the average number of species in the guild decreased by one. The dense conifer canopy however, appears to be essential to one of the most characteristic species of the mature plantation community, the blackburian warbler.

The suggested correlations between several of the successional trends in the vegetation and the bird community composition were further investigated with regression analysis. Development of the tree canopy was significantly correlated with a decrease in the number of shrub nesters (density of shrub nesters vs. tree density, $R^2 = .42$); with an increase in the number of tree nesters (density of tree nesters vs. tree density, $R^2 = .38$), and with an increase in the density of pursuers (density of pursuers vs. tree basal area, $R^2 = .36$).

Development of the shrub layer was significantly correlated with an increase in the density of ground nesters (density of ground nesters vs. the number of high shrub species, $R^2 = .72$) and with an increase in the density of pickers and gleaners (density of pickers and gleaners vs. basal area of high shrubs, $R^2 = .49$). All correlations were significant at the 5% level.

The net effect of all these relationships upon the breeding bird community of the mature plantation is a loss of approximately 400 birds per km^2 and 5 species. The low density of breeding birds in monotypic plantations has been reported by others (MacDonald 1965). The low diversity of species has also been noted and it is generally agreed that the interior of large, solid plantations that have reached the closed canopy stage is of limited use to game and non-game wildlife species (Resler 1973, MacDonald 1965). Not only is the structural diversity of the vegetation extremely low in monotypic plantations (the poorly developed subcanopy and the monotypic tree canopy), Martin (1961, in MacDonald 1965) also reports that the abundance of "diurnal ground surface insects and foliage insects" is low. As a result, both nesting sites and prey populations are reduced in the closed conifer plantations, and likewise cause a decline in bird numbers. Therefore, although the diversity of breeding bird populations in natural, unmanaged stands may increase as ecological succession progresses the same does not appear to be true in the ecological succession of managed pine plantations. A few other studies have also failed to support the hypothesis on natural regenerated forests (Odum 1950, Karr 1968, and Kendiegh 1945).

Winter - One recent clearcut stand and four mature plantations were sampled during the winter of 1977. The young plantation habitat was not sampled.

Approximately five birds were observed on the clearcut stand for every five hours spent in the field (Figure 14). The most abundant species were the hairy woodpecker and downy woodpecker. Both were clearly associated with several aspen and birch trees that were left standing after the original red pine was harvested. The only other species present in the stand was the black-capped chickadee.

Although a direct comparison between the population size of the winter and summer avifauna is not possible, the data suggest that the wintering population of the clearcut community is considerably smaller than the breeding population. Hooper (1967) also reported that recently cut stands were of relatively lower value to the avifauna during the winter than during the summer. The larger accumulation of snow and higher wind velocities reported in clearcuts (Pengelly 1972) may discourage utilization of the habitat by birds. However, the data for the RCNSA were collected during a year when many finches were extremely rare, making it difficult to fully assess utilization of the habitat during the winter season.

The mature plantations reported an average of 2.6 observations of winter birds per five hours (Figure 14), the lowest of all six habitats sampled. Species observed on the plots included the great-horned owl, hairy woodpecker, common raven, black-capped chickadee, downy woodpecker and black-backed three-toed woodpecker. During years when pines produce a good seed crop the plantations are likely to be a more important habitat for winter birds.

DECIDUOUS UPLAND BIRD COMMUNITIES

Summer - Aspen-birch is the most abundant cover type in the RCNSA. Recognized as a major stage in the ecological succession of many upland communities, the aspen-birch forest has been designated a "pioneer forest". The shade-intolerant aspen and birch trees are usually the first to invade an open stand and, unless harvested, they are soon replaced by more shade tolerant conifers.

Within the mineral resource zone of the Copper-Nickel Study four major breeding bird communities were recognized in the aspen-birch forests: 1) the recent clearcut community; 2) the aspen sapling community; 3) the disturbed shrub community; and 4) the mature deciduous forest community. As in the coniferous upland communities these four communities reflect both the floral and faunal successsion that proceeds from the time a stand is harvested to the growth of a mature forest. The disturbed shrub community however, is not to be interpreted as the third stage of community succession. Although structurally its vegetation represents a midpoint between the shrub community and the forest community, its distinguishing features, both floristically and faunistically, were a more direct result of historical influences than natural influences.

Characteristics of the four communities are illustrated in Figures 19 and 20.

The Recent Clearcut Bird Community - As discussed earlier, a total of six stands were sampled which had been recently harvested. Four stands previously supported conifer forests and two stands previously supported deciduous forests (G37 and G40). Although the composition of the clearcut bird community did not reflect this distinction, the two groups are presented separately for presenting a successional scheme to community characterizations.

Like the conifer clearcuts, the mourning warbler/chestnut-sided warbler association was the most important species association in the deciduous clearcuts. Although members of the sparrow hawk/brown thrasher species association were also important in conifer stands, they were actually absent from deciduous stands. The only species in the association that may have demonstrated a preference for conifer stands was the sparrow hawk. A cavity nester, the sparrow hawk was observed nesting in very large pine snags that remained on two of the conifer clearcuts. Such tress are less likely to be found on deciduous stands.

Characteristic species of the community were the mourning warbler, white-throated sparrow and chestnut-sided warbler. The mourning warbler was also the dominant species on one stand (G37) while the red-eyed vireo was dominant on the second (G40). G40 was the only clearcut stand where the red-eyed vireo was important. The species was always observed within two small pockets of young red maple (Acer rubrum) that remained after the plot was harvested. A species unique to the clearcut community, the killdeer, was recorded on G37.

The major difference between the bird communities on the conifer clearcuts and those on the deciduous clearcuts was the total population density (697 pairs/km^2 on deciduous plots vs 467 pairs/km^2 on conifer plots). The discrepancy appears to be largely a result of the greater contribution by tree nesters on the deciduous plots. The young red maples on G40 were important to several tree nesters, such as the chipping sparrow (Spizella passerina), robin (Turdus migratorus), and purple finch (Carpodacus purpureus). Young aspen trees that infringed upon one corner of G37 were important to such tree nesters as the evening grosbeak (Hesperiphona vespertina) and cedar waxwing. Furthermore, unlike the plots located within the conifer clearcuts, the plots within the deciduous clearcuts bordered upland forest stands. Many of the tree nesters that were recorded in the deciduous plots may have been feeding in the clearcut or near the edge, but nesting in trees of the nearby forest. The higher density and diversity of bird populations along forest edges has been well-documented (Odum 1971).

Despite the relative abundance of trees on the deciduous stands both the deciduous and coniferous clearcuts supported an average of 11 species per plot. The additional habitat dimension provided by the trees did not cause a relative increase in the number of species the stands could support. A possible explanation lies in the observation that, although deciduous clearcuts had more dimensions to the habitat, they lacked diversity in the ground layer. Some of the conifer clearcuts, on the other hand, contained small, shrub-covered ravines that attracted species not found on the deciduous stands.

The Aspen Regeneration Bird Community - Unless a clearcut stand has been prepared for pine regeneration and the aspen growth has been controlled, two to three years after timber harvest a very dense growth of young aspen, 2-4 meters high, will be present. Three such stands (G07, G08 and G10), ranging from 4-6 years in age, were sampled during 1977. The composition of their bird communities was recognized as distinct from that found in all other deciduous upland habitats.

Like the younger clearcut bird community, the mourning warbler/chestnut-sided warbler association is the most important species association in the aspen sapling community (Figure 12). Both the mourning warbler and chestnut-sided warbler were present on all three stands and exhibited their highest population densities and importance values in this community. The red-eyed vireo was also common to all stands. Five species that were recorded in the community, the mourning warbler, veery, cedar waxwing, Nashville warbler and golden-winged warbler, were among the ten species chosen by discriminant analysis for ordination. Only one of the species, the mourning warbler, was characteristic of the aspen sapling community.

The dominant species on all 3 stands was the chestnut-sided warbler, contributing between 25% and 38% of the population density. The mourning warbler was second in dominance contributing between 12% and 24% of the density.

Upon examination of Figure 12, the similarity in species composition of the young aspen community and the young plantation community is obvious. The vegetational structure of the communities is quite similar and attracts many of the same species. Their similarity was also apparent during cluster analysis; sample stands from the two communities were often clustered together (see Figure 11). The clearest distinction between the communities is evident when the raw data matrix for Figure 12 is examined. Members of the red-eyed vireo/ovenbird association, one of the most characteristic species associations of the mature deciduous community, were of greater importance to the young aspen community than to the young plantation community. On the other hand, members of the hermit thrush/blackburian warbler association, the most characteristic species association of the mature plantation, were of greater importance to the young plantation community. Therefore, the importance of species associations that distinguish the avifauna of mature conifer forests from mature deciduous forests, also served as the best distinction between the young successional stages of each forest.

Like the young plantation community, the addition of a dense shrub canopy to the original clearcut appears to be responsible for a large increase in the population density (1050 breeding pairs per km^2). Among the nesting guilds the increase was largely absorbed by an expansion of the shrub nesting and ground nesting guilds. Among the foraging guilds the increase was largely absorbed by expansion in the number of pickers and gleaners. The increased cover of the shrub and herbaceous layers appeared to be a greater advantage to species that nest on the ground than to species that forage on the ground.

Although the young plantation bird community supported about five more species than the clearcut community, the aspen sapling community supports only one more species. The structural diversity of the young aspen stands was much lower than that in the young plantation stands. Young aspen cover was nearly 100% in all 3 stands and trees were scarce. Scattered clumps of trees and small ravines were far more common on the young plantations. The dense deciduous growth that was common to the aspen sapling stands had often been controlled by hand-release or the use of herbicide, so as not to out-compete the young conifers. The influence that such structural diversity and patchiness has upon the diversity of breeding birds has been discussed by several authors (e.g. MacArthur and MacArthur 1961, Willson 1974, and Rov 1975).

The Disturbed Shrub Bird Community - During the past 30 to 40 years the Partridge River and Stony River watersheds have been heavily disturbed by logging activities (Figure 1). The vegetation cover in the area is now characterized by a patchy tree canopy with scattered clumps of aspen, birch, and pine, and by a very well-developed high shrub canopy. Young red pine and jack pine plantations are also scattered throughout the area. The bird community associated with this heterogeneous region was recognized as distinct from all other deciduous upland bird communities. The community is represented by two stands that were sampled during 1977, G04 and G05.

Two species associations were prominent in the disturbed shrub community, the mourning warbler/chestnut-sided warbler association and the red-eyed vireo/ovenbird association. The contribution of all other associations was relatively small. Five of the ten discriminating species used for ordination were also recorded: mourning warbler, veery, cedar waxwing, Nashville warbler, and blue jay. The blue jay demonstrated its highest population density and importance value in this community and may be consid... the species best capable of distinguishing the disturbed shrub avifauna from all others.

Five additional species also demonstrated their highest population densities and importance values in this community; the black-and-white warbler, canada warbler (*Wilsonia canadensis*), rose-breasted grosbeak, magnolia warbler (*Dendroica magnolia*) and yellow-bellied sapsucker (*Sphyrapicus varius*). The chestnut-sided warbler was the dominant species on both stands, contributing 19% and 24% of the population density.

The vegetational diversity that was characteristic of the region supports a high density of breeding birds (1158 breeding pairs per km^2) and several more species than any of the other deciduous communities (18 species). As pointed out earlier, such diversity in the avifauna is directly related to the structural diversity and patchiness in the vegetation. A diverse community structure provides many more opportunities for avian utilization of the habitat than a structurally simple community.

The primary structural difference between the disturbed shrub habitat and the aspen sapling habitat is that the continuous shrub canopy in the young aspen community was broken up by the addition of scattered clumps of mature trees. The net effect that this change had upon the composition of the bird community was to decrease the number of shrub nesters and pickers and gleaners and to increase the number of cavity nesters, tree nesters, and timber feeders (Figure 19). Cavity nesters and timber feeders, represented primarily by the yellow-bellied sapsucker, made a greater contribution to the disturbed shrub avifauna than to any other. This suggests that the optimum habitat requirements of the guild members is an open canopy of mature deciduous trees. Breaking up the shrub canopy also appeared to have had a positive effect upon ground nesters and ground foragers.

The Mature Deciduous Upland Bird Community - Ten to 20 years after a stand has been harvested, the young deciduous saplings have grown into a closed canopy aspen-birch forest. The understory now contains several deciduous shrub species, such as hazel (*Corylus cornuta*) and mountain maple (*Acer spicatum*) and, in the older stands, a subcanopy of balsam fir. Eleven upland deciduous stands, ranging from 20 to 90 years in age, were sampled in 1977. The bird community associated with the deciduous forest habitat was faunistically more distinct than any of the younger successional communities preceeding it.

The most important species association in the community was the red-eyed vireo/overbird association. Three members of the association were common to all 11 sample plots; the red-eyed vireo, ovenbird and veery. The veery was also one of ten species chosen for its ability to discriminate among all communities. Other characteristic species included the least flycatcher (*Empidonax minimus*) and black-throated green warbler (*Dendroica virens*). Two species, the ruffed grouse (*Bonasa umbellus*) and black-capped chickadee were unique to the community.

The most common dominant species was the ovenbird, contributing between 27% and 41% of the population density on six stands. Other dominants included the least flycatcher (three stands), red-eyed vireo (one stand) and chestnut-sided warbler (one stand). The dominance of the red-eyed vireo and ovenbird in the deciduous broad-leafed community was also recognized by Kendeigh (1948) who designated this community as the "Vireo-Sieurus broad-leafed forest biociation".

A major distinction among the 11 forest stands was the relative importance of conifer trees (primarily balsam fir) in the canopy and subcanopy. The presence of conifers in a deciduous stand provides an additional structural dimension to the habitat that may be exploited by birds that are otherwise absent. When the stands were clustered by their vegetation composition, aspen-birch stands (G09, G32, G33 or G39) were recognized as a community distinct from aspen-birch-fir stands (G12, G14, G15, G38, G41, G42 and G47; see Regional Copper-Nickel Study Vegetation Report, Level I.). Although a clear distinction in the avifauna of these two vegetation communities was not apparent their corresponding bird communities will be presented as two different facies of the mature deciduous upland community.

Overall, the presence and abundance of species in the aspen-birch and aspen-birch-fir facies of the community was quite similar. Although conifers never contributed more than 18% of the basal area of the tree canopy, several species appear to utilize the aspen-birch forest only as the basal area of conifers increases. Species displaying this trend included the white-throated sparrow, black-capped chickadee, magnolia warbler, yellow-rumped warbler and winter wren. Erskine (1977) also observed such a trend for the white-throated sparrow and magnolia warbler in the deciduous forests of Canada. These birds often depend upon coniferous trees for nesting, food, or shelter, and can only accommodate their needs in the deciduous forest when conifers are present.

On the other hand, the density of two species, the chestnut-sided warbler and yellow-bellied sapsucker, demonstrated a clear trend to decrease as the basal area of conifers increased.

The average density of breeding pairs in the aspen-birch-fir stands was approximately 913 pairs per km^2, only a shade higher than the breeding density in the "pure" aspen-birch stands (869 pairs per km^2). The average density for all 11 stands was 898 breeding pairs per km^2. The presence of an additional habitat dimension in the aspen-birch-fir forest would suggest that the community could support additional species. Within the forest stands sampled by the Copper-Nickel Study, the aspen-birch-fir forest supported, on the average, one more species per plot (10) than stands recognized primarily as aspen-birch forest (9).

Like the conifer bird communities, the density of breeding birds in the mature deciduous forest is lower than the breeding bird density in the younger successional communities. The decrease has occurred primarily at the expense of the shrub nesters and the foliage gleaners. Both pursuers and tree nesters however, have increased in numbers. A significant decrease in the density of high shrubs, from 5.4 stems per m^2 in the young aspen community to 1.0 stem per m^2 in the forest, is likely to be the major reason for the decrease in shrub nesters. Because of the increased foliage volume that the closed canopy of the forest provides, the decrease among the pickers and gleaners suggests that many of these individuals are dependent upon the subcanopy for food resources and that the only significant foraging niche that the closed canopy provides is that for pursurers who feed above the canopy.

The only significant difference in the guild composition of the aspen-birch and aspen-birch-fir facies is the larger contributions by timber feeders and cavity nesters to the aspen-birch community. The most important bird representing these two guilds, the yellow-bellied sapsucker, was already noted as demonstrating a tendency to decrease in numbers as conifers increased in importance.

Discussion - As was pointed out in the discussion of conifer bird communities, the vegetational changes that accompany community succession have a profound effect upon the size and composition of breeding bird populations. Many of these changes, discussed in detail in the earlier discussion of conifer bird communities, have similar impacts upon deciduous bird communities.

The lack of available resources in the "two-dimensional" habitat of the recent clearcut, supported fewer individuals and fewer species than older successional communities. Although the deciduous clearcuts supported fewer breeding pairs than any other deciduous upland habitat, they supported an average of one more species per plot (11) than the mature forest stands (10). It was pointed out earlier that the presence of trees within the deciduous clearcuts and the available forest edge bordering the plots appeared to be a major influence upon the abundance and composition of the avifauna.

Development of the shrub layer, which consists primarily of young aspen saplings, resulted in nearly a two-fold increase in the population density and a small increase in the number of species. This increase was almost entirely absorbed by a corresponding increase in the abundance of shrub nesters and foliage gleaners. The addition of individuals and species to the shrub stage in community succession has been noted by several authors (Odum 1950, and Shugart and James 1973).

The importance of structural diversity was clearly illustrated by the size and composition of the disturbed shrub bird community. Although the structure of the habitat resulted from historical factors related to the cutting history of the region, it represented a midpoint between the shrub and forest stages of community succession. It contained a well-developed but patchy shrub layer and an open tree canopy with mature trees. Because it supported more individuals and species than either the shrub or forest communities it illustrated the important influence of structural diversity in the horizontal layers of the forest as well as structural diversity in the vertical layers. As long as timber management prevents forest succession to proceed beyond the monotypic conifer plantation or the mature "pioneer" forest stages of deciduous uplands the results presented in this paper suggest that horizontal patchiness or diversity has a greater impact upon bird communities than vertical diverstiy. In both the coniferous and deciduous upland communities, the addition of a well-developed tree canopy had a negative impact upon the size and diversity of the breeding bird populations. However, by breaking up and increasing the patchiness within each layer, opportunities appear to increase for utilization of the habitat by more individuals and more species. Several avian ecologists have recently pointed out the large impact horizontal diversity has upon the composition of bird populations (Willson 1974 and Roth 1976).

With regard to species composition, the disturbed shrub community further represented a mid-point between the shrub and forest bird communities (Figure 20). Species that clearly depended upon the presence of a forest canopy, such as the ovenbird and scarlet tanager were not important in the earlier successional stages but began to become important members of the avifauna in the disturbed shrub community. Other species that clearly depended upon open scrubby habitats, such as the song sparrow and blue jay, were important in the younger communities but, although still present, became less important members of the avifauna in the disturbed shrub community.

The responses of the functional guilds in the deciduous bird communities to changes in habitat structure that accompanied community succession were statistically tested with regression analysis. As was illustrated in the coniferous communities, the development of the high shrub canopy had a significant impact upon many aspects of the composition of bird communities. The density of high shrubs was positively correlated with the density of shrub nesters ($p < .05$, $R^2 = .65$) and pickers and gleaners ($p < .05$, $R^2 = .73$). Although the correlation was much lower, shrub density was also the best predictor of the density of cavity nesters ($p < .05$, $t > 0$, $R^2 = .26$) and timber feeders ($p < .05$, $t > 0$, $R^2 = .33$). It is not suggested that these two guilds responded directly to the high shrub density but rather to conditions in the canopy that are reflected by the high shrub density. For example, the yellow-bellied sapsucker, the most important member of these two guilds in the deciduous communities, appeared to respond best to an open canopy of mature trees. The open canopy however, had a direct effect upon the density of high shrubs.

Development of the tree canopy was positively correlated with an increase in the density of tree nesters ($p < .05$, $R^2 = .37$) and an increase in the density of ground feeders ($p < .05$, $R^2 = .47$). The increased importance of gound foragers in the closed canopy forest has been noted by others (Probst 1976, and Haapanen 1965). It is postulated that the increase in availability of food resources in the older successional communities and the opening of the understory once the tree canopy closes, is favorable to species that forage on the forest floor. The increase in the basal area of the canopy was also positively correlated with an increase in the density of pursuers ($p < .05$, $R^2 = .43$). As pointed out earlier, the majority of foliage gleaners appear to be dependent upon the subcanopy for resources because the tremendous increase in foliage volume that accompanies development of the tree canopy does not seem to result in a similar increase in the foliage-gleaning guild. Many foliage gleaners are also shrub nesters and the decrease in availability of nesting sites as the shrub layer becomes less luxuriant may also be a limiting factor.

Winter - During the winter of 1977, three aspen-birch plots and three mixed upland plots (containing aspen-birch and various conifers, such as white pine, jack pine and balsam fir) were sampled. Population summaries are presented in Table 7. Winter bird observations in the mixed upland averaged 12 per 5 hours, the highest number among all 6 habitats sampled. Supporting the most diverse fauna, among the ten species recorded were the black-capped chickadee, gray jay, pine grosbeak, hairy woodpecker and downy woodpecker. Although all three stands sampled supported a relatively large number of individuals the most diverse and abundant fauna was recorded on a stand less than one-quarter mile from the Kawishiwi Field Station. Because personnel at the station were maintaining bird feeders the attraction of birds to the area may have had a significant influence upon the observations recorded on the nearby study plot.

Registering a total of six species, the aspen-birch plots averaged seven observations per five hours. The larger number of individuals recorded in the mixed upland suggests that the presence of conifers in a deciduous stand may be important for winter birds. Clearly the conifers could offer more protection from chilling winds.

During the winter of 1976 when winter finches were more abundant, biologists at the Minnamax project in Babbitt (Doran, et al. 1977), recorded an average of 41 observations per 5 hours in an upland deciduous plot. The common redpoll alone account for 22 of the observations.

THE GRASSLAND BIRD COMMUNITY

Forest openings for settlement or agriculture are sparse within the mineral resource zone of the Copper-Nickel Study Area. One such opening along the St. Louis River is the site of an abandoned logging mill. The clearing is now overgrown with a dense growth of dogbane and scattered clumps of willow. One plot, G29, was established in the opening for study during the summer of 1977. The bird community within the stand was unique from those discussed above. The population summary is presented in Table 6. Although the community supported members of several species associations none of the associations were clearly dominant over the others (Figure 12). The dominant species in the community was the song sparrow, which was dependent primarily upon the scattered clumps of shrubs. Two other shrub nesters important in the community were the brown thrasher and clay-colored sparrow (*Spizella pallida*). One of the best indicator species in the avifauna was the barn swallow (*Hirundo rustica*). Unique to the community, it has widened its preference for nesting substrates by adapting to the presence of man-made structures nearby.

CLASSIFICATION OF 1976 BREEDING BIRD DATA

The breeding bird data collected during the 1976 field season was gathered by censusing along road transects, as opposed to censusing within plots as was done during the 1977 field season. Because of the very disturbed and patchy nature of the vegetation within the mineral resource zone, over half of the transects traversed more than one habitat. On those transects where 50% or more of the vegetation represented a single habitat, breeding bird populations were estimated for that habitat alone. The data was then classified with the discriminant functions that were generated for the communities recognized in 1977. The classification served two functions: 1) to test the applicability of the community classification derived from the 1977 data; and 2) to increase the available data base for bird communities in the RCNSA. Although the results will not be presented in this report the classification was successful and proved the utility of the 1977 classification.

SUMMARY AND CONCLUSION

Numerous studies have documented the direct impacts that habitat alterations have upon the size and composition of the avifauna (Odum 1950, Hooper 1967, Karr 1968, and Conner and Adkisson 1975). Birds respond directly to the structure and composition of the vegetation and when changes in land-use alter the existing structure the bird community is immediately effected. In order to accurately assess the potential impacts of such changes it is essential to characterize bird communities and to define the influence of the vegetation upon their composition prior to prospective alterations. To this end, the primary objective of the avian program of the Copper-Nickel Study was to characterize the breeding bird communities associated with the major habitats of the RCNSA.

During the 1976 and 1977 summer field seasons, breeding bird data were collected on a total of 48 transects and 39 plots. The sites were selected to proportionately represent the relative abundance of major cover types in the mineral resource zone of the Copper-Nickel Study Area. Territory mapping was the census technique employeed for collecting population data. Numerical classification techniques and discriminant analysis were used for classifying the sample stands into major communities.

Nine major breeding bird communities and nine speices associations were recognized on the Copper-Nickel Study sites. The communities were charactized under three major headings: 1) wetland bird communities; 2) conifer upland bird communities; and 3) deciduous upland bird communities. The characterization of the conifer and deciduous communities was organized to present the ecological trends in community succession. Overall, the species composition in all nine communities was dominated by the presence and abundance of wood warblers. The composition of the regional avifauna, dominated by the parulids, was shown to be significantly different from the relative species composition of Minnesota's statewide avifauna.

Faunistically, the most unique bird community in the RCNSA is the conifer lowland community. Many rare and uncommon species were either confined to the lowland habitat or relatively insignificant elsewhere. Included among these species are the yellow-bellied flycatcher, Connecticut warbler, Cape May warbler and Tennessee warbler. Nearly 70% of the individuals in the community depended on the unique substratum of the lowland for nesting cover, but were equally dependent upon the shrub and tree canopies for food resources.

Faunistically, the early successional communities of the upland conifer and upland deciduous forests are nearly indistinguishable. Once a stand has been harvested, the dominant cover type that was present before harvest has relatively little influence upon the size and composition of the bird community. Trees that were not cut down however, can exert a significant influence on the community composition. The presence of trees in the "two-dimensional" habitat of the clearcut may provide nesting cover for various tree nesters and shrub nesters that would otherwise be absent. Because of the lack of available resources the structurally simple clearcut supports the lowest density of breeding pairs of all upland communities.

The development of a shrub layer in both the coniferous and deciduous habitats had a profound effect upon bird populations. The increase in nesting cover and food resources provided by the shrubs was correlated with a two- to three-fold increase in population density. The increase in total numbers was primarily absorbed by an expansion in the number of shrub nesters and foliage gleaners. Although the number of ground nesters also increased the relative contribution of ground feeders to the population decreased somewhat. It was suggested that the increased coverage of shrubs was an advantage to ground nesters but may actually hamper the foraging activities of species that forage on the ground.

The average number of species in the shrub communities also increased above that found in the clearcut community. The young conifer plantations however, demonstrated a more significant increase than the young aspen plots. Structurally the young plantation stands were more diverse providing more opportunities for exploitation of the habitat by different species. Many stands, for example, that have been cleared and prepared for pine regeneration contain windrows which harbor a dense growth of Rubus and aspen. Such deciduous growth is important to many shrub nesters.

Although still quite similar, the species composition of the young, seral stages of the upland conifer and deciduous forests, begin to reflect differences that in time will clearly distinguish their avifuana. Members of the red-eyed vireo/ovenbird association, the dominant association in the mature deciduous forest, are more important in the young aspen community. Members of the hermit thrush/blackburian warbler association, the characteristic association of the mature conifer plantation, are more important in the young plantation bird community.

The tree layer development of forest stands is accompanied by a decrease in both the diversity and size of the corresponding bird populations. Closure of the tree canopy appeared to correlate with a decrease in the number of shrub nesters and foliage gleaners and with an increase in the number of tree-nesters and pursuers. The trends suggests that most foraging occurs underneath the canopy or above it rather than within it.

Faunistically, the mature conifer and deciduous forests are more distinct from one another than any of the bird communities in the early successional stages. The red-eyed vireo/ovenbird association is clearly dominant in the deciduous forest whereas, in the conifer plantation it is co-dominant with the more characteristic hermit thrush/blackburian warbler association.

The decreased size and diversity of the forest bird communities does not support the finding from several studies that ecological diversity increases with the age of the community (e.g. Shugart and James 1973). It needs to be pointed out however, that the mature deciduous and coniferous forests discussed in this report are very young, even-aged forests. If succession were to proceed beyond the stage at which most stands are now harvested, natural openings would begin to appear in the stand due to a variety of natural disturbances. These openings would increase the structural diversity of the stand and thereby increase the diversity of breeding birds.

The concept of diversity has received a great deal of attention by wild-life and forest managers over the past decade. The observed increase in the size and diversity of the young shrub stages of community succession has often been used as a justification of the beneficial effects of timber management. Increased diversity however, should not be a prime consideration or justification for habitat alteration. 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.

REFERENCES CITED

Anderberg, M.R. 1973. Cluster analysis for applications. Academic Press, New York. 359p.

Anderson, S.H. and H.H. Shugart. 1974. Habitat selection of breeding birds in an east Tennessee deciduous forest. Ecology 55:828-837.

Arib, R. 1977. The 1978 Blue List. American Birds 31:1087-1096.

Balda, R.P. 1975. Vegetation structure and breeding bird diversity. Proceedings of the symposium on management of forest and range habitats for non-game birds, May 5-6, 1975. USDA Forest Service, General Technical Roport WO-1, p.59-86.

Bergstedt, B. and G. Niemi. 1974. A comparison of two breeding bird censuses following the Little Souix Fire. Loon 46:28-33.

Bock, C.E. and L.W. Lepthien. 1976. Synchronous eruptions of boreal seed-eating birds. American Naturalist 110:559-571.

Boesch, D.F. 1977. Application of numerical classification in ecological investigations of water pollution. Environmental Protection Agency, Ecological Research Series, EPA-600/3-77-033. 115p.

Brewer, R. 1967. Bird populations of bogs, Willson Bulletin 79:371-396.

Cody, M.L. 1968. On the methods of resource division in grassland bird communities. American Naturalist 102:107-147.

Cody, M.L. 1974. Competition and the structure of bird communities. Monographs in Population Biology 7:1-318.

Conner, R.N. and C.S. Adkisson. 1975. Effects on clearcutting on the diversity of breeding birds. J. Forest 73:781-786.

Conner, R.N. and C.S. Adkisson. 1976. Discriminant function analysis: A possible aid in determining the impact of forest management on woodpecker nesting habitat. Forest Sci. 22:122-127.

Curtis, J.T. 1959. The Vegetation of Wisconsin. An ordination of plant communities. University of Wisconsin Press, Madison. 657p.

Curtis, R.L. and T.H. Ripley. 1975. Water management practices and their effect on non-game bird habitat values in a deciduous forest community. Proceedings of the symposium on management of forest and range habitats for non-game birds, May 5-6, 1975. USDA Forest Service, General Technical Report WO-1. p.128-141.

Dickinson, J.G. 1978. Comparison of breeding bird census techniques. American Birds 32:10-13.

Doran, P. and J. Todd. 1975. Golden-winged warblers near Babbitt, Minnesota. Loon 47:144.

Doran, P., J. Todd and T. Hargy. 1977. Minnamax-avian update for 1976. Loon 49:70-77.

Emlen, J.T. 1971. Population densities of birds derived from transect counts. Auk 88:323-341.

Eriksson, K. 1970. Ecology of the irruption and wintering of Fennoscandian Redpolls. Ann. Zool. Fennici 7:273-282.

Erskine, A. 1977. Birds in boreal Canada. Canadian Wildlife Service, Report Series No. 41. 73p.

Field, J.G. 1977. A numerical analysis of changes in the soft-bottom fauna along a transect across False Bay, South Africa. J. Exp. Mar. Biol. Ecol. 7:215-253.

Gleason, H.A. 1926. The individualistic concept of the plant association. Bull. Torrey Botan. Club 53:7-26.

Green, J.C. 1971. Summer birds of the Superior National Forest, Minnesota. Loon 43:103-107.

Green, J.C. and R.B. Janssen. 1975. Minnesota Birds. University of Minnesota Press. 217p.

Grigal, D.F. and L.F. Ohmann. 1975. Classification, description, and dynamics of upland plant communities within a Minnesota wilderness area. Ecological Monographs 45:389-407.

Haapanen, A. 1965. Bird fauna of the Finnish forests in relation to forest succession. I. Ann. Zool. Fennici 2:153-196.

Hagar, D.C. 1960. The interrelationships of logging, birds, and timber regeneration in the Douglas-fir region of northwestern California. Ecology 41:116-125.

Hooper, R.G. 1967. The influences of habitat disturbances on bird populations. Unplubished M.S. thesis, Virginia Polytechnic Institute.

Jackson, D.A. 1976. Nesting use and success in a conifer plantation in Clay County, Minnesota. Loon 48:92-94.

James, F.C. 1971, Ordinations of habitat relationships among breeding birds. Wil. Bull, 83:215-235.

Kendeigh, S.C. 1944. Measurement of bird populations. Ecological Monographs 14:67-106.

Kendeigh, S.C. 1948. Bird populations and biotic communities in northern lower Michigan. Ecology 29:101-114.

Kendeigh, S.C. 1956. A trial census of birds at Itasca State Park, Minnesota. The Flicker 28:90-104.

Kilgore, B.M. 1971. Response of breeding bird populations to habitat changes in a giant sequoia forest. Amer. Midl. Nat. 85:135-152.

Kricher, J.C. 1975. Diversity in two wintering bird communities: possible weather effects. Auk 92:766-777.

Lack, D. 1954. The natural regulation of animal numbers. Clarendon, Oxford. 343p.

Lay, D.W. 1938. How valuable are woodland clearings to bird life? Willson Bulletin 50:254-256.

MacDonald J.E . 1965. A bird census in a red pine plantation and mixed stands in Kirkwood Township, Ontario Canadian Field Naturalist 79: 21-25.

MacArthur, R.H. 1958. Population ecology of some warblers of northern coniferous forests. Ecology 39:599-619.

MacArthur, R.H. and J.W. MacArthur. 1961. On bird species diversity. Ecology 42:394-398.

Marschner, F.J. 1930. The original vegetation of Minnesota. (a map). Published 1964 by Soil Conserv. Service., U.S. Dept. Agric. St. Paul, Minnesota.

Martin, N.D. 1960. An analysis of bird populations in relation to forest succession in Algonguin Provincial Park, Ontario, Ecology 41: 126-140.

Moyle, J.B. 1975. The uncommon ones: animals and plants which merit special consideration and management. Minnesota Department of Natural Resources, 32p.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons, Inc. 547p.

Niemi, G.J. 1977. Habitat alteration: its effect on avian composition and habitat selection. Unpublished M.S. thesis, Univerisity of Minnesota, Duluth.

Nobles, M., L. DeBoer, K. Johnson, B. Coffin, L. Fellows and N. Christensen, N. 1977. Quantitivate relationships among some Pinus banksiana-Picea mariana forests subjected to wildfire and postlogging treatments. Canadian Journal of Forest Research 7:378-377.

Odum, E.P. 1950. Bird populations of the Highlands (North Carolina) Plateau in relation to plant succession and avian invasion. Ecol. 31: 587-605.

Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Co. 574p.

Olcott, P.G. and D.I. Siegel. 1978. Physiography and surficial geology of the copper-nickel study region, northeastern Minnesota. Water-Resources Investigations 78-51, Open-file report. 41p.

Orloci, L. 1967. An agglomerative method for classification of plant communities. J. Ecol. 55:193-205.

Pengelly, W.L. 1972. Clearcutting; detrimental aspects for wildlife resources. Journal of Soil and Water Conservation 27:255-258.

Probst, J. 1976. Avian community structure in central Pennsylvania. Unpublished dissertation, Dept. of Biology, Princeton University. 76p.

Pielou, E.C. 1977. Mathematical Ecology. John Wiley & Sons, Inc. New York, 384p.

Resler, R.A. 1972. Clearcutting; beneficial aspects for wildlife resources. Journal of Soil and Water Conservation 27:250-254.

Robbins, C.S. 1970. An international standard for a mapping method in bird census work, recommended by the International Bird Census Committee. Aud. Field Notes 24:722-726.

Rov, N. 1975. Breeding bird community structure and species diversity along an ecological gradient in deciduous forests in western Norway. Ornis Scand. 6:1-14.

Schoener, T.W. 1969. Models of optimal size for solitary predators. Amer. Nat. 103:277-313.

Smith, K.C. 1977. Distribution of summer birds along a forest moisture gradient in an Ozark watershed. Ecol. 58:810-819.

Sturges, F W., R.T. Holmes, and G.E. Likens. 1974. The role of birds in nutrient cycling in a northern hardwoods ecosystem. Ecology 55:149-155.

Williams, A.B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Manogr. 6:317-408.

Willson, M.F. 1974. Avian community organization and habitat structure. Ecology 55:1017-1029.

FIGURE 1 The Regional Copper-Nickel Study Area

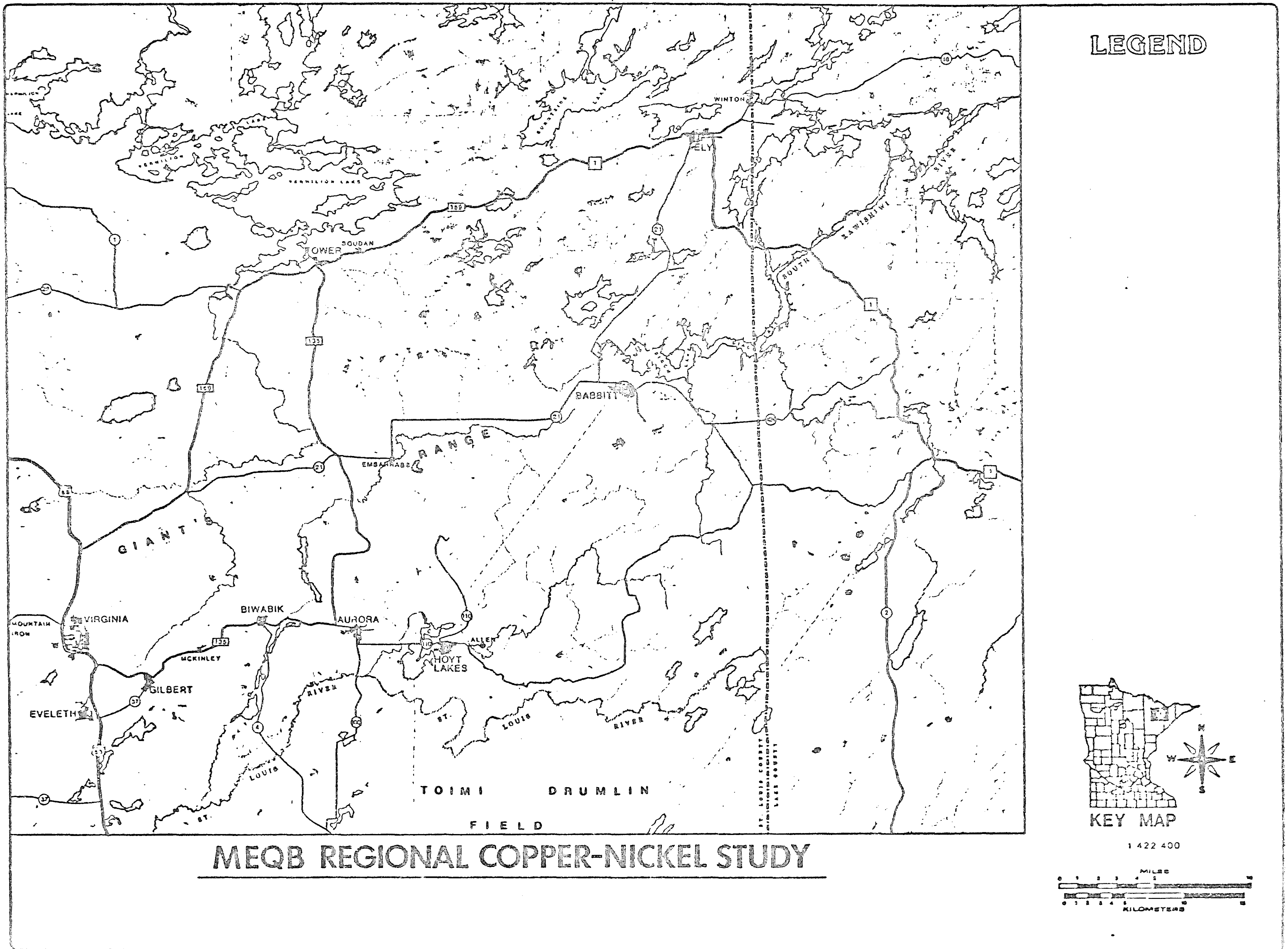


FIGURE 2 Summer 1976 Sample Sites

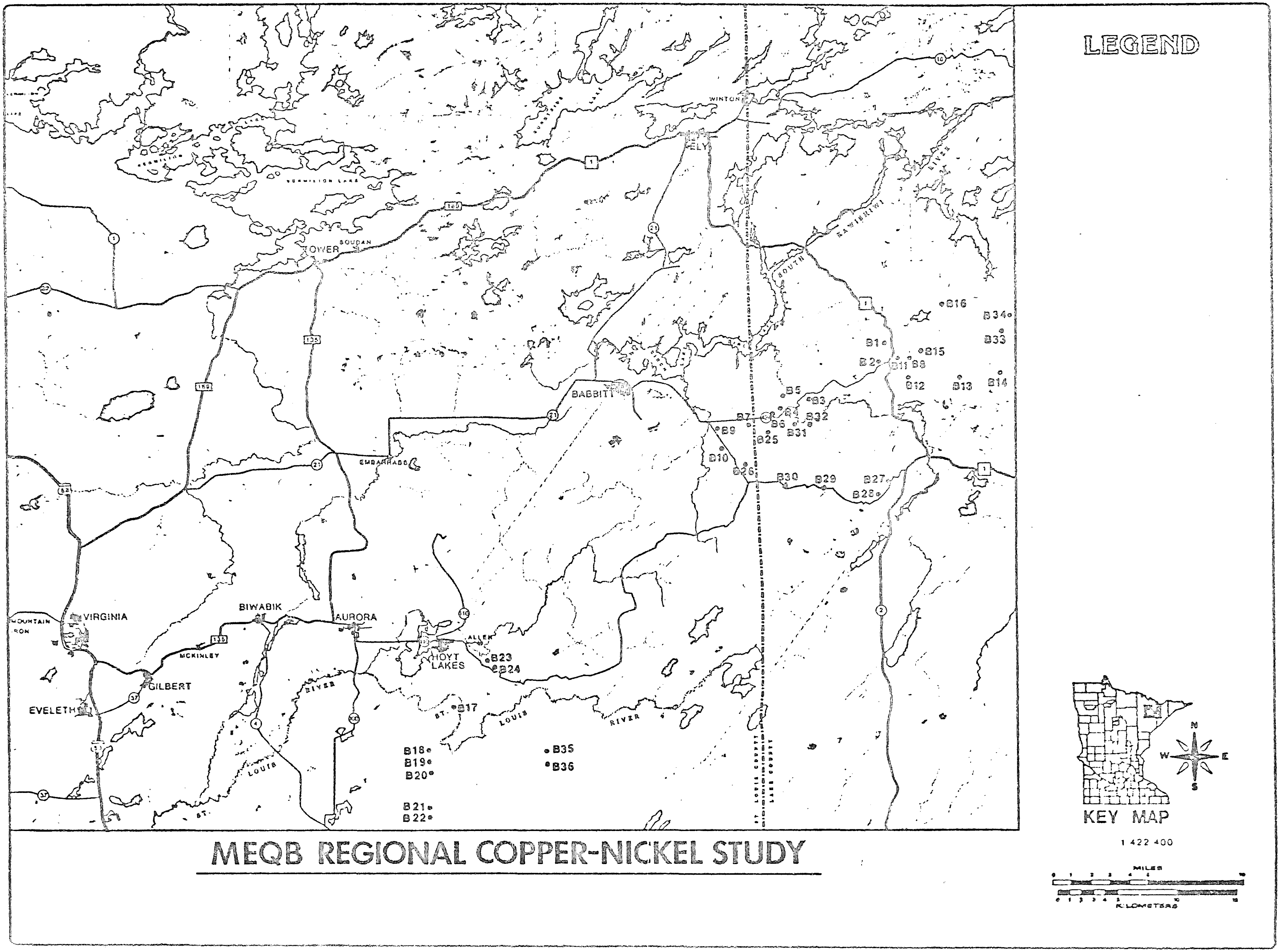
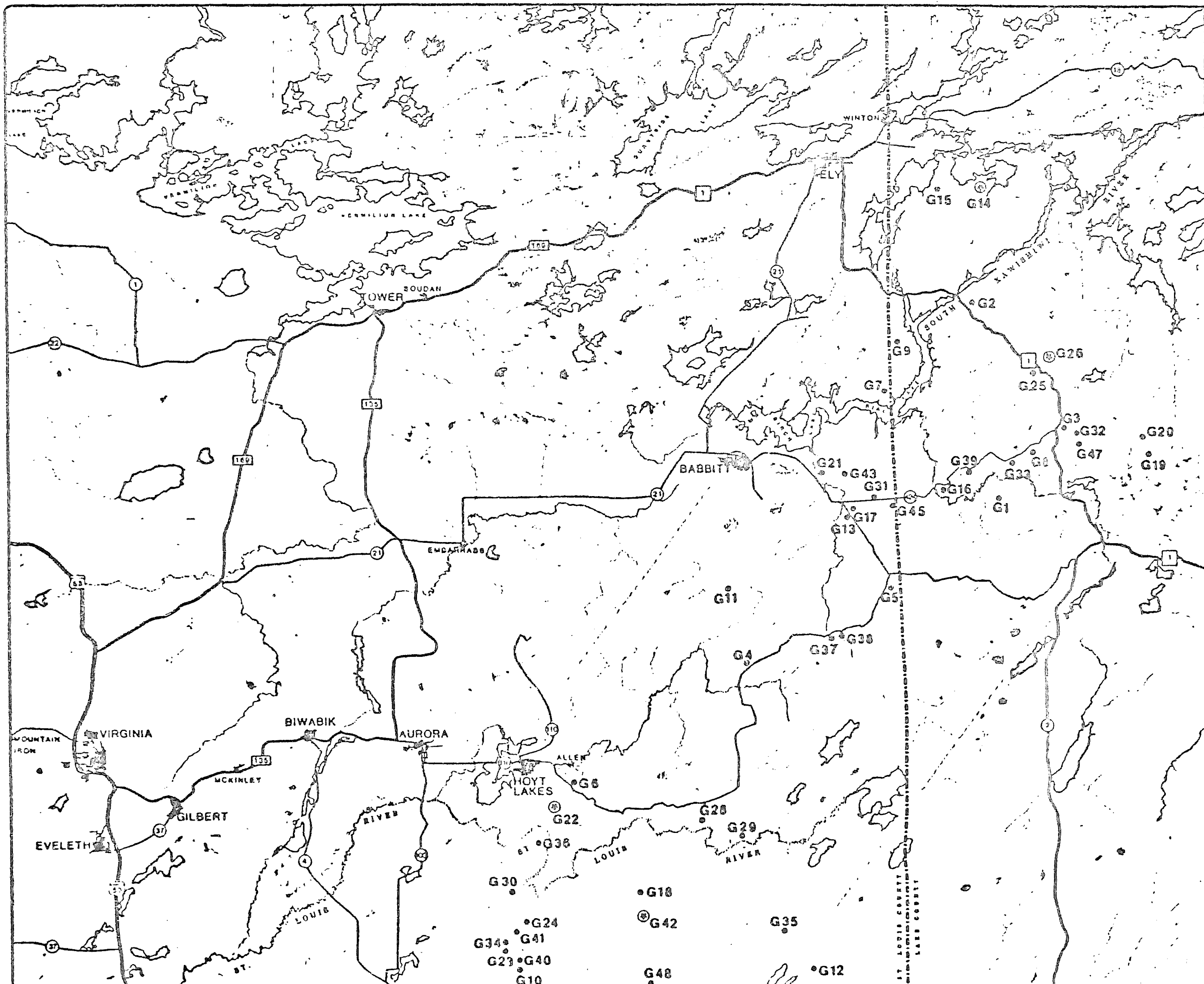


FIGURE 3   Summer 1977 Sample Sites



MEQB REGIONAL COPPER-NICKEL STUDY

LEGEND

⊛ Sites where both transects and plots were sampled.

KEY MAP

1 422 400

MILES

KILOMETERS

FIGURE 4 Winter 1977 Sample Sites

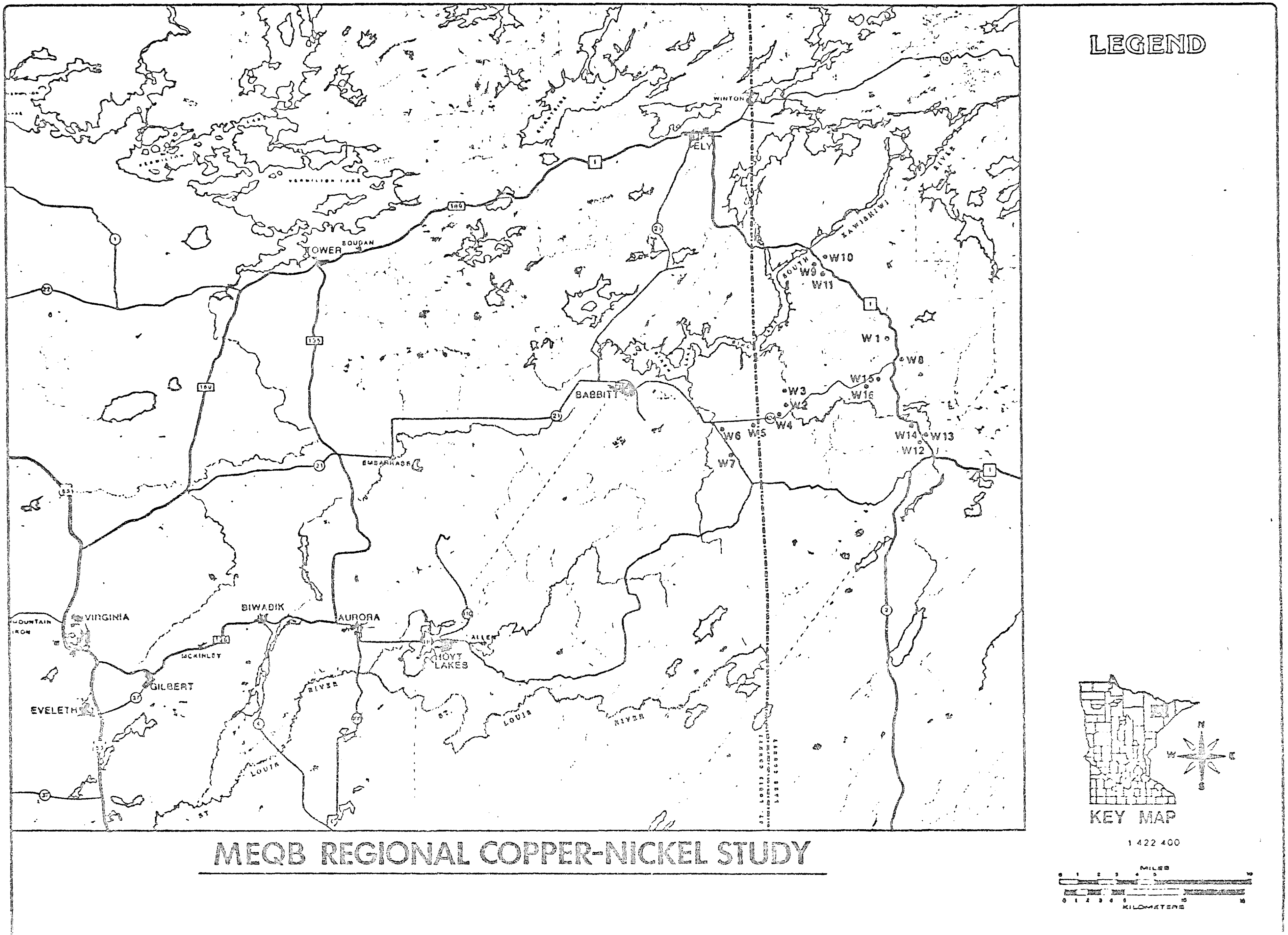


FIGURE 5 Relative abundance of major bird families in 1976 and 1977 (shaded). The total number of observations per family is recorded in parentheses.

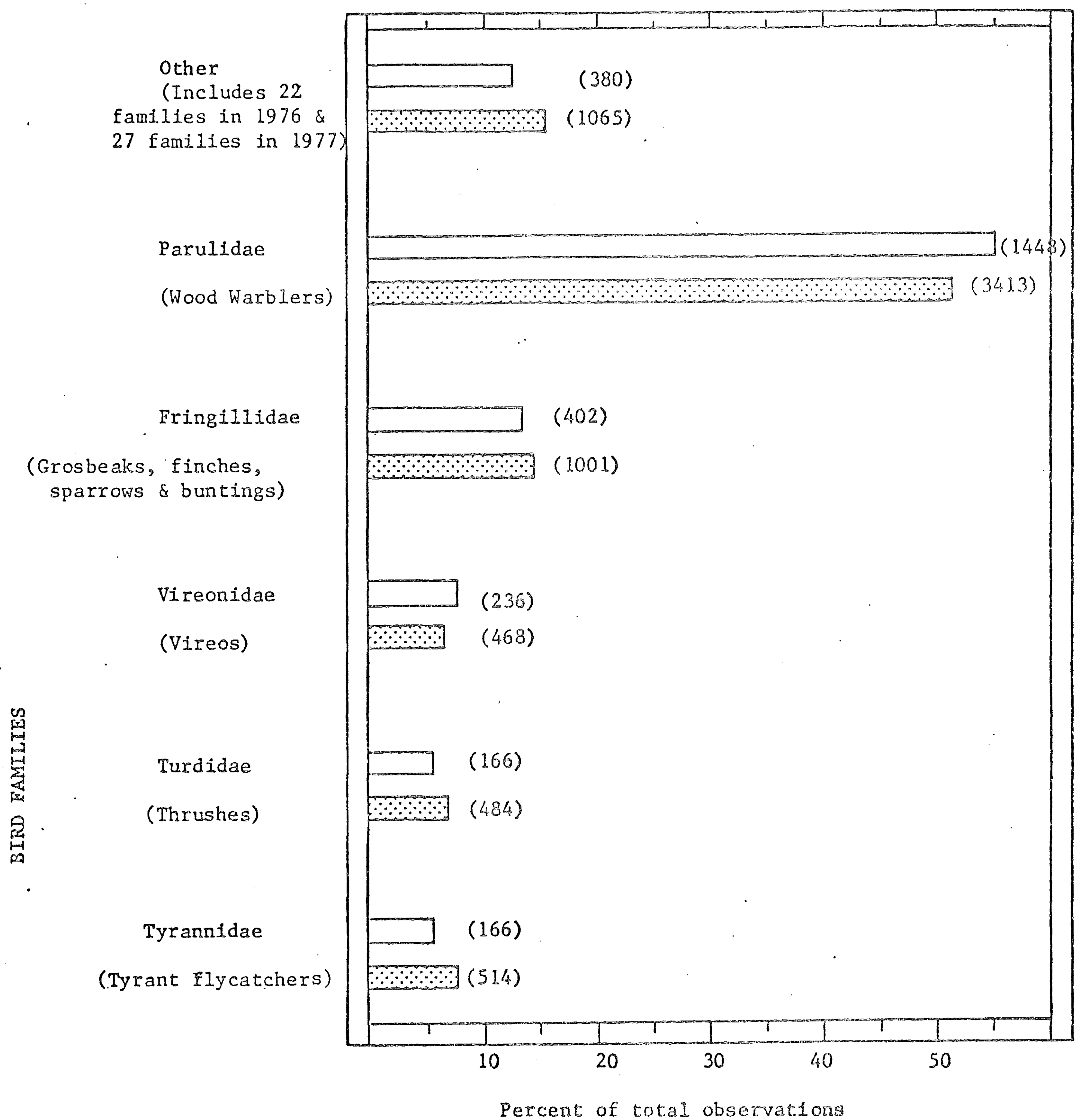
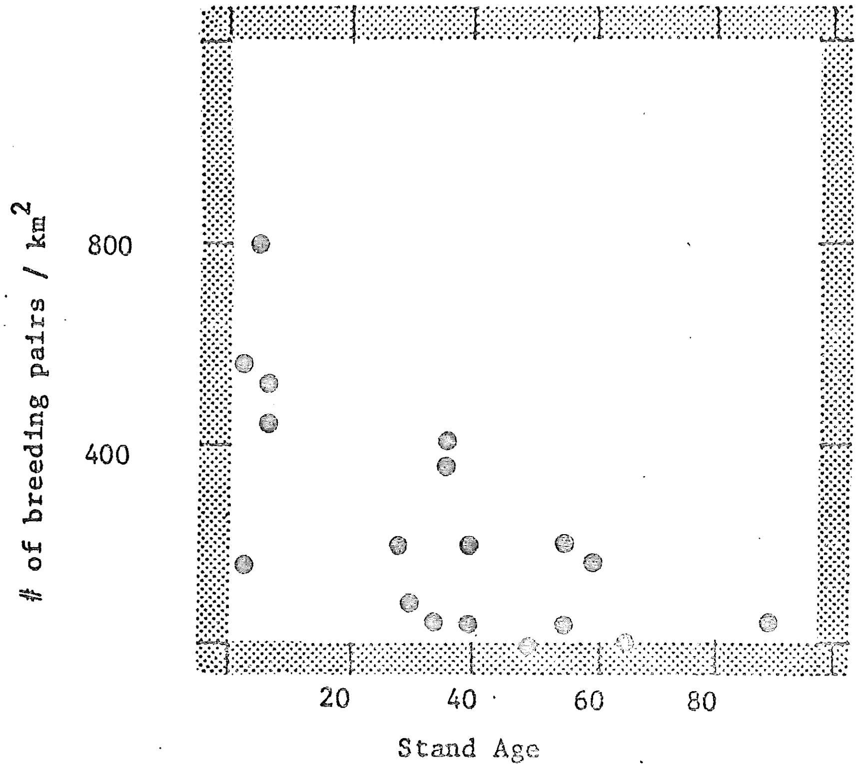


FIGURE 6 Breeding Densities of 3 common disturbance species (chestnut-sided warbler, mourning warbler and white-throated sparrow) plotted vs. stand age

A. Up[illegible]l Deciduous Plots



B. Upland Conifer Plots

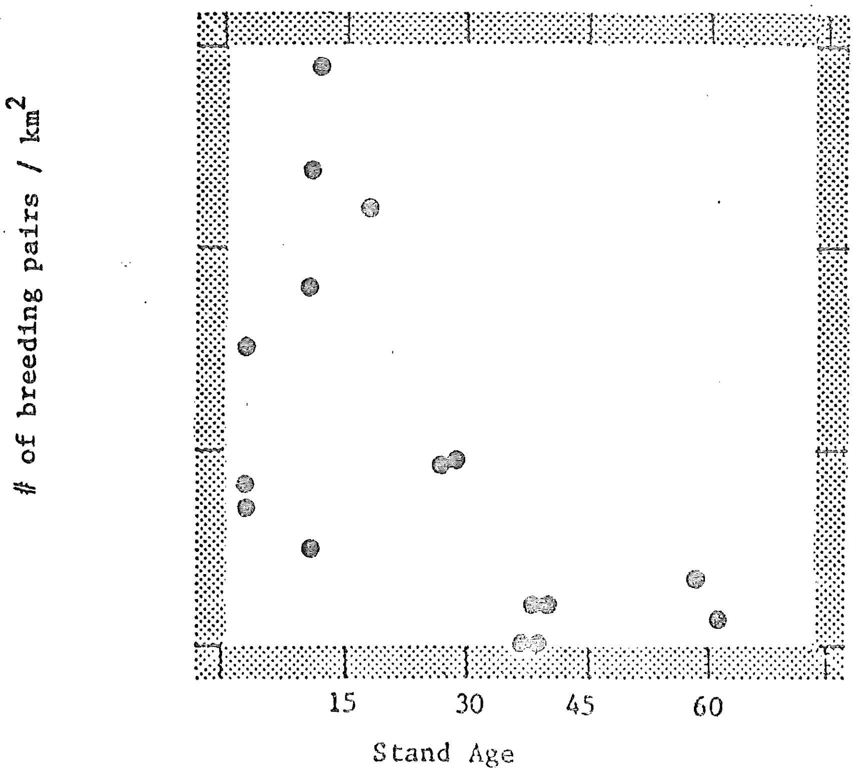


FIGURE 7 The relative abundance of major passerine bird families in the State of Minnesota compared with Cu-Ni Study Sites 1976-77.

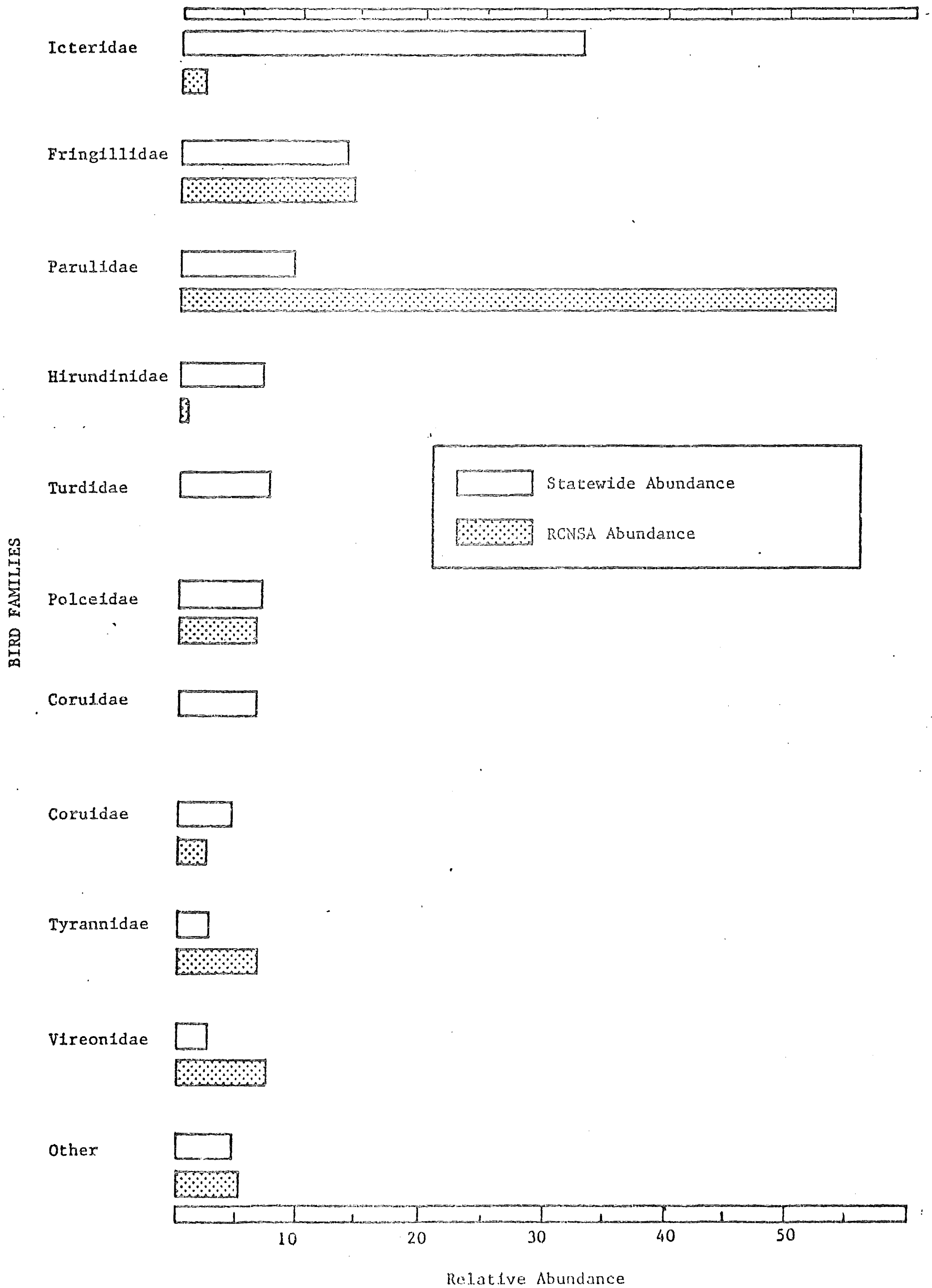


FIGURE 8 The Relative Abundance of Major Species Groups at Feeders compared with the Relative Abundance in the Field.

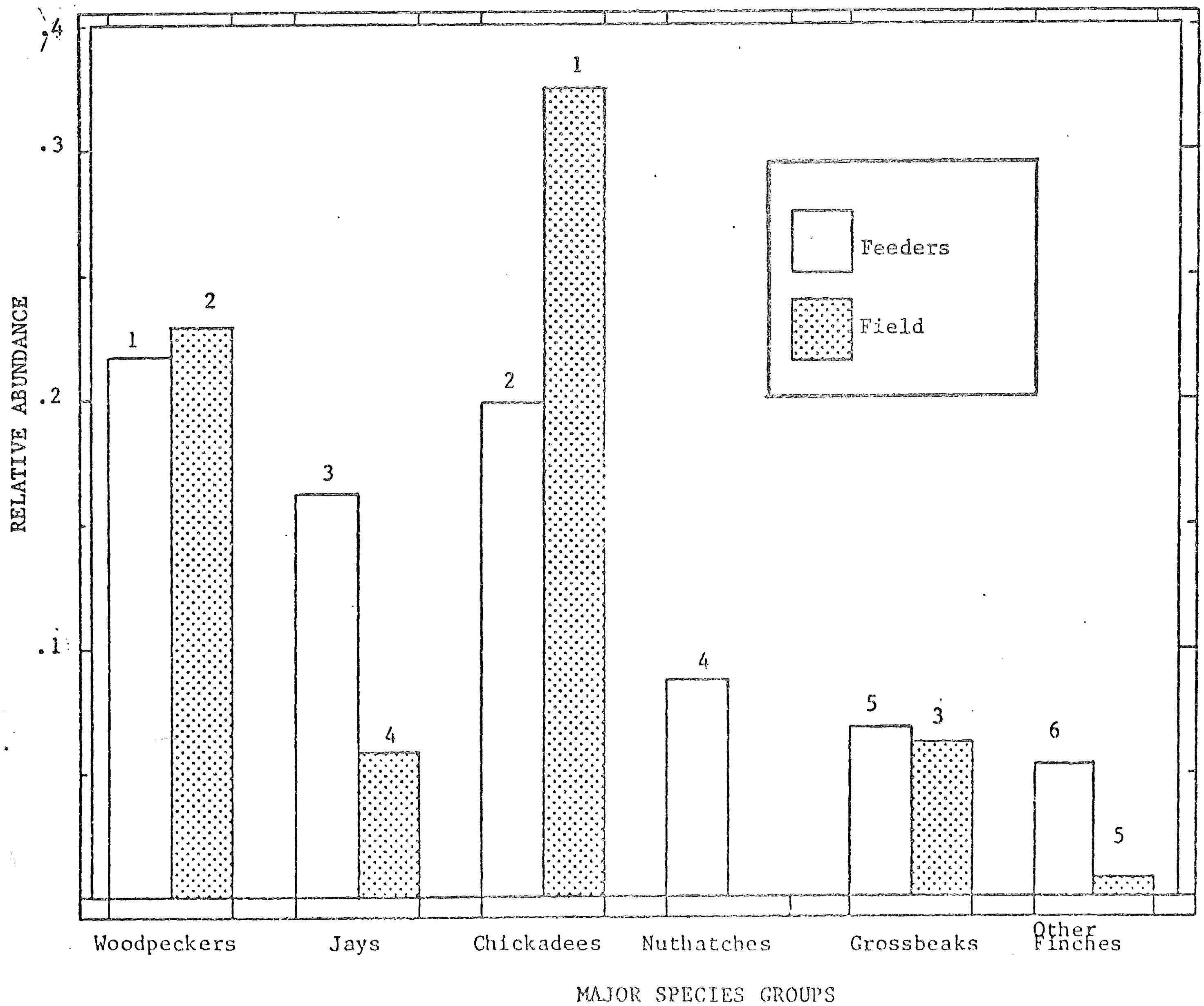


FIGURE 9 Yearly abundance of winter finches in Minnesota, determined by the Minnesota Christmas Bird Count, 1963-1976.

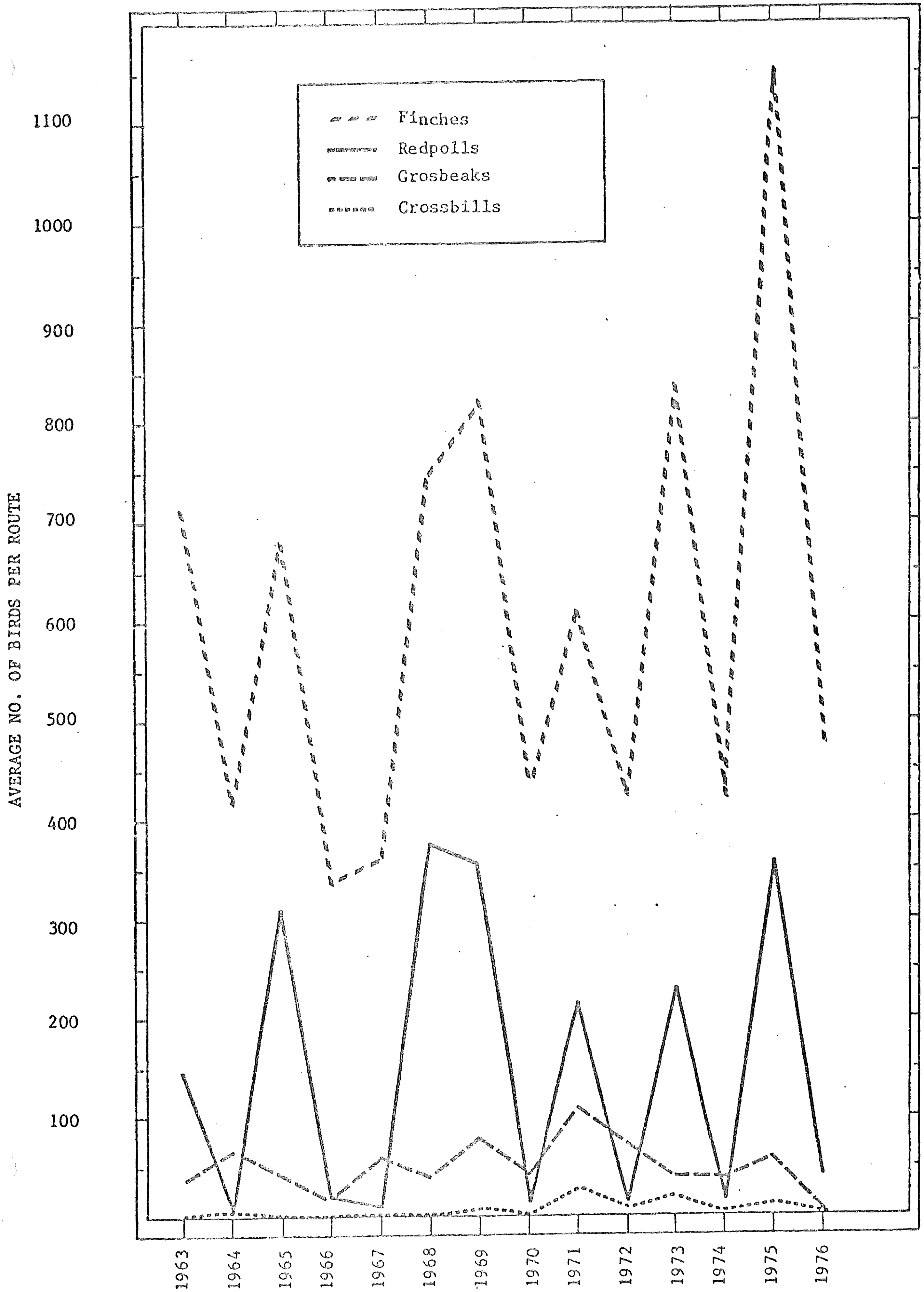
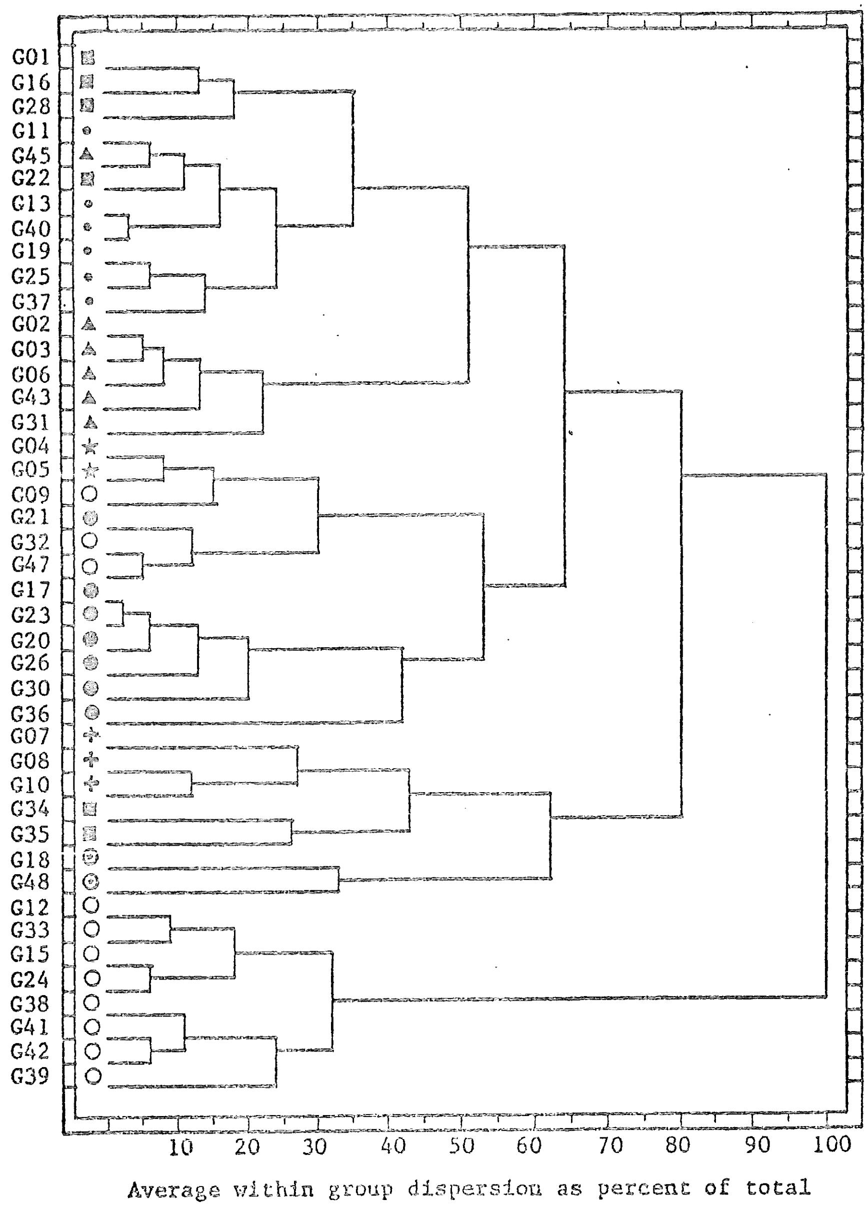


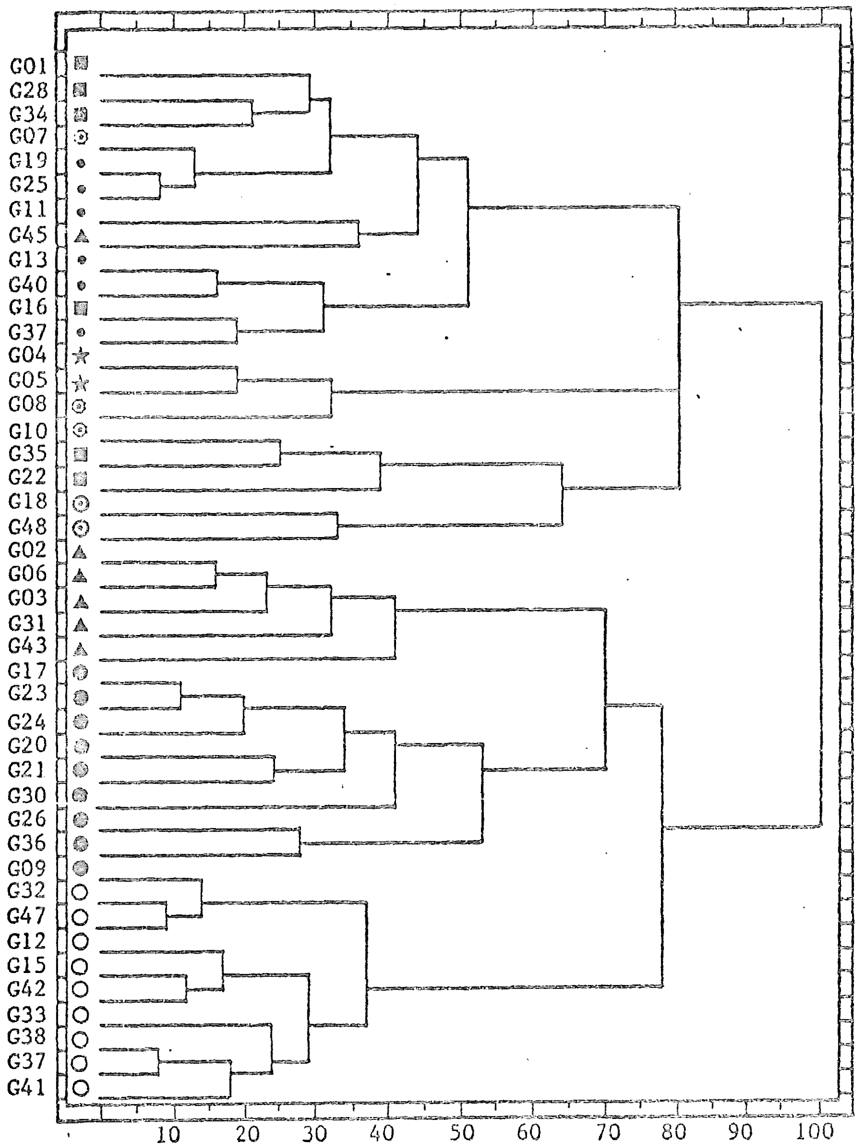
FIGURE 10 Dendrogram showing heirarchial relationships among bird communities of 43 stands based on the density of 56 bird species.



Key to major vegetation cover types on each plot:

- ▩ Young plantation
- • Recent Clearcut
- ▲ Conifer lowland
- ○ Deciduous upland
- ☆ Disturbed shrub
- ◍ Conifer upland
- ✢ Aspen regeneration
- ⊕ Alder

FIGURE 11 Dendrograms showing heirarchial relationships among the bird communities of 43 stands based on the importance value of 56 bird species.



Average within group dispersion as percent of total

Key to major vegetation cover types on each plot:

- Young plantation
- Recent clearcut
- Conifer lowland
- Deciduous upland
- Disturbed shrub
- Conifer upland
- Aspen regeneration
- Alder

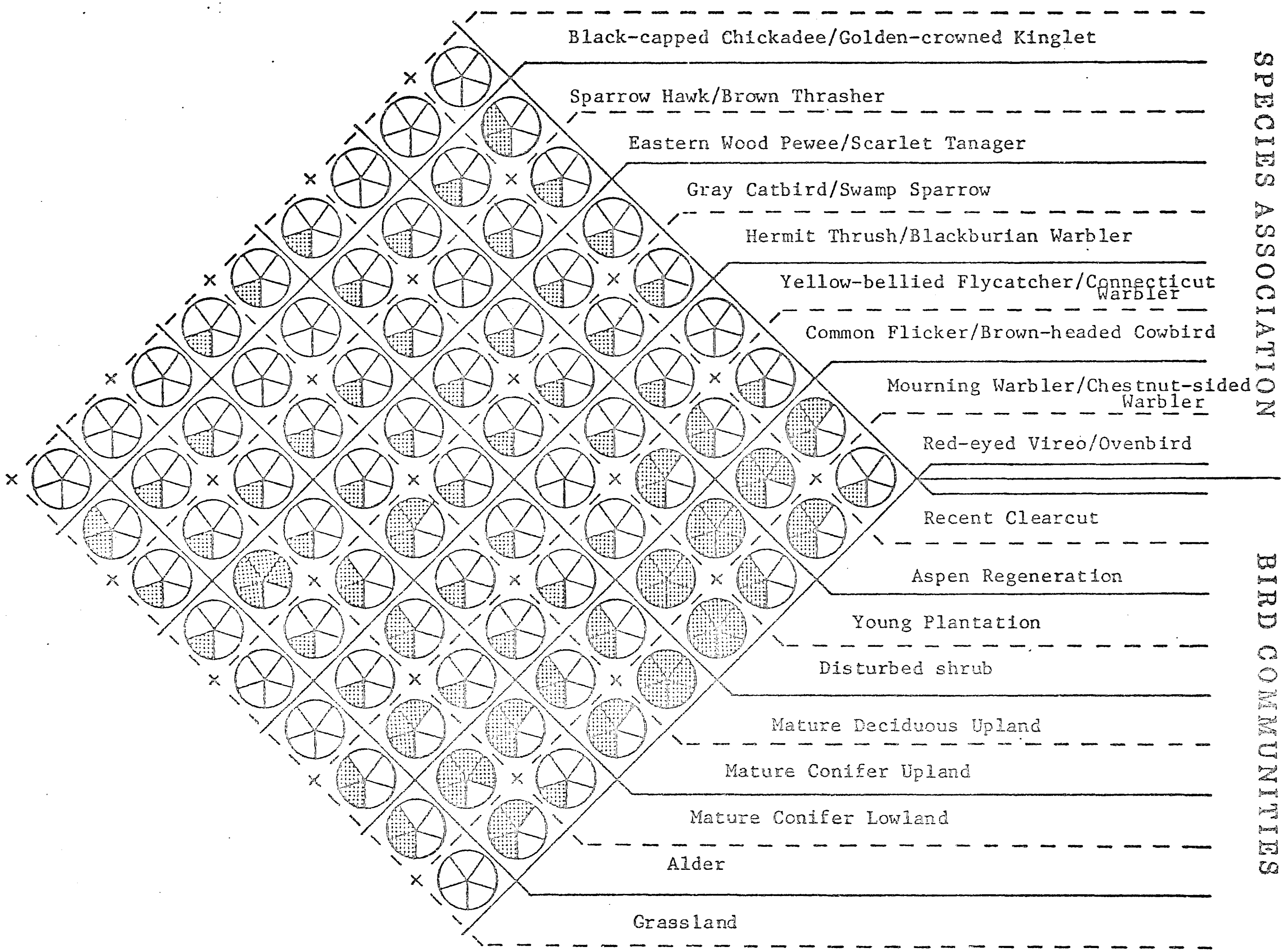


FIGURE 12. The relative importance of species associations within major bird communities of the RCNSA.

FIGURE 13 Spatial Relationships of bird communities on 43 of the 1977 sites when plotted using 2 discriminant functions

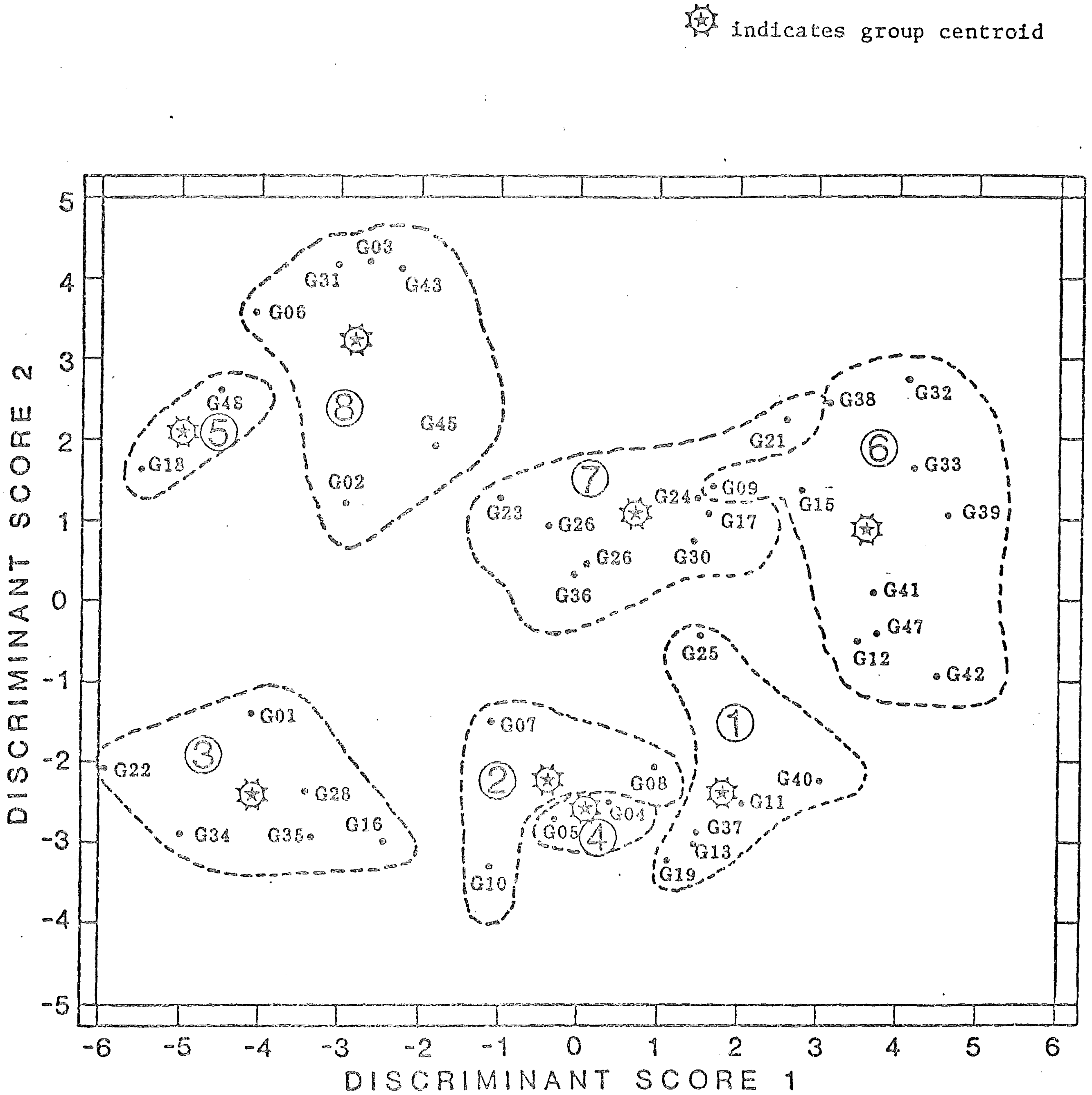


FIGURE 14 The average number of bird observations in 6 major habitats, Winter 1977.

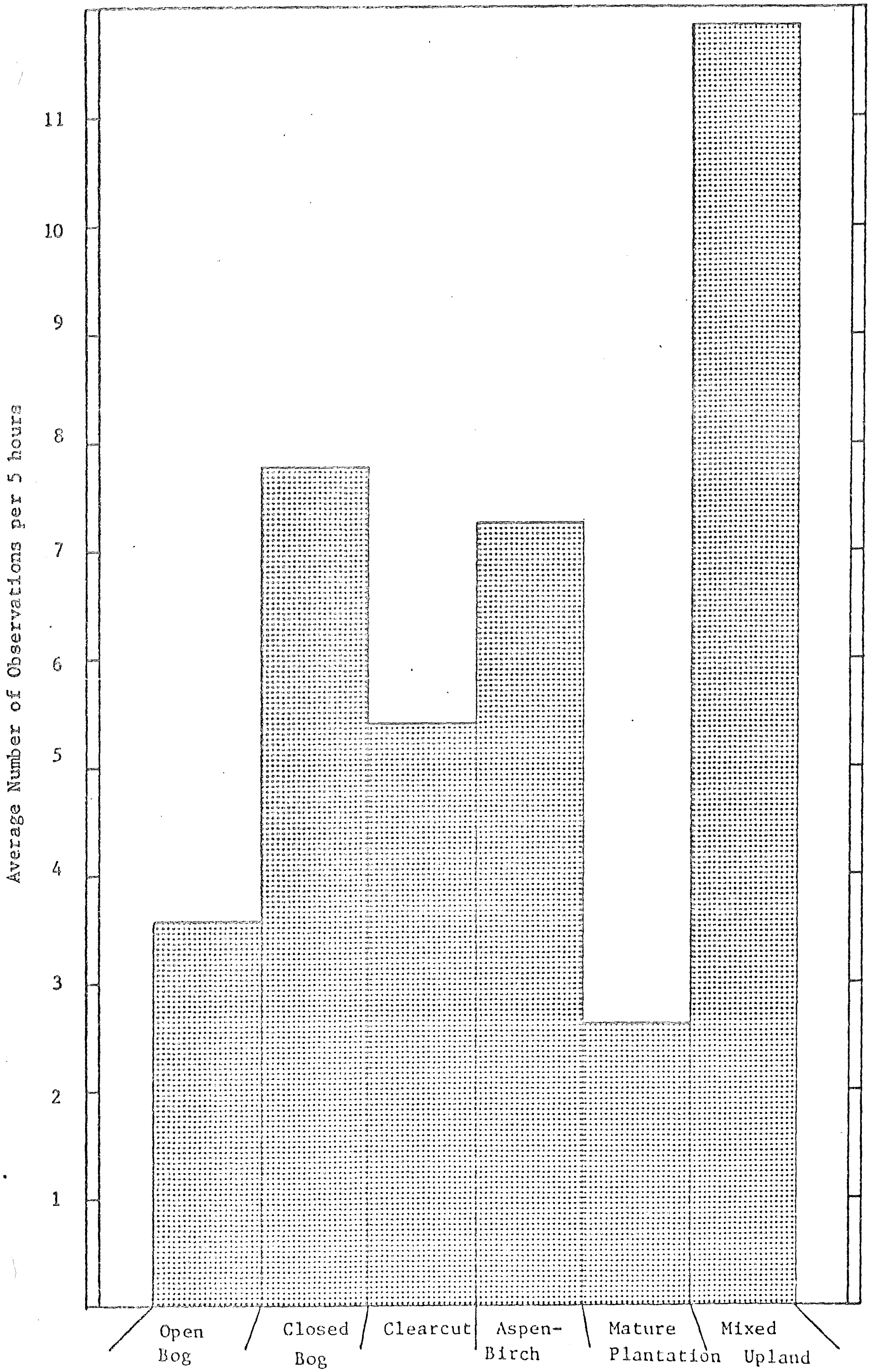


FIGURE 15 A. The nesting guild composition of three wetland bird communities.

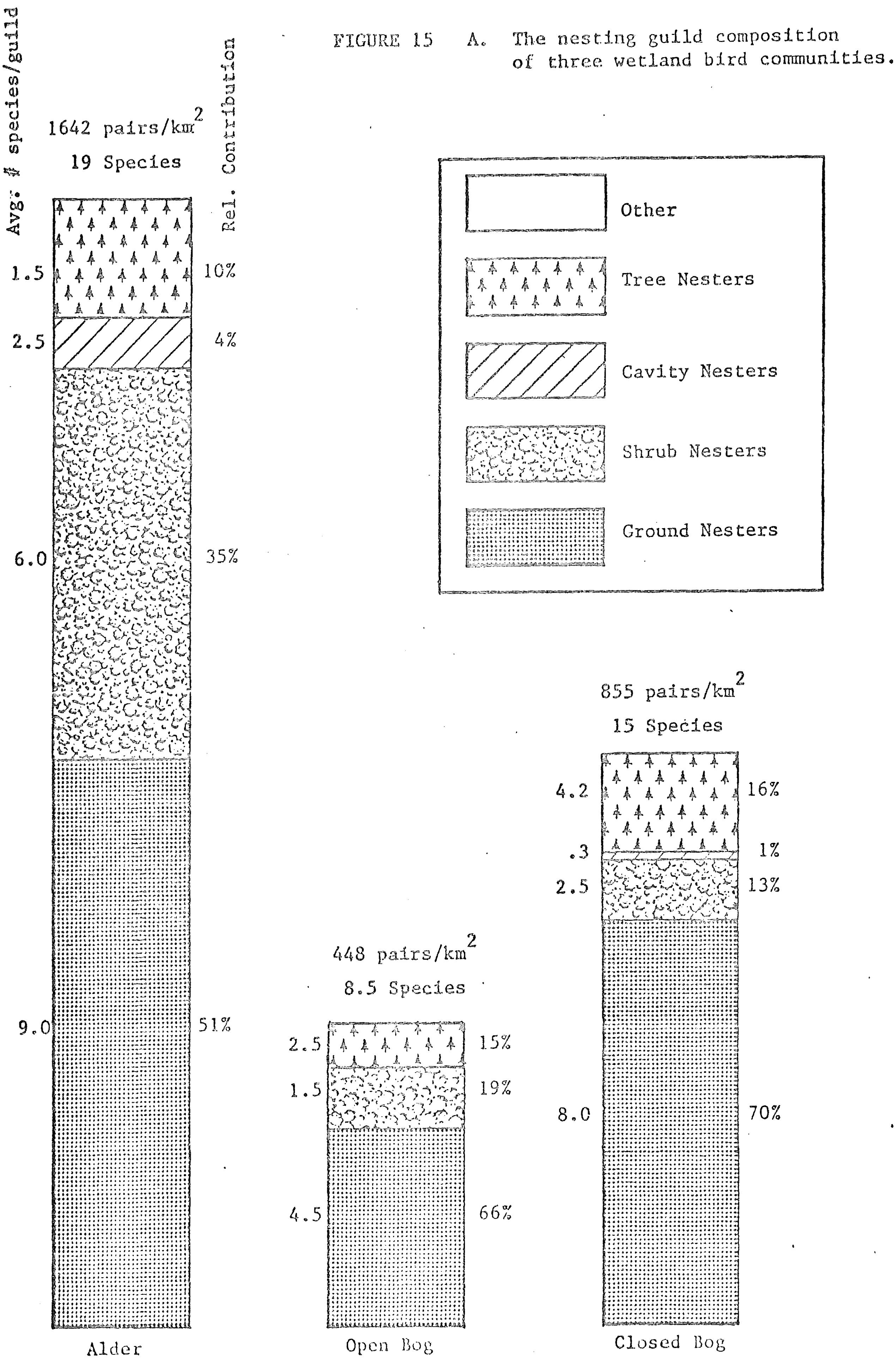
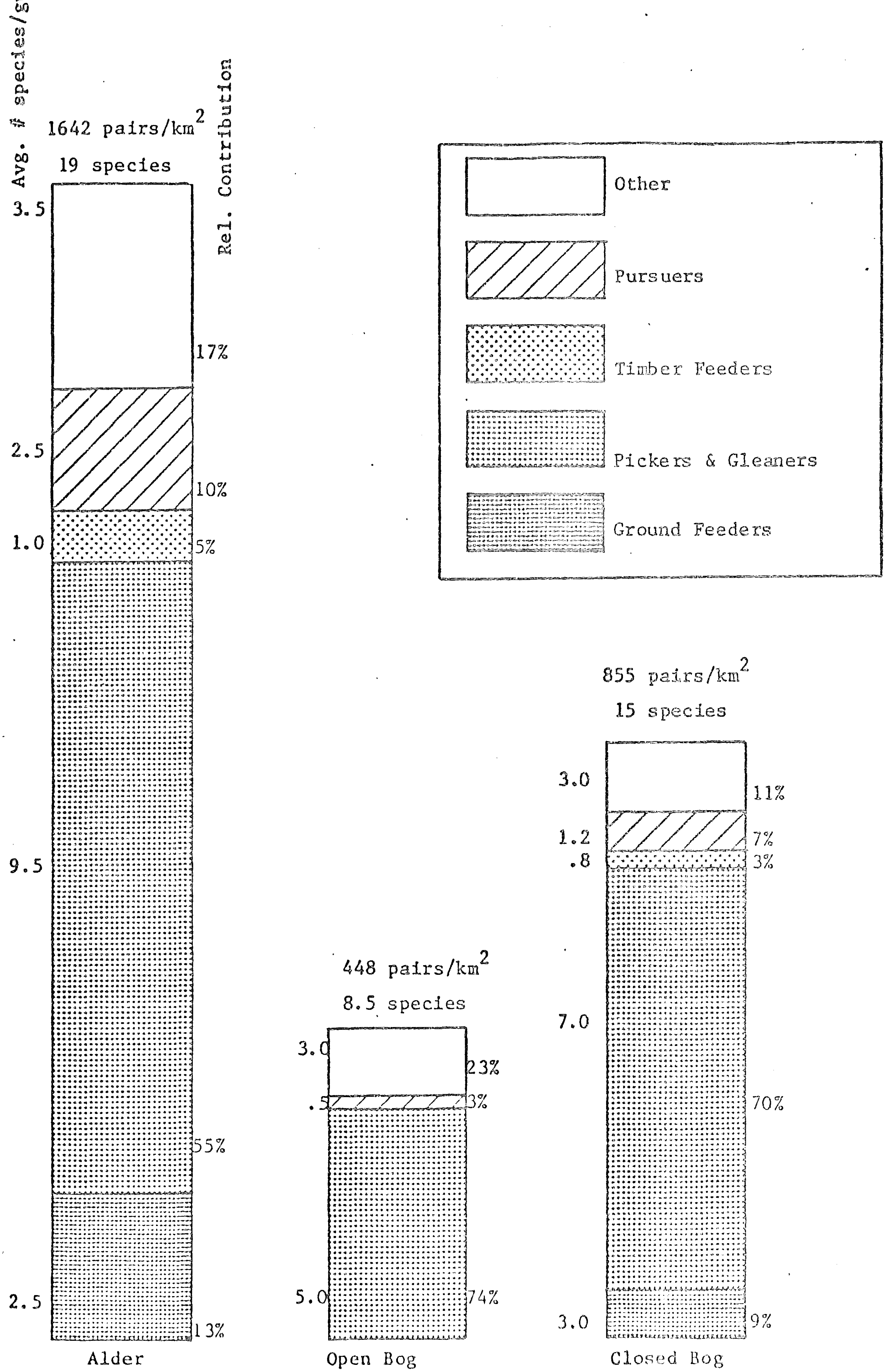


FIGURE 15 B. The foraging guild composition of three wetland bird communities



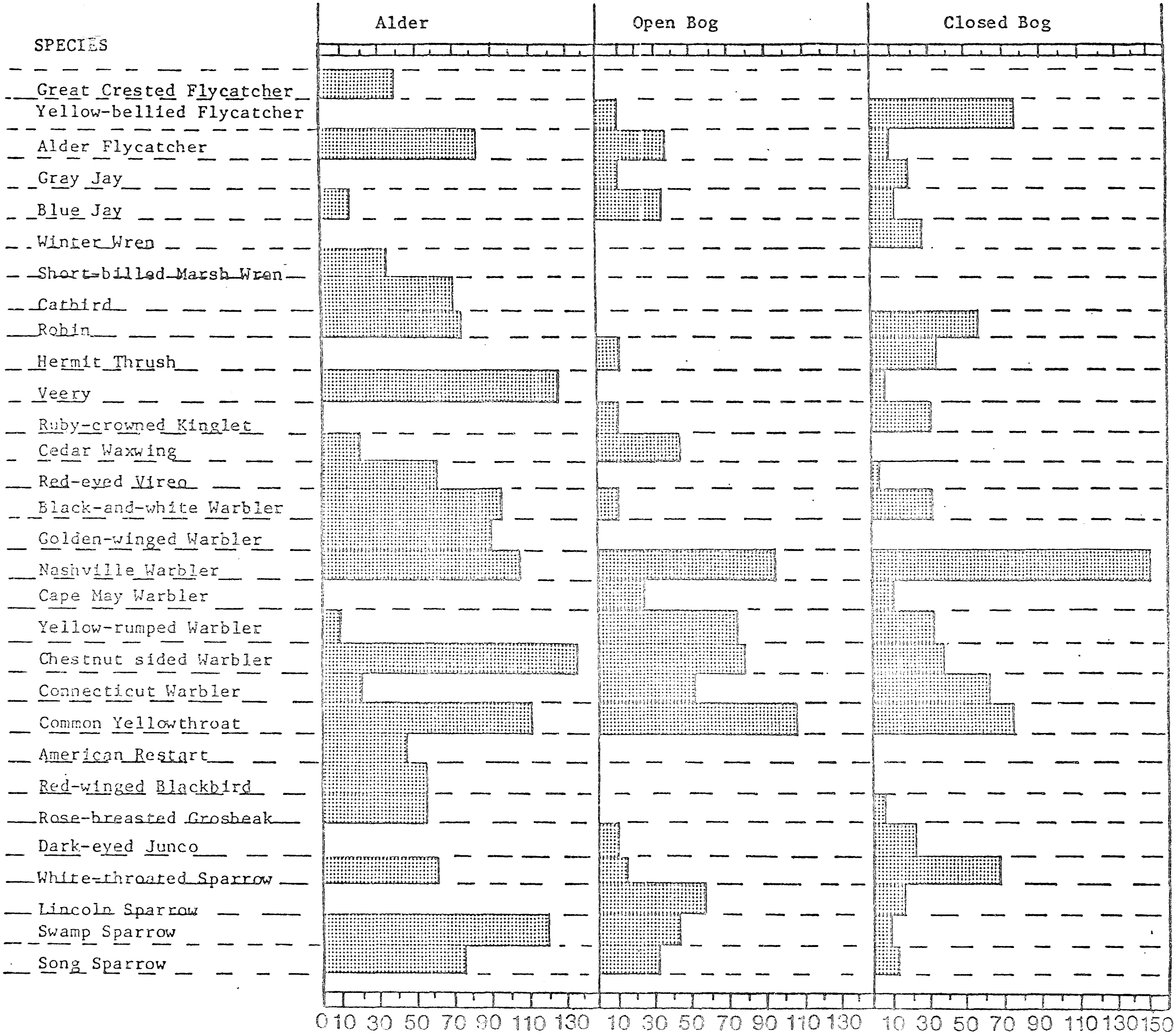


FIGURE 16

Important values for common species in the wetland bird communities

FIGURE 17 A. The nesting guild composition of conifer upland bird communities.

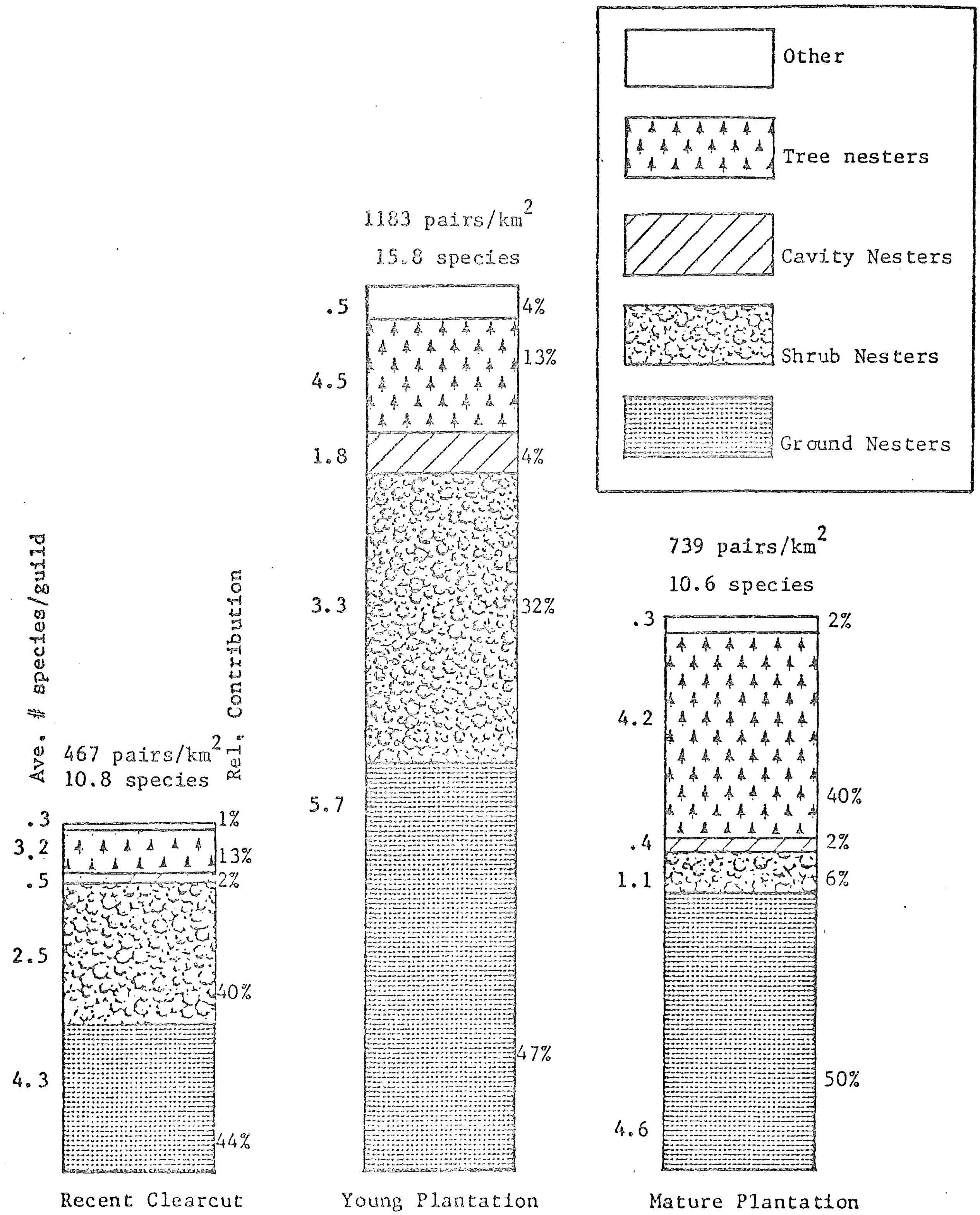
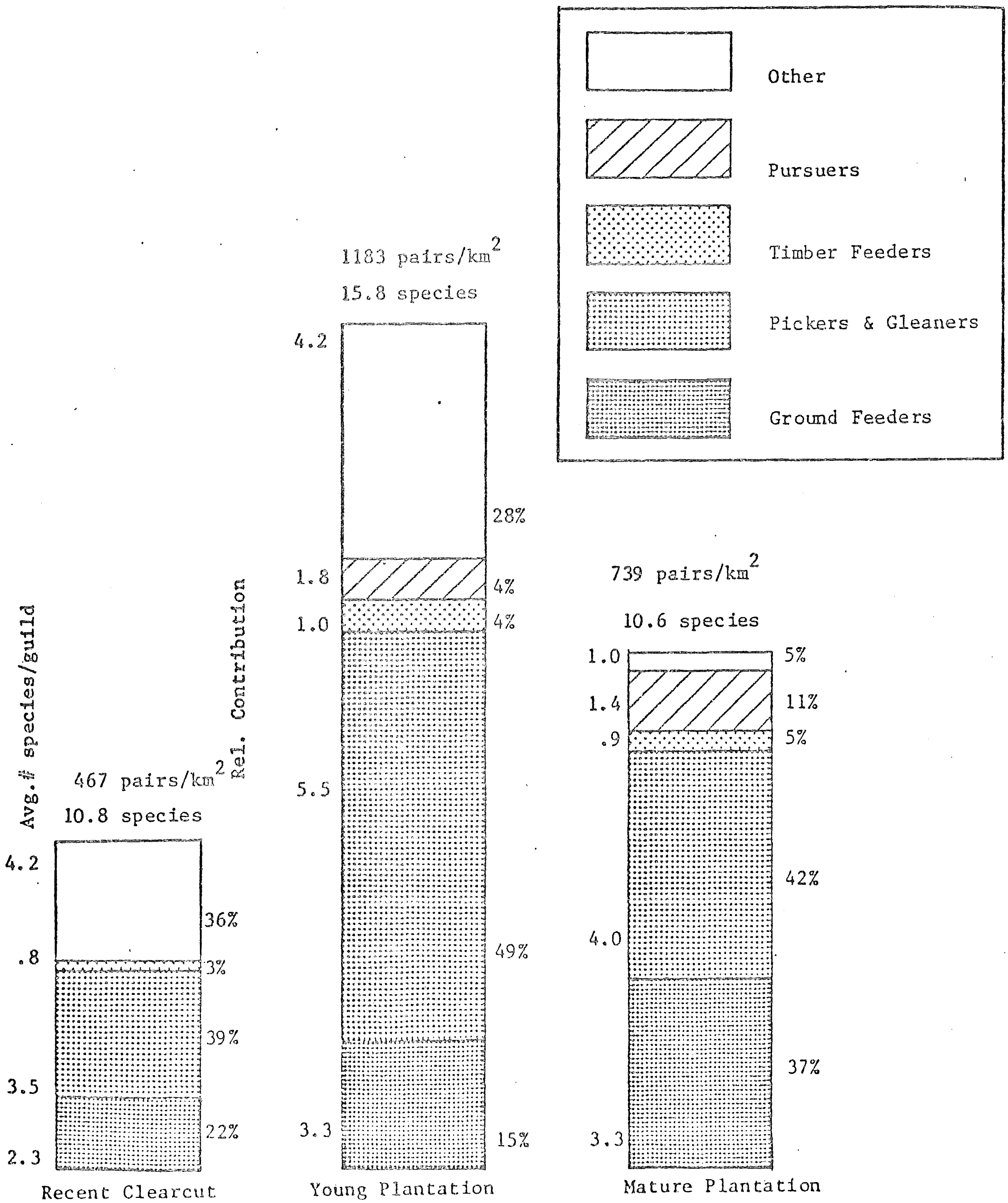


FIGURE 17 B. The foraging guild composition of conifer upland bird communities



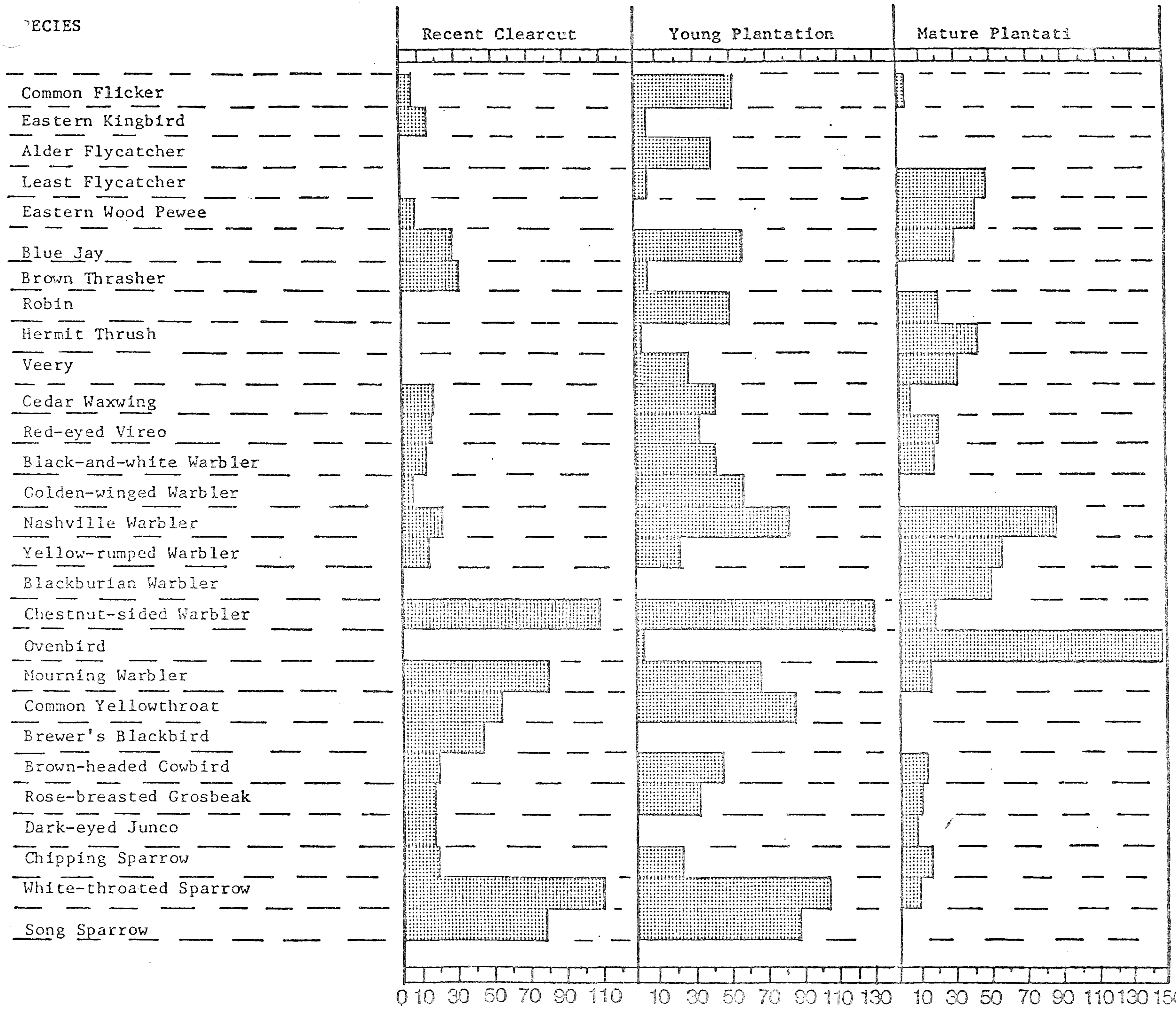


FIGURE 18 Importance values for common species in conifer upland bird communities

FIGURE 19 A. The nesting guild composition of Deciduous upland bird communities

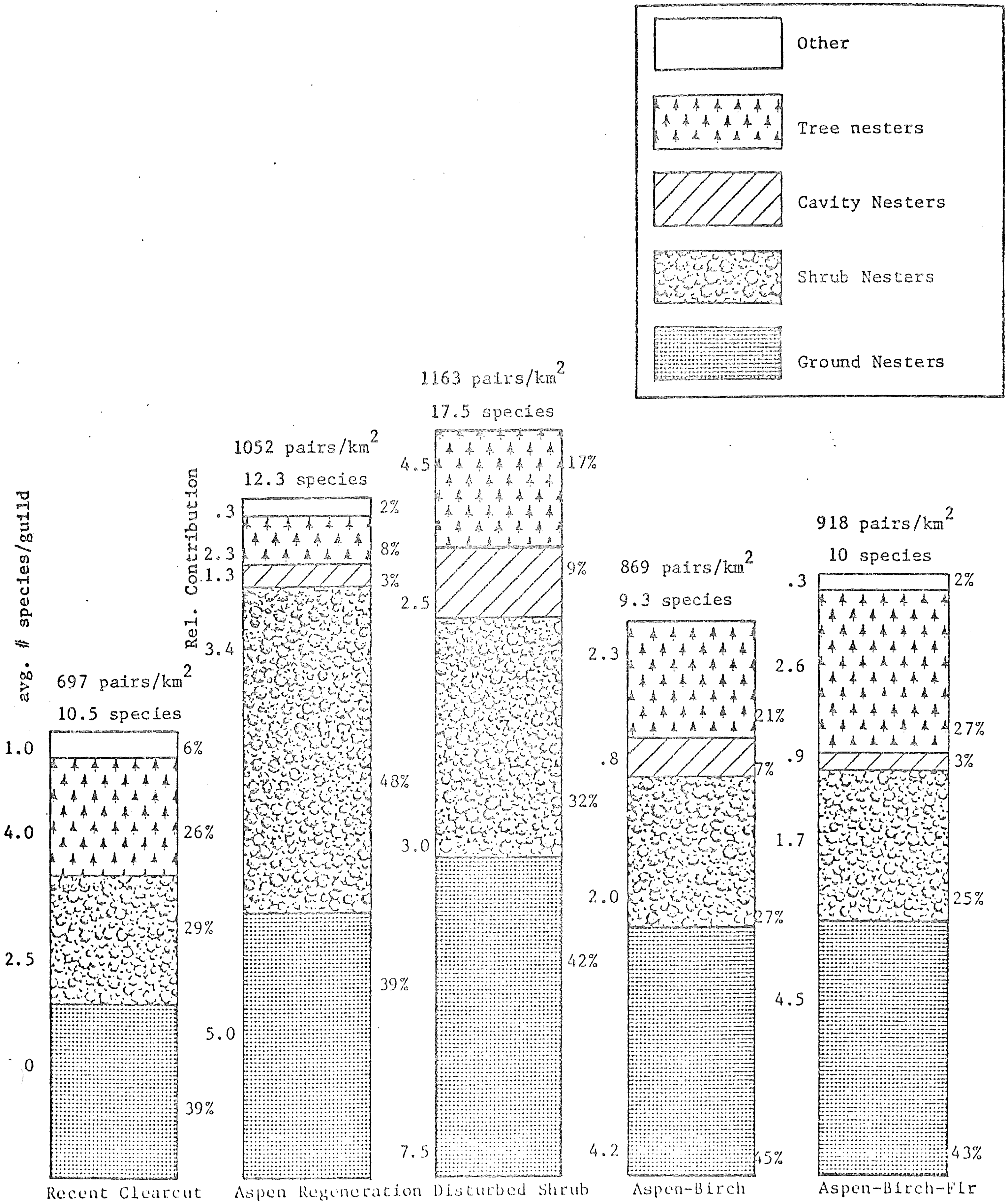


FIGURE 19 B. The foraging guild composition of deciduous upland bird communities.

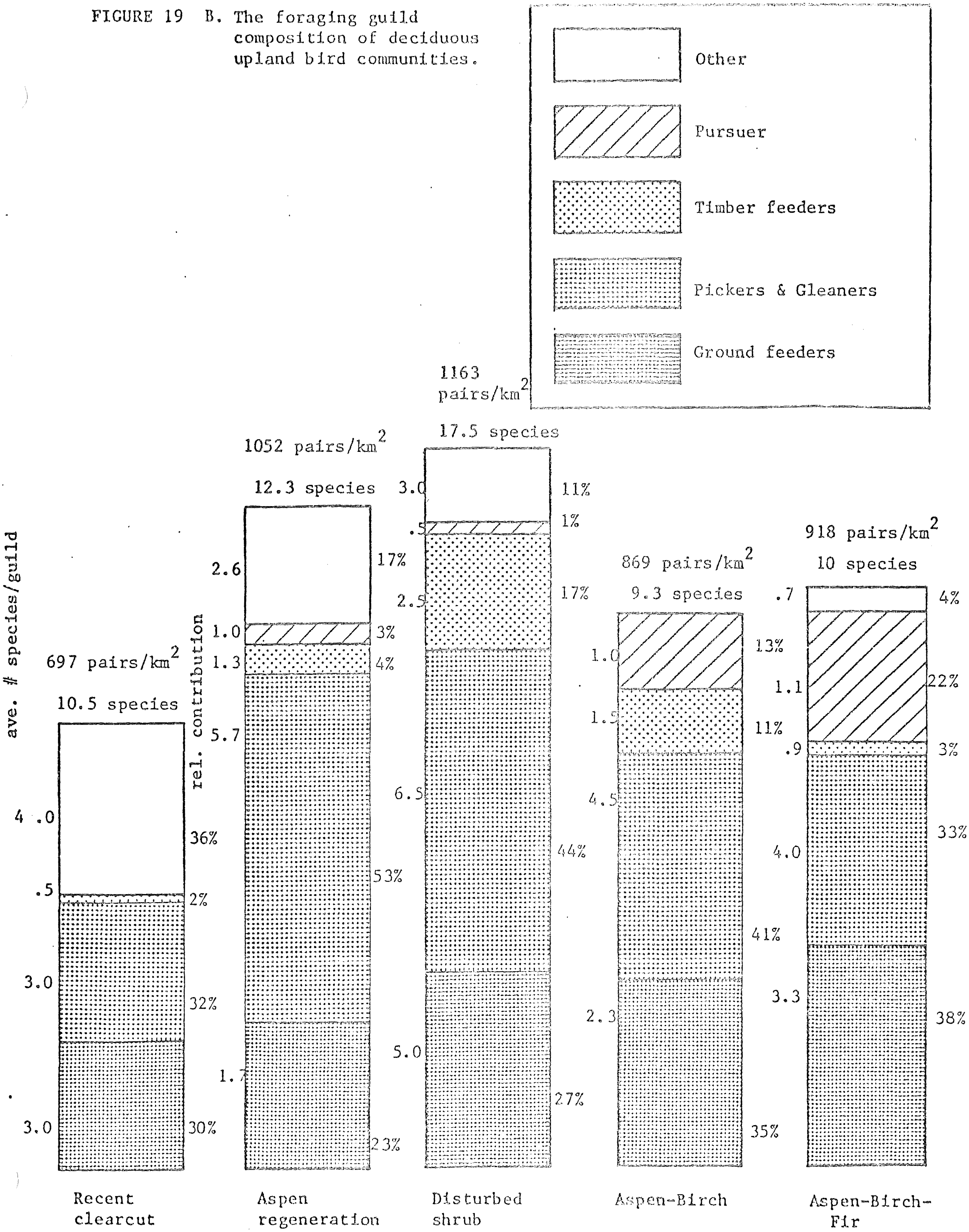


FIGURE 20 Important values for common species in the deciduous upland bird communities

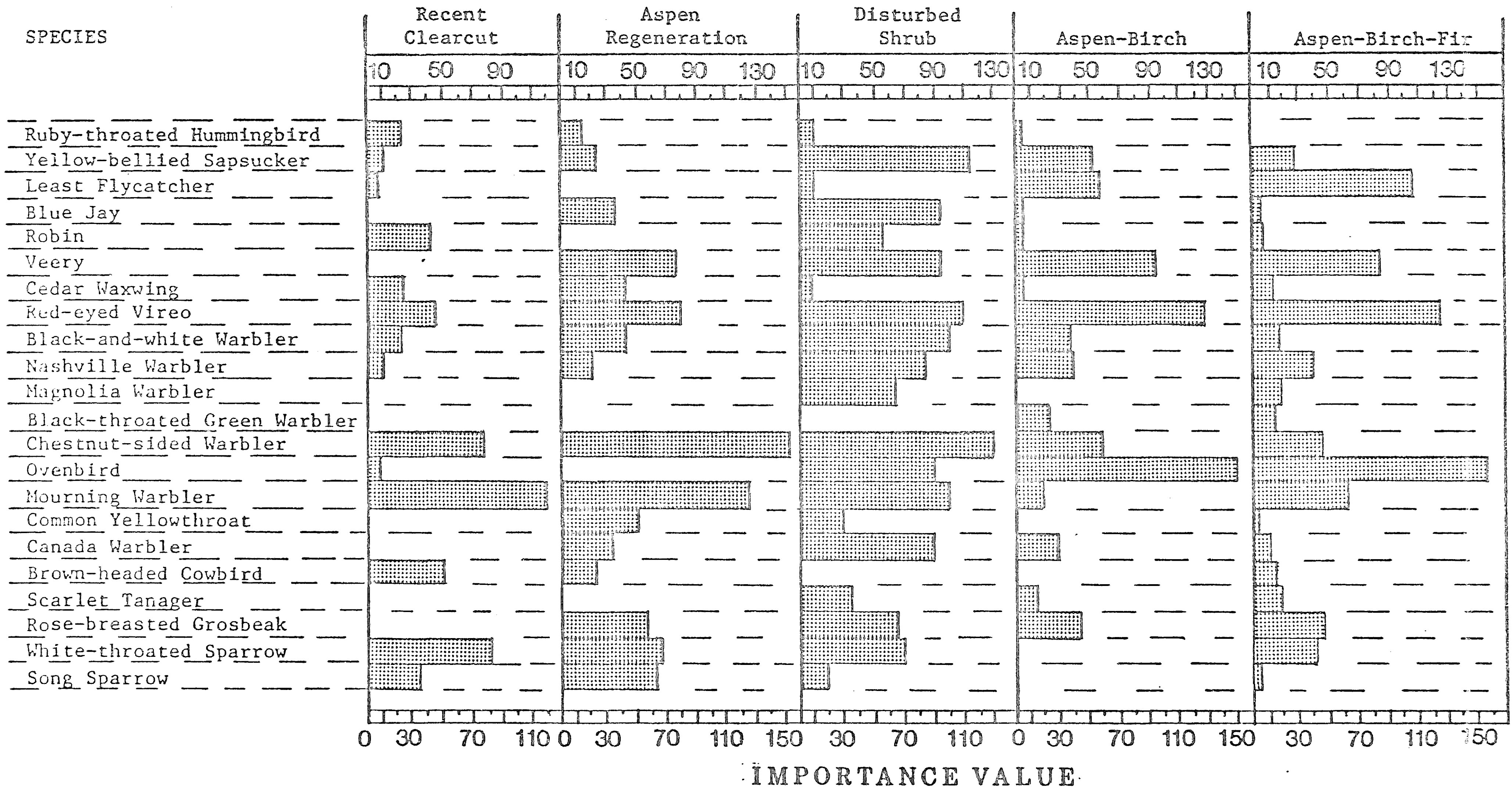


TABLE 1 The 20 most common breeding birds in the mineral resource zone of the RCNSA during 1976 and 1977.

1976 SPECIES	TOTAL NUMBER	RELATIVE ABUNDANCE	CUMULATIVE ABUNDANCE	1977 SPECIES	TOTAL NUMBER	RELATIVE ABUNDANCE	CUMULATIVE ABUNDANCE
Ovenbird	520	.17		Ovenbird	793	.11	
Chestnut-sided Warbler	254	.08	.25	Chestnut-sided Warbler	736	.11	.22
Nashville Warbler	240	.08	.33	Nashville Warbler	494	.07	.29
Red-eyed Vireo	225	.08	.41	Red-eyed Vireo	442	.06	.35
Mourning Warbler	169	.06	.47	White-throated Sparrow	383	.06	.41
Common Yellowthroat	145	.05	.52	Mourning Warbler	341	.05	.46
White-throated Sparrow	119	.04	.56	Least Flycatcher	287	.04	.50
Least Flycatcher	100	.03	.59	Common Yellowthroat	277	.04	.54
Swamp Sparrow	85	.03	.62	Veery	262	.04	.58
Song Sparrow	76	.03	.65	Song Sparrow	211	.03	.61
Veery	71	.02	.67	Yellow-rumped Warbler	161	.02	.63
Robin	66	.02	.69	Rose-breasted Grosbeak	153	.02	.65
Blackburian Warbler	59	.02	.71	Black-and-white Warbler	147	.02	.67
Black-and-white Warbler	52	.02	.73	Cedar Waxwing	146	.02	.69
Golden-crowned Kinglet	49	.02	.75	Robin	144	.02	.71
Yellow-rumped Warbler	49	.02	.77	Blue Jay	140	.02	.73
Canada Warbler	41	.01	.78	Magnolia Warbler	124	.02	.75
Blue Jay	38	.01	.79	Brown-headed Cowbird	123	.02	.77
Rose-breasted Grosbeak	38	.01	.80	Yellow-bellied Sapsucker	105	.02	.79
Tree Swallow	27	.01	.81	Canada Warbler	75	.01	.80

TABLE 2 Summary of potentially critical, unique, or indigenous species dependent upon northeastern Minnesota habitats (excluding pure water binds)[1]

Goshawk	Short-billed Marsh Wren
Sharp-shinned Hawk	Solitary Vireo
*Bald Eagle	Philadelphia Vireo
*Marsh Hawk	Tennessee Warbler
Osprey	Cape May Warbler
*Peregrine Falcon	*Black-throated Blue Warbler
*Merlin	Bay-breasted Warbler
Spruce Grouse	*Pine Warbler
Solitary Sandpiper	*Palm Warbler
*Long-eared Owl	Northern Waterthrush
*Short-eared Owl	Connecticut Warbler
Saw-whet Owl	*Wilson's Warbler
Black-backed 3-toed Woodpecker	*Rusty Blackbird
Northern 3-toed Woodpecker	Scarlet Tanager
Yellow-bellied Flycatcher	Evening Grosbeak
Olive-sided Flycatcher	*Red Crossbill
Gray Jay	*White-winged Crossbill
Boreal Chickadee	Dark-eyed Junco
Brown Creeper	White-throated Sparrow
Winter Wren	Lincoln's Sparrow

1. Niemi (Unpublished)

*Species not observed during the summer or winter field census program in the RCNSA

TABLE 3 COMPARISON OF ROAD CENSUS AND PLOT CENSUS

	G22		G26		G14		G42	
	Road	Plot	Road	Plot	Road	Plot	Road	Plot
Number of Species observed on at least two visits to site	16	15	17	17	13	13	7	7
Number of Species observed on only one visit to the site	8	8	7	7	10	9	5	2
Number of Common Species	11	11	12	12	11	11	7	7
% of Population accounted for by common species	70%	86%	80%	86%	92%	94%	100%	100%
Number of breeding pairs per km^2	709	706	650	829	710	648	733	1009
Mean number of observations per ha	7.6	6.7	5.3	5.7	6.0	6.2	6.2	8.2
% of observations that were sightings	55%	43%	11%	9%	9%	16%	11%	17%

TABLE 4 SPECIES COMPOSITION OF THE 9 MAJOR SPECIES ASSOCIATIONS RECOGNIZED WITHIN THE RCNSA[1]

I. Mourning Warbler/ Chestnut-sided Warbler

Blue Jay
Robin
Cedar Waxwing
Black-and-white Warbler
Nashville Warbler
Magnolia Warbler
Chestnut-sided Warbler
Mourning Warbler
Common Yellowthroat
White-throated Sparrow
Song Sparrow

II. Red-eyed Vireo/ Ovenbird

Yellow-bellied Sapsucker
Least Flycatcher
Veery
Red-eyed Vireo
Ovenbird
Canada Warbler
Rose-breasted Grosbeak

III. Common Flicker/ Brown-headed Cowbird

Common Flicker
Great Crested Flycatcher
Alder Flycatcher
Tree Swallow
Golden-winged Warbler
Brown-headed Cowbird

IV. Black-capped Chickadee/ Golden-crowned Kinglet

Spruce Grouse
Black-capped Chickadee
Brown Creeper
Golden-crowned Kinglet

V. Gray Catbird/ Swamp Sparrow

Killdeer
Ruby-throated Hummingbird
Gray Catbird
American Redstart
Red-winged Blackbird
Swamp Sparrow

VI. Yellow-bellied Flycatcher/Connecticut Warbler

Gray Jay
Yellow-bellied Flycatcher
Winter Wren
Ruby-crowned Kinglet
Cape May Warbler
Connecticut Warbler

VII. Sparrow Hawk/ Brown Thrasher

Sparrow Hawk
Brown Thrasher
Brewer's Blackbird
Lincoln's Sparrow

VIII. Hermit Thrush/ Blackburian Warbler

Hermit Thrush
Solitary Vireo
Yellow-rumped Warbler
Blackburian Warbler
Evening Grosbeak

IX. Eastern Wood Pewee/ Scarlet Tanager

Eastern Wood Pewee
Red-breasted Nuthatch
Black-throated Green Warbler
Scarlet Tanager
American Goldfinch

1 The strength of the relationships among the species in each association is dependent upon: (1) the amount of information available for each species and (2) the range of habitat tolerance for each species. The weaker associations in the above table include associations IV, VII and IX; all represent species that were relatively uncommon in the RCNSA.

TABLE 5 The F-test matrix

	Aspen Regeneration	Young Plantation	Disturbed Shrub	Mature Deciduous Upland	Mature conifer Upland	Mature Conifer Lowland	Alder
Clearcut	2.99	8.99	3.20	6.83	5.91	12.12	12.35
Aspen Regeneration		3.43	1.73*	5.20	5.43	7.19	5.30
Young Plantation			3.46	20.11	10.16	9.18	5.02
Disturbed Shrub				4.88	3.13**	7.00	6.30
Mature Deciduous Upland					6.41	15.93	11.19
Mature Conifer Upland						7.61	8.40
Mature Conifer Lowland							6.10

* Not significant at the 5% level of significance

** Not significant at the 1% level of significance

TABLE 6 Population Summaries for Major Bird Communities on Copper-Nickel Study Sites, 1977. Each entry gives the species density in pairs/km^2 and in parentheses, the number of plots on which the species was observed. The total number of plots sampled is given in the column headings.

SPECIES	CLEARCUT (6)	ASPEN REGENERATION (3)	YOUNG PLANTATION (6)	DISTURBED SHRUB (2)	MATURE DECIDUOUS ASPEN-BIRCH (4)	MATURE UPLAND ASPEN-BIRCH-FIR (7)	MATURE CONIFER UPLAND (7)	MATURE CONIFER LOWLAND OPEN BOG (2)	MATURE CONIFER LOWLAND CLOSED BOG (4)	ALI R (2	GRASSLAND (1)
Broad-winged Hawk											70 (1)
American Kestrel	8 (2)	9 (1)		13 (1)							
Spruce Grouse							5 (1)				
Ruffed Grouse						5 (1)					
Sora Rail										20 (1)	
Killdeer	7 (1)										
Common Snipe	2 (1)										
Black-billed Cuckoo	4 (1)					5 (1)					
Common Nighthawk			8 (1)								
Ruby-throated Hummingbird	7 (1)	9 (1)								20 (1)	
Belted Kingfisher	7 (1)										
Common Flicker			24 (5)	13 (1)						14 (1)	
Yellow-bellied Sapsucker		6 (1)	9 (2)	62 (2)	63 (3)	15 (3)	12 (2)		12 (1)		
Hairy Woodpecker		9 (1)									
Downy Woodpecker				17 (1)							
Eastern Kingbird	4 (1)		3 (1)								
Great Crested Flycatcher		11 (1)	6 (2)			5 (1)				36 (1)	
Yellow-bellied Flycatcher							9 (2)		52 (4)		
Alder Flycatcher		22 (2)	23 (4)					13 (1)		56 (2)	
Least Flycatcher					102 (2)	189 (5)	57 (5)		6 (1)		
Eastern Wood Pewee	2 (1)			17 (1)	7 (1)	7 (2)	18 (3)				
Olive-sided Flycatcher	1 (1)		2 (1)								
Tree Swallow			11 (2)							20 (1)	
Barn Swallow											70 (1)

TABLE 6 Population Summaries for Major Bird Communities on Copper-Nickel Study Sites, 1977. Each entry gives the species density in pairs/km^2 and in parentheses, the number of plots on which the species was observed. The total number of plots sampled is given in the column headings.

SPECIES	CLEARCUT (6)	ASPEN REGENERATION (3)	YOUNG PLANTATION (6)	DISTURBED SHRUB (2)	MATURE DECIDUOUS ASPEN-BIRCH (4)	MATURE UPLAND ASPEN-BIRCH-FIR (7)	MATURE CONIFER UPLAND (7)	MATURE CONIFER LOWLAND OPEN BOG (2)	MATURE CONIFER LOWLAND CLOSED BOG (4)	ALDER (2)	GRASSLAND (1)
Gray Jay									11 (2)		
Blue Jay	6 (3)	20 (2)	37 (6)	48 (2)			18 (3)	10 (1)	6 (1)		
Common Raven	4 (1)										
Black-capped Chickadee						8 (2)					
Red-breasted Nuthatch							5 (1)				
Brown Creeper						4 (1)	9 (1)				
Winter Wren						5 (1)			18 (3)		
Short-billed Marsh Wren										20 (1)	
Gray Catbird										56 (2)	
Brown Thrasher	8 (2)										70 (1)
American Robin	9 (2)		19 (3)	46 (2)		1 (1)	14 (2)		26 (3)	40 (1)	70 (1)
Hermit Thrush			3 (1)				21 (5)		11 (2)		
Swainson's Thrush									5 (1)		
Veery		68 (2)	25 (3)	64 (2)	83 (4)	47 (7)	33 (2)			138 (2)	
Golden-crowned Kinglet							11 (1)				
Ruby-crowned Kinglet									27 (3)		
Cedar Waxwing	11 (2)	20 (2)	22 (4)			4 (1)		16 (1)	21 (2)	20 (1)	
Solitary Vireo					7 (1)		12 (3)		14 (2)		
Red-eyed Vireo	17 (2)	83 (3)	15 (2)	84 (2)	166 (4)	172 (7)	11 (2)			20 (1)	
Black-and-white Warbler	5 (1)	29 (2)	37 (4)	116 (2)	35 (3)	6 (2)	7 (2)		15 (2)	76 (2)	
Golden-winged Warbler		11 (1)	44 (4)							56 (2)	
Tennessee Warbler									6 (1)		
Nashville Warbler	6 (2)	14 (2)	115 (5)	37 (2)	26 (2)	17 (3)	95 (7)	106 (2)	281 (4)	132 (2)	
Northern Parula Warbler			5 (1)								

TABLE 6 Population Summaries for Major Bird Communities on Copper-Nickel Study Sites, 1977. Each entry gives the species density in pairs/km^2 and in parentheses, the number of plots on which the species was observed. The total number of plots sampled is given in the column headings.

SPECIES	CLEARCUT (6)	ASPEN REGENERATION (3)	YOUNG PLANTATION (6)	DISTURBED SHRUB (2)	MATURE DECIDUOUS ASPEN-BIRCH (4)	MATURE UPLAND ASPEN-BIRCH-FIR (7)	MATURE CONIFER UPLAND (7)	MATURE CONIFER LOWLAND OPEN BOG (2)	MATURE CONIFER LOWLAND CLOSED BOG (4)	ALDER (2)	GRASSLAND (1)
Yellow Warbler										20 (1)	
Magnolia Warbler			30 (1)	45 (2)		8 (1)	4 (1)		39 (2)		
Cape May Warbler								8 (1)	8 (2)		
Yellow-rumped Warbler	2 (1)		10 (2)			4 (1)	91 (5)	36 (2)	19 (2)		
Black-throated Green Warbler					26 (1)	10 (2)			12 (1)		
Blackburian Warbler					7 (1)	2 (1)	44 (4)		6 (1)		
Chestnut-sided Warbler	114 (6)	345 (3)	217 (6)	248 (2)	63 (3)	45 (4)	20 (2)	47 (1)	29 (2)	299 (2)	113 (1)
Ovenbird				83 (2)	205 (4)	261 (7)	175 (7)		8 (2)		
Connecticut Warbler							5 (1)	23 (1)	47 (3)	20 (1)	
Mourning Warbler	95 (6)	174 (3)	96 (5)	83 (2)	10 (1)	32 (6)	9 (3)				21 (1)
Common Yellowthroat	20 (3)	33 (2)	100 (5)	13 (1)				93 (2)	91 (3)	172 (2)	21 (1)
Canada Warbler		9 (1)		49 (2)	29 (3)	2 (1)				16 (1)	
American Redstart					7 (1)					60 (1)	
Red-winged Blackbird			8 (1)							40 (1)	
Brewer's Blackbird	13 (1)										70 (1)
Brown-headed Cowbird	12 (2)	22 (1)	44 (3)			14 (1)	5 (1)				70 (1)
Scarlet Tanager				17 (1)		5 (1)	5 (1)				
Rose-breasted Grosbeak	2 (1)	29 (2)	15 (3)	41 (2)	33 (3)	21 (4)	15 (1)			30 (1)	
Evening Grosbeak	22 (3)		20 (3)				5 (1)		6 (1)		
Purple Finch	8 (1)										
American Goldfinch	7 (1)						5 (1)				70 (1)
Dark-eyed Junco	4 (1)						5 (1)		11 (2)		
Chipping Sparrow	14 (2)		16 (3)				8 (12)				
Clay-colored Sparrow											70 (1)
White-throated Sparrow	72 (6)	74 (2)	133 (6)	50 (2)		22 (3)	6 (1)	6 (1)	48 (4)	41 (2)	
Lincoln's Sparrow	2 (1)							35 (2)	5 (1)		
Swamp Sparrow								31 (1)	6 (1)	144 (2)	
Song Sparrow	49 (4)	55 (2)	86 (6)	17 (1)		2 (1)		24 (1)	9 (1)	56 (2)	190 (1)
TOTAL	544	1052	1183	1163	869	918	739	448	855	1642	905

TABLE 7 Observation Summaries for Major Habitats sampled during Winter, 1977. Each entry gives the average number of observations per 5 hours and, in parentheses, the number of plots on which the species was observed. The total number of plots sampled is given in the column headings

SPECIES	OPEN BOG (3)	CLOSED BOG (3)	CLEARCUT (1)	ASPEN-BIRCH FOREST (3)	MATURE CONIFER PLANTATION (3)	MIXED UPLAND FOREST (3)
Ruffed Grouse				.2 (1)		
Great Horned Owl					.2 (1)	
Pileated Woodpecker		.3 (1)				.3 (1)
Hairy Woodpecker			2.3 (1)	.6 (3)	.2 (1)	.4 (2)
Downy Woodpecker		.1 (1)	2.7 (1)	1.3 (2)	.1 (1)	.4 (2)
Black-backed 3-toed Woodpecker		.1 (1)			.1 (1)	.1 (1)
Northern 3-toed Woodpecker	.5 (2)	.5 (1)				.1 (1)
Gray Jay	.4 (2)	3.0 (3)		.2 (1)		2.5 (3)
Blue Jay		.2 (1)				.2 (1)
Raven	2.1 (3)	1.9 (3)		1.3 (3)	.6 (2)	1.0 (3)
Black-capped Chickadee	.4 (2)	1.0 (2)	.5 (1)	3.7 (3)	1.4 (2)	6.4 (3)
Boreal Chickadee	.2 (1)	.6 (1)				
Pine Grosbeak						.5 (2)
TOTAL	3.6	7.7	5.5	7.3	2.6	11.9

APPENDIX I Sample Site Descriptions and Locations

A. Technical Descripton of Bird Transects for the 1976 Summer Field Season

SITE NO.	COVER TYPE	TECHNICAL DESCRIPTION
B1	Red Pine/seedling	NE¼, Sec. 30, T61N, R10W
B2	Tamarack/sampling-pole Black Spruce/pole	NW¼, Sec. 31, T60N, R11W
B3	Mixed upland & lowland (primarily Aspen, Red Pine and Alder)	NE¼ and NW¼, Sec. 9, T60N, R11W
B4	Aspen/pole-saw	SE¼, Sec. 7, T60N, R11W
B5	Jack Pine and Aspen/pole-saw	NE¼ and SE¼, Sec. 7, T60N, R11W
B6	White Cedar/pole-saw	NW¼, Sec. 18, T60N, R11W
B7	Tamarack/sapling	NE¼, Sec. 13, T60N, R12W NE¼, Sec. 18, T60N, R11W,
B8	Jack Pine-Red Pine/pole	SW¼, Sec. 28, T61N, R10W
B9	Jack Pine/pole-saw	SE¼, Sec. 15, T60N, R12W SW¼, Sec. 14, T60N, R12W
B10	Red Pine/pole-saw	SE¼, Sec. 23, T60N, R12W
B11	Black Spruce/pole	NE¼, Sec. 31, T61N, R10W NW¼, Sec. 32, T61N, R10W
B12	Aspen-Birch/pole	SE¼, Sec. 32, T61N, R10W NE¼, Sec. 5 , T60N, R10W
B13	Red Pine/Sapling	SE¼, Sec. 3, T60N, R10W
B14	Aspen-Birch/pole-saw	NW¼ and NE¼, Sec. 6, T60N, R9W
B15	Aspen-Fir-Jack Pine-Paper Birch/pole	NE¼ and SE¼, Sec. 28, T61N, R10W
B16	Red Pine/seedling & Red Pine/saw	NE¼ and SE¼, Sec. 10, T61N, R10W
B17	Aspen/pole	NW¼, Sec. 33, T58N, R14W
B18	Jack Pine/pole	NE¼, Sec. 7, T57N, R14W NW¼, Sec, 8, T57N, R14W

APPENDIX I A. Continued

SITE NO.	COVER TYPE	TECHNICAL DESCRIPTION
B19	Mixed Lowland (primarily White Cedar and Alder)	SE¼, Sec. 7, T57N, R14W NE¼, Sec. 18, T57N, R14W
B20	Red Pine/seedling & Red Pine/pole	SE½, Sec. 18, T57N, R14W
B21	Aspen-Fir/pole	NW¼ and SW¼, Sec. 29, T57N, R14W
B22	Mixed Upland and Lowland (primarily ash, hazel & alder)	NE¼, Sec. 31, T57N, R14W NW¼, Sec. 32, T57N, R14W
B23	Paper Birch/pole	NE¼, Sec. 22, T58N, R14W NW¼, Sec. 23, T58N, R14W
B24	Black Spruce/pole	SW¼ and SE¼, Sec. 15, T58N, R14W
B25	Cut and Burn Area	SE¼, Sec. 18, T60N, R11W NE¼, Sec. 19, T60N, R11W
B26	Jack Pine/sapling	SE¼, Sec. 24, T60N, R12W NE¼, Sec. 25, T60N, R12W
B27	Birch/pole-saw	SE¼, Sec. 31, T60N, R10W
B28	Aspen-Birch/pole	SE¼, Sec. 1, T59N, R11W
B29	Black Spruce/pole	SW¼, Sec. 34, T60N, R11W NW¼, Sec. 3, T59N, R11W
B30	Mixed Upland (Aspen-Birch-Fir-Spruce-Pine)/pole	SW¼, Sec. 32, T60N, R11W
B31	Aspen-Jack Pine/pole (w/small logged area)	SW¼, Sec. 16, T60N, R11W
B32	Aspen/pole & Black Spruce/pole	SE¼, Sec. 16, T60N, R11W NE¼, Sec. 21, T60N, R11W
B33	Old Burn (w/Aspen, Pine Spruce/sapling-pole)	NE¼, Sec. 19, T61N, R9W NW¼, Sec. 20, T61N, R9W
B34	Jack Pine/seedling	NE¼, Sec. 17, T61N, R9W
B35	Alder	SW¼, Sec. 5, T57N, R13W NW¼, Sec. 8, T57N, R13W
B36	Alder-Willow	NW¼ and SW¼, Sec. 8, T57N, R13W

APPENDIX I

B. Technical Descriptions of the 1977 Winter Bird Plots

SITE NO.	COVER TYPE	TECHNICAL DESCRIPTION
W1	Red Pine/seedling	NE¼, NE¼, Sec. 30, T61N, R10W
W2	Aspen/pole	SE¼, SE¼, Sec. 7, T60N, R11W
W3	Jack Pine/pole	NE¼, NE¼, Sec. 7, T60N, R11W
W4	White Cedar/pole	SE¼, NW¼, Sec. 18, T60N, R11W
W5	Tamarack/sapling	NW¼, SW¼, Sec. 18, T60N, R11W
W6	Jack Pine/pole	SE¼, NE¼, Sec. 7, T57N, R14W
W7	Red Pine/pole	NW¼, SE¼, Sec. 23, T60N, R12W
W8	Black Spruce/pole	NE¼, NE¼, Sec. 31, T61N, R10W
W9	Aspen-Birch-Fir-Pine/pole	SW¼, SE¼, Sec. 33, T62N, R11W
W10	Black Spruce/pole	NW¼, SW¼, Sec. 34, T62N, R11W
W11	Black Spruce-Tamarack/pole	NW¼, SE¼, Sec. 3, T61N, R11W
W12	Aspen-Birch-White Pine-Jack Pine/pole	SW¼, NW¼, Sec. 21, T60N, R10W
W13	Red Pine/pole	NE¼, NW¼, Sec. 21, T60N, R10W
W14	Birch/pole	NW¼, SE¼, Sec. 17, T60N, R10W
W15	Aspen-Birch/pole	NE¼, SW¼, Sec. 2, T60N, R11W
W16	Black Spruce/pole	SE¼, SE¼, Sec. 4, T60N, R11W

APPENDIX I

C. Technical Descriptions of New Bird Plots for the 1977 Summer Field Season

SITE NO.	COVER TYPE	TECHNICAL DESCRIPTION
G01	Black Spruce/seedling sapling	SE¼, NE¼, Sec. 14, T60N, R11W
G02	Black Spruce/sapling	NW¼, SW¼, Sec. 34, T62N, R11W
G03	Black Spruce/pole	NE¼, NE¼, Sec. 31, T61N, R10W
B04	Mixed Upland/pole (primarily Aspen, Birch, Fir)	NW¼, SE¼, Sec. 24, T59N, R13W
G05	Mixed Upland/pole (primarily Aspen, Birch, Pine)	SW¼, SE¼, SEc. 36, T60N, R12W
G06	Black Spruce/pole	NE¼, SW¼, Sec. 15, T58N, R14W
G07	Aspen/sapling	NW¼, NW¼, Sec. 24, T61N, R12W
G08	Aspen/sapling	SW¼, NW¼, Sec. 1, T60N, R11W
G09	Aspen/pole-saw	SE¼, NW¼, Sec. 7, T61N, R11W
G10	Aspen/sapling	NE¼, NW¼, Sec. 32, T57N, R14W
G11	Jack Pine/seedling	NW¼, NE¼, Sec. 2, T59N, R13W
G12	Aspen/pole	SW¼, SW¼, Sec. 28, T57N, R12W
G13	Jack Pine/seedling	NE¼, SE¼, Sec. 15, T60N, R12W
G14	Aspen-Fir/sapling-pole	NE¼, SE¼, Sec. 3, T62N, R11W
G15	Aspen-Fir/pole	NE¼, SE¼, Sec. 5, T62N, R11W
G16	Jack Pine/sapling	SE¼, SW¼, Sec. 8, T60N, R11W
G17	Jack Pine/pole-saw	NE¼, NE¼, Sec. 15, T60N, R12W
G18	Alder	NW¼, NW¼, Sec. 8, T57N, R13W
G19	Red Pine/seedling-sapling	SW¼, NE¼, Sec. 2, T60N, R10W
G20	Red Pine sapling-pole	SW¼, NE¼, Sec. 35, T61N, R10W
G21	Red Pine/pole	SE¼, SE¼, Sec. 4, T60N, R12W

APPENDIX I C. Continued

SITE NO.	COVER TYPE	TECHNICAL DESCRIPTION
G22	Red Pine/sapling	SW¼, SW¼, Sec. 22, T58N, R14W
G23	Red Pine/pole	SW¼, NE¼, Sec. 30, T57N, R14W
G24	Red Pine/pole	NE¼, NW¼, Sec. 20, T57N, R14W
G25	Jack Pine/seedling	SW¼, NE¼, Sec. 13, T61N, R11W
G26	Jack Pine/Sapling	SE¼, SW¼, Sec. 7, T61N, R10W
G28	Jack Pine/sapling	SW¼, NW¼, Sec. 27, T58N, R13W
G29	Grass	SW¼, NW¼, Sec. 36, T58N, R13W
G30	Jack Pine/pole	SE¼, NE¼, Sec. 7, T57N, R14W
G31	Tamarack-Black Spruce/pole	SE¼, SW¼, Sec. 12, T60N, R12W
G32	Aspen-Birch/sapling-pole	SE¼, NE¼, Sec. 32, T61N, R10W
G33	Aspen/pole-saw	NW¼, SE¼, Sec. 2, T60N, R11W
G34	White Spruce/seedling	NW¼, NE¼, Sec. 19, T57N, R14W
G35	White Spruce/sapling	SE¼, SW¼, Sec. 18, T57N, R12W
G36	White Spruce/pole	SE¼, NE¼, Sec. 32, T58N, R14W
G37	Aspen/seedling	NE¼, NE¼, Sec. 16, T59N, R12W
G38	Aspen-Birch-Fir/pole-saw	NW¼, NW¼, Sec. 15, T59N, R12W
G39	Birch/pole-saw	NW¼, NE¼, Sec. 9, T60N, R11W
G40	Birch/seedling	SW¼, SE¼, Sec. 29, T57N, R14W
G41	Birch/pole	NW¼, SW¼, Sec. 20, T57N, R14W
G42	Birch-Fir/pole	NE¼, NW¼, Sec. 17, T57N, R13W
G43	White Cedar/saw	SE¼, SW¼, Sec. 2, T60N, R12W
G45	Tamarack/sapling	NW¼, SW¼, Sec. 18, T60N, R11W
G47	Aspen-Birch/pole	SE¼, NE¼, Sec. 32, T61N, R10W
G48	Alder	SW¼, SW¼, Sec. 5, T57N, R13W

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Gavia immer	Common Loon	Summer Resident	common		9 (*)
Botaurus lentiginosus	American Bittern	Summer Resident	uncommon	1 (*)	5 (*)
Anas rubripes	Black Duck	Summer Resident	uncommon		1 (*)
Mergus merganser	Common Merganser	Summer Resident	uncommon		3 (*)
Accipiter gentilis	Goshawk	Winter[4] Visitant	rare		1 (*)
Accipiter striatus	Sharp-shinned Hawk	Summer Resident	rare		1 (*)
Buteo jamaicensis	Red-tailed Hawk	Summer Resident	uncommon	3 (*)	3 (*)
Buteo platypterus	Broad-winged Hawk	Summer Resident	common	9 (*)	10 (*)
Pandion haliaetus	Osprey	Summer Resident	uncommon	1 (*)	
Falco sparverius	American Kestrel	Summer Resident	rare	8 (*)	22 (*)
Canachites canadensis	Spruce Grouse	Permanent Resident	rare		2 (*)
Bonasa umbellus	Ruffed Grouse	Permanent Resident	common		15 (*)

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Porzana carolina	Sora Rail	Summer Resident	rare		2 (*)
Charadrius vociferus	Killdeer	Summer Resident	rare	3 (*)	3 (*)
Philohela minor	American Woodcock	Summer Resident	uncommon	1 (*)	2 (*)
Capella gallinago	Common Snipe	Summer Resident	rare	1 (*)	6 (*)
Actitis macularia	Spotted Sandpiper	Summer Resident	common	1 (*)	
Tringa solitaria	Solitary Sandpiper	Migrant[4]	rare	1 (*)	
Larus argentatus	Herring Gull	Summer Resident	common		2 (*)
Coccyzus erythropthalmus	Black-billed Cuckoo	Summer Resident	uncommon	1 (*)	12 (*)
Strix varia	Barred Owl	Permanent Resident	rare		1 (*)
Aegolius acadicus	Saw-whet Owl	Summer Resident	rare	1 (*)	
Caprimulgus vociferus	Whip-poor-will	Summer Resident	very rare		1 (*)
Chordeiles minor	Common Nighthawk	Summer Resident	common		9 (*)

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Archilochus colubris	Ruby-throated Hummingbird	Summer Resident	uncommon	7 (*)	12 (*)
Megaceryle alcyon	Belted Kingfisher	Summer Resident	uncommon	4 (*)	8 (*)
Colaptes auratus	Common Flicker	Summer Resident	abundant	15 (*)	51 (*)
Dryocopus pileatus	Pileated Woodpecker	Permanent Resident	rare	4 (*)	8 (*)
Sphyrapicus varius	Yellow-bellied Sapsucker	Summer Resident	common	24 (*)	105 (.02)
Dendrocopos villosus	Hairy Woodpecker	Permanent Resident	uncommon	6 (*)	9 (*)
Dendrocopos pubescens	Downy Woodpecker	Permanent Resident	uncommon	7 (*)	15 (*)
Picides articus	Black-backed 3-toed Woodpecker	Winter Visitant[4]	rare		1 (*)
Tyrannus tyrannus	Eastern Kingbird	Summer Resident	uncommon	6 (*)	21 (*)
Myiarchus crinitus	Great Crested Flycatcher	Summer Resident	very rare	1 (*)	27 (*)
Sayornis phoebe	Eastern Phoebe	Summer Resident	rare		1 (*)
Empidonax flaviventris	Yellow-bellied Flycatcher	Summer Resident	uncommon	24 (*)	55 (*)

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Empidonax alnorum	Alder Flycatcher	Summer Resident	common	17 (*)	59 (*)
Empidonax minimus	Least Flycatcher	Summer Resident	common	100 (.03)	287 (.04)
Contopus virens	Eastern Wood Pewee	Summer Resident	uncommon	15 (*)	44 (*)
Nuttallornis borealis	Olive-sided Flycatcher	Summer Resident	uncommon	3 (*)	20 (*)
Iridoprocne bicolor	Tree Swallow	Summer Resident	common	27 (*)	27 (*)
Hirundo rustica	Barn Swallow	Summer Resident	uncommon		6 (*)
Perisoreus canadensis	Gray Jay	Permanent Resident	uncommon	10 (*)	14 (*)
Cyanocitta cristata	Blue Jay	Permanent Resident	common	38 (*)	140 (.02)
Corvus corax	Common Raven	Winter Visitant[4]	common	7 (*)	24 (*)
Corvus brachyrhynchos	Common Crow	Summer Resident	common		2 (*)
Parus atricapillus	Black-capped Chickadee	Permanent Resident	common	26 (*)	27 (*)
Parus hudsonicus	Boreal Chickadee	Permanent Resident	rare	5 (*)	2 (*)

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Sitta carolinensis	White-breasted Nuthatch	Permanent Resident	rare		2 (*)
Sitta canadensis	Red-breasted Nuthatch	Permanent Resident	common	13 (*)	11 (*)
Certhia familiaris	Brown Creeper	Migrant[4]	rare	9 (*)	15 (*)
Troglodytes aedon	House Wren	Summer Resident	rare	2 (*)	
Troglodytes troglodytes	Winter Wren	Summer Resident	common	10 (*)	25 (*)
Cistothorus platensis	Short-billed Marsh Wren	Summer Resident	rare		4 (*)
Dumetella carolinensis	Gray Catbird	Summer Resident	rare	4 (*)	14 (*)
Toxostoma rufum	Brown Thrasher	Summer Resident	very rare	6 (*)	26 (*)
Turdus migratorius	American Robin	Summer Resident	abundant	66 (.02)	144 (.02)
Catharus guttatus	Hermit Thrush	Summer Resident	uncommon	24 (*)	64 (*)
Catharus ustulatus	Swainson's Thrush	Summer Resident	common	5 (*)	13 (*)
Catharus fuscescens	Veery	Summer Resident	abundant	71 (.02)	262 (.04)

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Regulus satrapa	Golden-crowned Kinglet	Summer Resident	uncommon	49 (.02)	14 (*)
Regulus calendula	Ruby-crowned Kinglet	Summer Resident	uncommon	17 (*)	21 (*)
Bombycilla cedrorum	Cedar Waxwing	Summer Resident	abundant	24 (*)	146 (.02)
Vireo solitarius	Solitary Vireo	Summer Resident	common	3 (*)	26 (*)
Vireo olivaceous	Red-eyed Vireo	Summer Resident	abundant	225 (.08)	442 (.06)
Vireo philadelphicus	Philadelphia Vireo	Summer Resident	rare	8 (*)	
Mniotilta varia	Black-and-white Warbler	Summer Resident	common	52 (.02)	147 (.02)
Vermivora chrysoptera	Golden-winged Warbler	Summer Resident	no breeding records	7 (*)	27 (*)
Vermivora peregrina	Tennessee Warbler	Summer Resident	common		16 (*)
Vermivora ruficapilla	Nashville Warbler	Summer Resident	abundant	240 (.08)	494 (.07)
Parula americana	Northern Parula	Summer Resident	uncommon	4 (*)	10 (*)
Dendroica petechia	Yellow Warbler	Summer Resident	rare	3 (*)	4 (*)

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Dendroica magnolia	Magnolia Warbler	Summer Resident	common	22 (*)	124 (.02)
Dendroica tigrina	Cape May Warbler	Summer Resident	uncommon	27 (*)	11 (*)
Dendroica coronata	Yellow-rumped Warbler	Summer Resident	common	49 (.02)	161 (.02)
Dendroica virens	Black-throated Green Warbler	Summer Resident	uncommon	21 (*)	40 (*)
Dendroica fusca	Blackburian Warbler	Summer Resident	common	59 (.02)	62 (*)
Dendroica pensylvanica	Chestnut-sided Warbler	Summer Resident	abundant	254 (.08)	736 (.11)
Dendroica castanea	Bay-breasted Warbler	Summer Resident	uncommon	5 (*)	
Seiurus aurocapillis	Ovenbird	Summer Resident	abundant	520 (.17)	793 (.11)
Seiurus noveboracensis	Northern Waterthrush	Summer Resident	uncommon	4 (*)	2 (*)
Oporornis agilis	Connecticut Warbler	Summer Resident	rare	23 (*)	51 (*)
Oporornis philadelphia	Mourning Warbler	Summer Resident	abundant	169 (.06)	341 (.05)
Geothlypis trichas	Common Yellowthroat	Summer Resident	common	145 (.05)	277 (.04)

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Wilsonia canadensis	Canada Warbler	Summer Resident	common	41 (*)	75 (*)
Setophaga ruticilla	American Redstart	Summer Resident	common	3 (*)	15 (*)
Agelaius phoeniceus	Red-winged Blackbird	Summer Resident	common	12 (*)	24 (*)
Icterus galbula	Northern Oriole	Summer Resident	rare		2 (*)
Euphagus cyanocephalus	Brewer's Blackbird	Summer Resident	rare		43 (*)
Quiscalus quiscula	Common Grackle	Summer Resident	uncommon	1 (*)	4 (*)
Molothrus ater	Brown-headed Cowbird	Summer Resident	common	15 (*)	123 (.02)
Piranga olivacea	Scarlet Tanager	Summer Resident	uncommon	7 (*)	30 (*)
Pheucticus ludovicianus	Rose-breasted Grosbeak	Summer Resident	common	38 (*)	153 (.02)
Passerina cyanea	Indigo Bunting	Summer Resident	rare	1 (*)	
Hesperiphona vespertina	Evening Grosbeak	Summer Resident	uncommon	15 (*)	65 (*)
Carpodacus purpureus	Purple Finch	Summer Resident	abundant	5 (*)	18 (*)

APPENDIX II. A. Birds observed in the mineral resource zone of the Regional Copper-Nickel Study Area during the 1976 and 1977 summer field seasons.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	ABUNDANCE IN THE SUPERIOR NATIONAL FOREST[2]	NUMBER OF OBSERVATIONS (RELATIVE ABUNDANCE)[3] 1976	1977
Spinus tristis	American Goldfinch	Summer Resident	uncommon	9 (*)	17 (*)
Junco hyemalis	Dark-eyed Junco	Summer Resident	uncommon	15 (*)	28 (*)
Spizella passerina	Chipping Sparrow	Summer Resident	abundant	24 (*)	57 (*)
Spizella pallida	Clay-colored Sparrow	Summer Resident	very rare		6 (*)
Zonotrichia albicollis	White-throated Sparrow	Summer Resident	abundant	119 (.04)	383 (.06)
Melospiza lincolnii	Lincoln's Sparrow	Migrant[4]	rare	18 (*)	17 (*)
Melosphiza georgiana	Swamp Sparrow	Summer Resident	common	85 (.03)	46 (*)
Melospiza melodia	Song Sparrow	Summer Resident	abundant	76 (.03)	211 (.03)

1. Green and Janssen, 1975
2. Green, 1971
3. *represents a relative abundance ≤ .02
4. Known to have bred in the state

APPENDIX II B. Birds observed in the mineral resource zone of the RCNSA during the 1977 winter field study.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURENCE[1]	NUMBER OBSERVED	RELATIVE ABUNDANCE[3]
Bucephala clangula	Common Goldeneye	Summer Resident	Present at Birch Lake Dam	-
Accipiter gentilis	Goshawk	Winter Visitant[2]	3	*
Canachites canadensis	Spruce Grouse	Permanent Resident	6	*
Bonasa umbellus	Ruffed Grouse	Permanent Resident	4	*
Bubo virginianus	Great Horned Owl	Permanent Resident	1	*
Nyctea scandiaca	Snowy Owl	Winter Visitant	1	*
Strix varia	Barred Owl	Permanent Resident	1	*
Dryocopus pileatus	Pileated Woodpecker	Permanent Resident	16	.04
Dendrocopus villosus	Hairy Woodpecker	Permanent Resident	18	.04
Dendrocopus pubescens	Downy Woodpecker	Permanent Resident	47	.11
Picoides articus	Black-backed 3-toed Woodpecker	Winter Visitant[2]	7	.02
Picoides tridactylus	Northern 3-toed Woodpecker	Winter Visitant	12	.03
Perisoreus canadensis	Gray Jay	Permenant Resident	16	.04
Cyanocitta cristata	Blue Jay	Permanent Resident	9	.02
Corvus corvax	Common Raven	Winter Visitant[2]	123	.28
Parus atricapilius	Black-capped Chickadee	Permanent Resident	114	.26
Parus hudsonicus	Boreal Chickadee	Permanent Resident	28	.06
Lanius excubitor	Northern Shrike	Winter Visitant	1	*
Pinicola enucleator	Pine Grosbeak	Winter Visitant	27	.06
Junco hyemalis	Dark-eyed Junco	Summer Resident	3	*

1. Green and Janssen, 1975
2. Known to have bred in the State
3. *represents a relative abundance of $< .02$

APPENDIX II C. Birds observed at feeders during the winter of 1977 near Ely, Minnesota.

SCIENTIFIC NAME	COMMON NAME	SEASONAL OCCURRENCE[1]	# DAYS SPECIES WAS RECORDED[3] / # OF OBSERVER DAYS
Canachites canadensis	Spruce Grouse	Permanent Resident	*
Bonasa umbellus	Ruffed Grouse	Permanent Resident	*
Columba livia	Rock Dove	Permanent Resident	.08
Bubo virginianus	Great Horned Owl	Permanent Resident	*
Aegolius acedius	Saw-whet Owl	Summer Resident	*
Dryocopus pileatus	Pileated Woodpecker	Permanent Resident	.02
Dendrocopus villosus	Hairy Woodpecker	Permanent Resident	.32
Dendrocopus pubescens	Downy Woodpecker	Permanent Resident	.33
Picoides articus	Black-backed 3-toed Woodpecker	Winter Visitant[2]	*
Picoides tridactylus	Northern 3-toed Woodpecker	Winter Visitant	*
Perisoreus canadensis	Gray Jay	Permanent Resident	.24
Cyanocitta cristata	Blue Jay	Permanent Resident	.28
Pica pica	Black-billed Magpie	Winter Visitant[2]	.09
Corvus corax	Common Raven	Winter Visitant[2]	.42
Parus atricapillus	Black-capped Chickadee	Permanent Resident	.56
Parus hudsonicus	Boreal Chickadee	Permanent Resident	.08
Sitta carolinensis	White-breasted Nuthatch	Permanent Resident	.08
Sitta canadensis	Red-breasted Nuthatch	Permanent Resident	.20
Certhia familiaris	Brown Creeper	Migrant[2]	*
Bombycilla garrulus	Bohemian Waxwing	Winter Visitant	*
Lanius excubitor	Northern Shrike	Winter Visitant	*
Passer domesticus	House Sparrow	Permanent Resident	.05
Hesperiphona vespertina	Evening Grosbeak	Summer Resident	.12
Pinicola enucleator	Pine Grosbeak	Winter Visitant	.10
Acanthis flammea	Common Redpoll	Winter Visitant	*
Junco hyemalis	Dark-eyed Junco	Summer Resident	.12
Spizella arborea	Tree Sparrow	Migrant	.05

1. Green and Janssen, 1975
2. Known to have bred in State
3. Participants in the feeder study only recorded the day on which a species was observed, not the number of individuals per species.
4. Represents values < .02