HABITAT STRUCTURE, SUCCESSION AND BIRD COMMUNITIES

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Abstract.--Birds select habitats by several different mechanisms to supply the requisite needs of the species. Several statistical tests can be used to correlate bird species with habitat variables. Combining variables by means of factor analysis can indicate how species relate to forms of disturbance in forest habitats.

Natural changes in forest community structure that occur in plant succession can be altered by many human caused disturbances. These disturbances, which include fire, logging, increasing edge, retention of snags and maintaining a diverse habitat, are also effective tools for the manager of nongame birds.

INTRODUCTION

If you are a bird watcher you know that different species of birds are found in characteristic habitats. To find Barred Owls[2/], for example, you go to hardwood forests in wet or swampy riverbottoms at night. The Black-backed Three-toed Woodpecker is found deep in coniferous forests where fire, logging or wind have left some standing snags with heavy understory. The Great Crested Flycatcher is often found in large woodlands with small openings and perch sites. The Red-breasted Nuthatch is wide ranging in mature evergreen forests whereas the White-eyed Vireo can be seen in the shrub and understory of southern forests and forest edge. The Black-and-white Warbler is found in mature forests and the Swamp Sparrow nests in bogs and marshes.

In North America there are 821 species of birds of which at least 225 species occur in the regions of concern to members of this Workshop. How can we manage for that large a number of species with their diverse needs? The key is to understand why species are found in a particular habitat, how habitat changes affect them, and how to manage for assemblages or communities of birds rather than individual species.

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2/ See Appendix 1 for scientific names of bird species discussed in paper.

AVIAN HABITAT SELECTION

Why are birds where they are? Birds adapt to areas where their requisite needs are found. Their breeding habitat must supply all the needs, including nesting site, nesting material, food, and protection for each species. Within the evolutionary process, birds develop mechanisms enabling them to find these areas. When they arrive in their habitat they apparently instinctively perceive signals from the environment indicating their requisite needs are present (Klopfer and Hailman 1965, Wiens 1969) and do not attempt to breed in other habitats (Lack 1933). Some species of birds are known to imprint on the place of their birth. For example, Klopfer (1963) shows how Chipping Sparrows return either to the deciduous or coniferous forested areas around North Carolina depending on the particular forest in which they are born. Hilden (1965) summarizes several studies on gulls to show learning in habitat selection.

Since territorial animals seek their habitat rather than randomly disperse and settle through the environment, ethologists feel that structural features of the habitat provide "sign stimuli" (Lack 1933, 1937, Hilden 1965). These stimuli serve as forms or guideposts to indicate which habitats can be expected to supply the species' needs (Wiens 1969). It is most important to recognize that minor habitat alterations which destroy such "sign stimuli" can result in changes in bird species composition. Although a species might be found in a number of habitat types, the population in each habitat has characteristics that separate it from another. For example, when

morphological characteristics of Red-breasted Nuthatches are examined in western Oregon, different bill and leg sizes are found in the fir and pine populations (Fig. 1) (Anderson 1976).

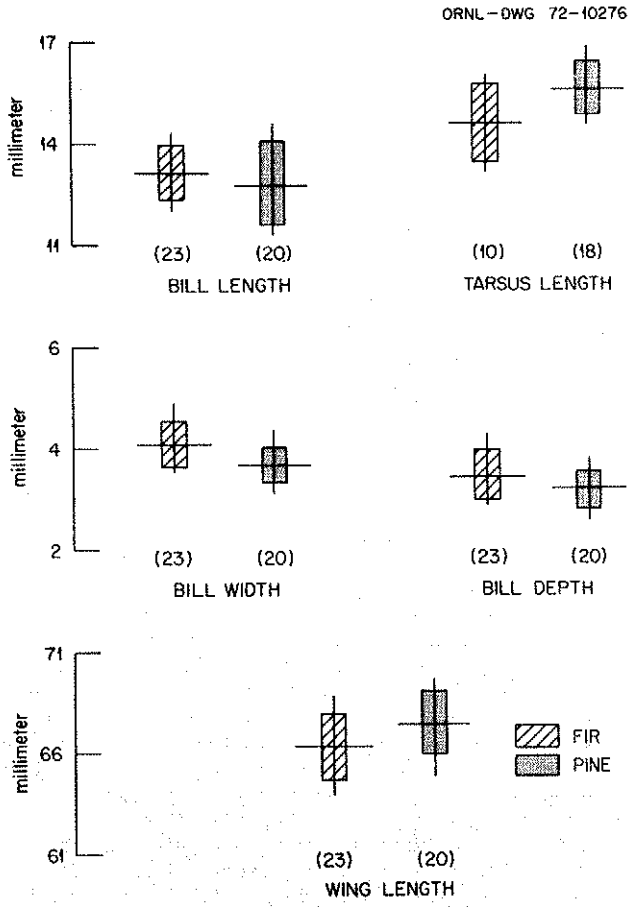

Figure 1.--Selected morphological characteristics of Red-breasted Nuthatches in western Oregon fir and pine forests. A two-tailed t-test shows a significant difference betwee the bill width, depth, and tarsus length. Horizontal line is the mean, rectangle represents the standard error, and vertical line the range.

Whereas most species seem to respond to the structure of the vegetation, other visual clues provide information about the habitat. Svardson (1949) indicates that water, overlooks, vegetation on the ground, and the shade of green influence the areas selected by some species of English birds.

Migratory birds do not begin to establish their territories or select nest sites until some weeks after they arrive in breeding habitat (Tinbergen 1961). Once birds have established their territory, they remain fixed to these sites despite frequent adverse conditions. Emlen (1970) shows that bird counts in Florida pine stands are essentially the same in burned and unburned stands when fire burned the area during the breeding period.

Habitat structure, however, is the basic reason for the presence of birds in an area. Management of nongame birds, therefore, requires an understanding of the habitat structure and avian response mechanisms.

HABITAT CORRELATION

Information on the habitat of nongame birds can best be used by wildlife managers if it is translated into measurable features. Research biologists began to quantify habitat variables and correlate them with bird species in the late 1950s and 1960s. While more needs to be done on this subject, particularly in terms of seasonal and latitudinal differences, there are results that can be used by managers.

To describe avian habitat in Arkansas, James (1971) uses multivariate methods to indicate differences in vegetation variables. She points out that each species has a perceptual world to which it responds as an organized whole (niche-gestalt). This technique allows biologists to quantify the different vegetation components necessary for the species. Warbling Vireos are found in deciduous forests 40-100 feet tall that are relatively uniform in height and near the edge habitat. White-eyed Vireos show a preference for forests with mixed size class trees around 40 feet tall. Specific components can be listed for each bird species in the forest (Fig. 2).

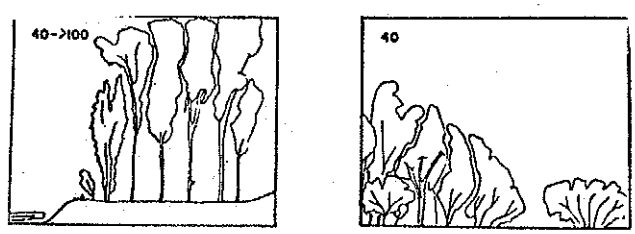

Figure 2.--Outline drawings of the niche-gestalt for the Warbling Vireo (left) and the White-eyed Vireo (right). Numbers give vertical scale in feet (from James 1971).

In another study using multivariate analysis, Anderson and Shugart (1974) show that Downy Woodpeckers in an east Tennessee deciduous forest are correlated with the number of saplings. White-breasted Nuthatches are correlated with understory vegetation and the biomass of trees in the lowest woody vegetation layer (Fig. 3). White-breasted Nuthatches

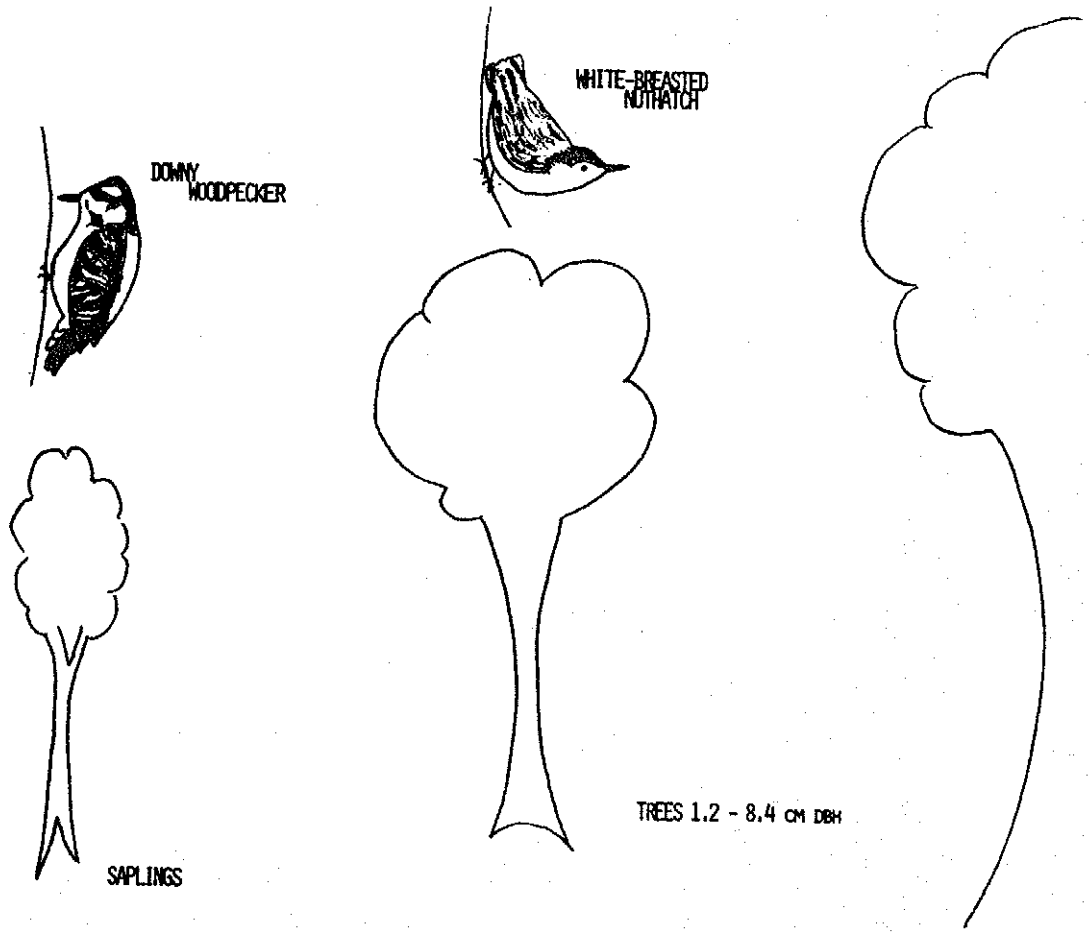

Figure 3.--Trees associated with Downy Woodpecker and White-breasted Nuthatch in east Tennessee deciduous forest (from Anderson and Shugart 1974).

and Downy Woodpeckers thus select their habitat using similar criteria. The distinction is that the woodpecker is found in areas with well developed understory whereas the nuthatch is in areas of sparse understory.

Whitmore (1975) used discriminant function analysis to determine important habitat variables for bird communities in Utah. He found that the percentage canopy cover was the most important individual habitat characteristic that could be used as a predictor of which bird species occupy a particular environment. The shrub density, number of trees 7.5 - 15 cm DBH and percentage ground cover followed in order of priority.

Ordination by means of principal component analysis is also possible as demonstrated by Smith (1977) in Arkansas. There he uses a combination of all habitat data to form the principal component axis. He found an ordination of birds along this axis with most species concentrated toward the moist forest.

Factor analysis is another statistical technique that is very similar to principal component analysis. Each test reduces the habitat variables in a multidimensional space to a linear component. Principal component analysis scales the variables so that the sum of the squares for the element in each vector equals one. When this is done the associated eigenvalue (characteristic root) is interpreted as the variance along the principal component axis. Vectors in factor analysis are scaled so that the coefficients are the correlation coefficients with the original measurements.

Factor analysis was used to evaluate the habitat of breeding birds in the Upper

Peninsula of Michigan. The purpose of this study was to evaluate the effect of a wildfire that burned over 260 square kilometers on the Seney National Wildlife Refuge in 1976. Seven paired eight-hectare plots, one of each pair on burned and one on unburned habitat, were established to conduct the evaluation. Two major habitats, the northern mixed forest and the bog/fen, were burned on the Refuge. The mixed forest consisted of a few pure stands of black spruce (*Picea mariana*), paper birch (*Betula papyrifera*) and quaking aspen (*Populus tremuloides*). There were many areas where the forest was quite open and trees sparse, allowing dense concentrations of alder to grow. Most of the region consisted of a mixture of aspen, cherry, spruce, maple, pine, fir and birch.

The fire burned in a very erratic manner. In some places it destroyed virtually all of the standing timber. In other places the fire simply burned in and around the bottom of trees, destroying some of them. In the spring following the fire, seedlings of quaking aspen and jack pine (*Pinus banksiana*) as well as lowbush blueberry (*Vaccinium augustifolium*) and bracken fern (*Pteridium aquilinum*) grew on the burned ground. By the spring of 1978, two years after the fire, the ground had a rich cover of aspen seedlings and blueberry.

On the Seney Wildlife Refuge, the bog habitat was covered by a thick layer of peat resting on sandy soil. The area had long (up to 2 kilometers) dense bog forests that were less than 0.25 kilometers wide. Tamarack (*Larix laricina*) and red maple (*Acer rubrum*) were the common tree species. Between the forests were flat bogs containing typical bog plant species as well as short tamarack and bog birch (*Betula pumila*). Fire burned rapidly through some of these areas, destroying the trees, grasses, sedges, and the upper layers of peat. Interspersed in the open bog areas were small sand islands less than 0.04 hectares with populations of red and white pine or aspen and birch. Most of the sand islands were no larger than a hectare.

Each plot was censused for breeding birds eight times each spring in 1977 and 1978. All birds heard and seen were recorded. The vegetation data were collected on ten 0.04-hectare points randomly selected within the plots by means of a modified James and Shugart (1970) method.

An ordination of the plots (Figs. 4, 5) was constructed by a principal axis factor analysis of the habitat variables with a varimax rotation (Overall and Klett 1972, Greg-Smith 1964, and Barr *et al.* 1976). Unrotated principal axis factors only differed for principal components by a scaling factor. Varimax rotation was used to obtain a simple structure that was easier to interpret. The factor scores for the variables on Table 1 allow the selection of the most significant variables.

An examination of the loading of the first factor shows that it represents the mature forest, with a strong positive correlation to the number of trees, the percentage canopy closure, and the mean canopy depth (high values for this variable indicate the presence of conifers). The second factor represents the effect of the burn and has a high positive correlation with the number of snags and the number of seedlings. The most marked change on burned plots between the first and second growing seasons after the fire is the high number of seedlings, mainly aspen (*Populus tremuloides* and *grandidentata*), that become established on the charred soil. High numbers of seedlings on unburned plots are due to advanced reproduction. The third factor represents the shrub component of the vegetation. The factor scores for variables on each plot can be examined (Table 2) and compared with the composite scores (Table 1) to determine the variation of the plot from the mean.

Figure 4 shows the two dimensional ordination of plots in the space of the habitat factors. The burned and unburned plots are best separated on the basis of factors one and two. All unburned plots except 6 and 7, which are located in the relatively open bog/fen, have positive scores for Factor 1. Burned plots 6 and 7 likewise have negative values for Factor 2. The dead trees of plot 6 are not standing as snags because the supporting root systems are burned away. The burn on plot 7 is not severe and has little effect on the bog shrubs and the few small trees. When Factor 3 is added (Fig. 5), burned and unburned plots 6 are clearly separated. There are high numbers of bog and lowland shrubs on the unburned plot of the pair; however, recovery cannot occur quickly because the shrubs and top layers of peat are burned away. Two years after the fire, only sedges (*Carex* sp.) and cotton grass (*Eriophorum* sp.) are established.

Burned plot 4 stands out as having scores close to zero for all factors. A smaller (72%) portion of this plot burned with a less intense fire. Consequently fewer trees are dead. The living trees give this plot a higher percentage of canopy closure than several of the unburned plots.

The factor score for each bird species is determined on the basis of weighted variables of the plots where the species is found (Table 3). Selected bird species are added

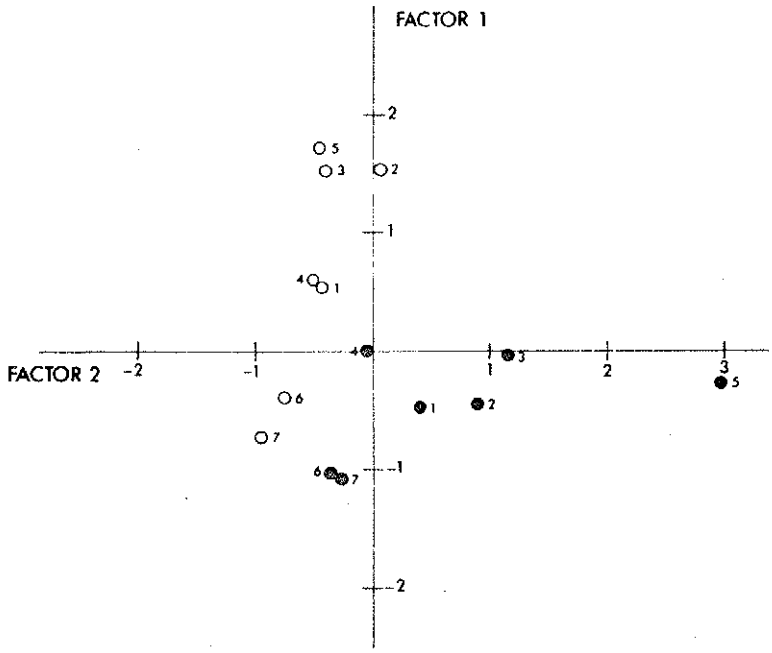

Figure 4.--Ordination of 20-acre plots on Seney National Wildlife Refuge in space of habitat factors 1 and 2 formed by a principal axis factor analysis with a varimax rotation. Dark circles represent burned plots, light circles represent unburned plots.

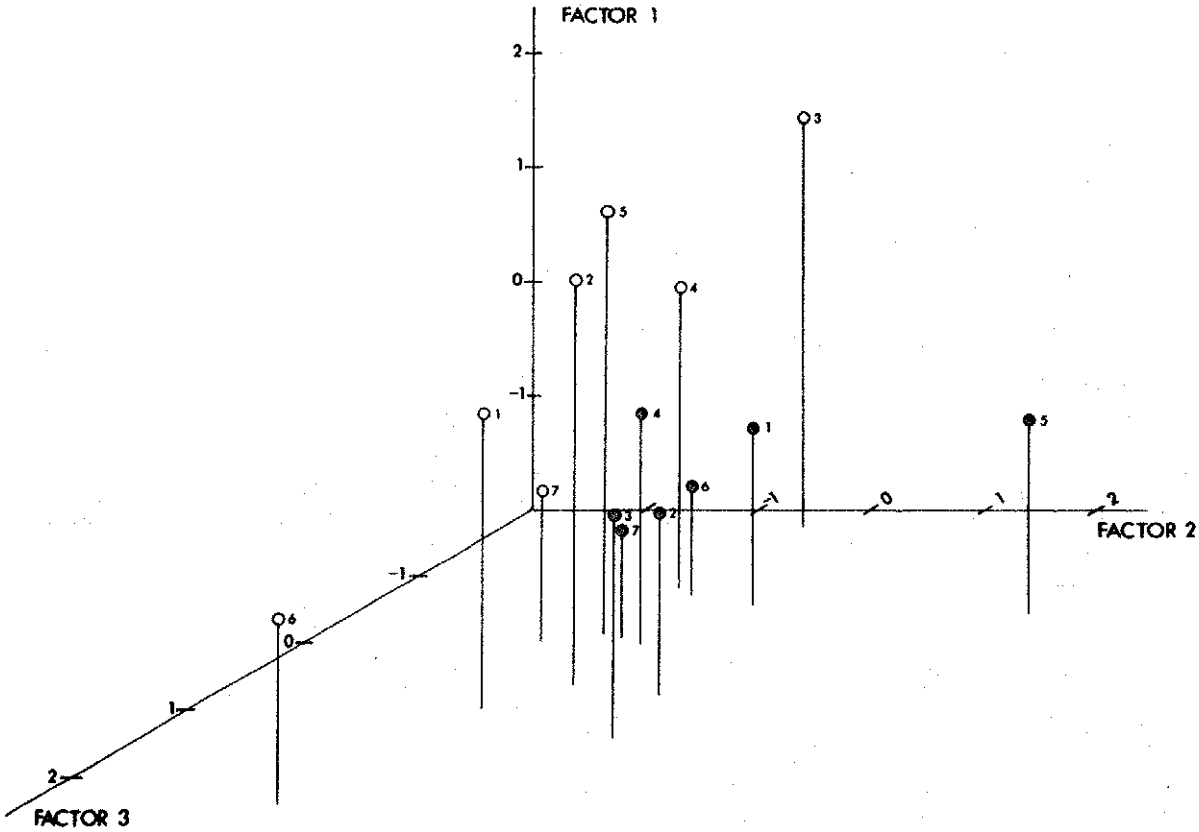

Figure 5.--Ordination of Seney plots as discussed in Figure 4 in space of factors 1, 2 and 3.

Table 1.--Habitat factor loadings (correlations with observed habitat variables) for the principal axis factor analysis with a varimax rotation.

	Factor 1	Factor 2	Factor 3
Trees 24-44 cm DBH	0.7367	-0.0107	-0.3713
Trees < 24 cm DBH	0.8180	-0.0780	-0.1465
Shrubs 50-150 cm tall	-0.1730	-0.0656	0.8408
No. saplings	0.5732	0.0928	0.6400
No. seedlings	0.0042	0.8564	0.1288
No. snags	-0.0312	0.8751	-0.1400
% of plot burned	-0.6004	0.5534	-0.1087
% canopy closure	0.9521	-0.0403	0.0148
Mean canopy depth (meters)	0.9417	0.1408	-0.0795
% cover - grasses and sedges	-0.5936	-0.6002	-0.0170

to Figure 6 by using the weighted variables. Species such as the Savannah Sparrow found only on burned plot 6 have the same factor scores as that plot. Bird species found on several plots are clustered in the center of the figure. The Black-backed Three-toed Woodpecker, strongly influenced by the presence of conifer snags, is located far to the right on the figure, with a high positive score for Factor 2. Species using plots with high numbers of trees (e.g., Cape May Warbler and Ovenbird) have a high positive correlation with Factor 1, represented by the vertical line supporting the species symbol on the figure.

Management for nongame birds can be most effective when the key habitat components associated with each community are known. While a number of biologists show that an increase in the structural complexity of a community is associated with an increase in bird species (MacArthur and MacArthur 1961; MacArthur, *et al.* 1966; Karr 1968), the effect of habitat change must be evaluated in terms of individual or groups of habitat components.

PLANT SUCCESSION AND BIRDS

Plant succession occurs, according to McIntosh (1970), because most species are temporary occupants of a site. Plants tend

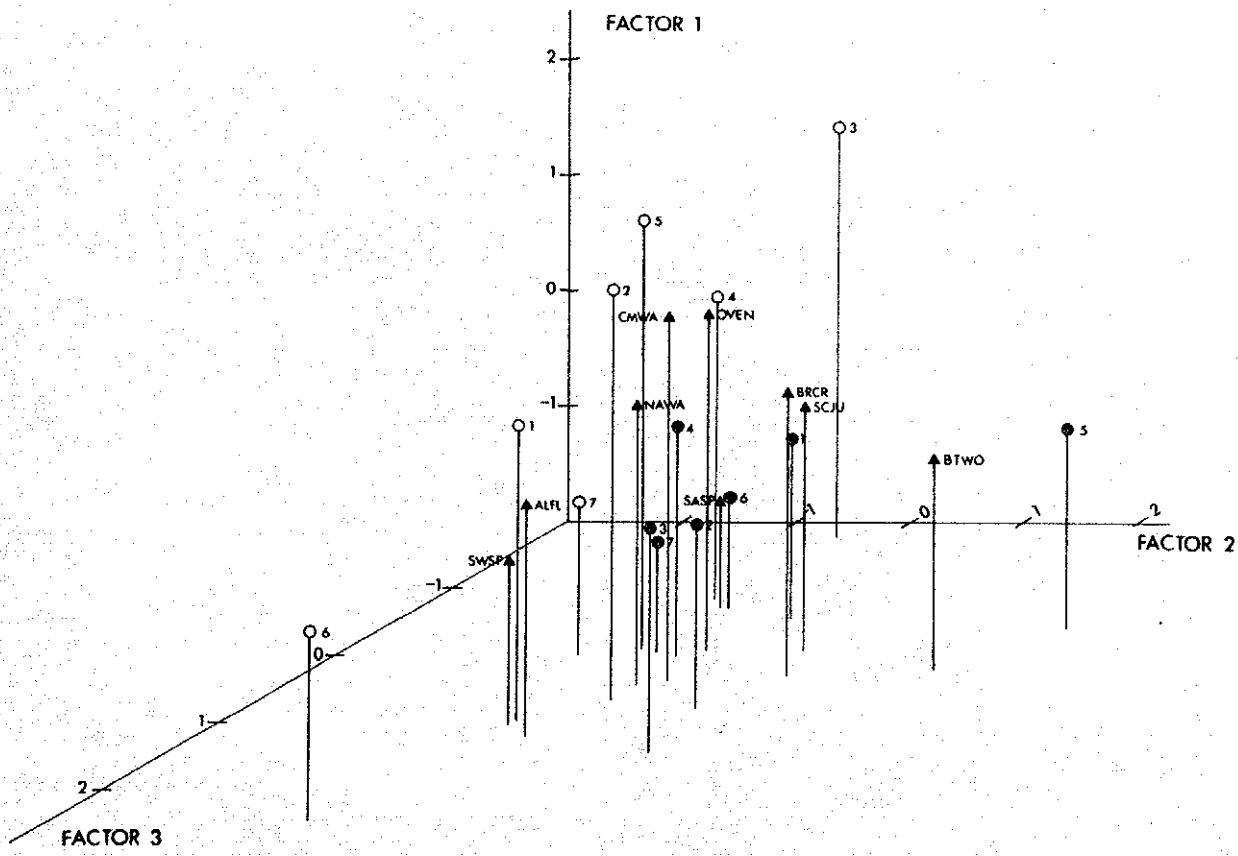

Figure 6.--Ordination of Seney plots in Figure 5 and selected species of birds. Species code in Table 3.

Table 2.--Factor scores and observed habitat variables for plots.

	UNBURNED						
Plot number	1	2	3	4	5	6	7
Factor 1	0.52	1.53	1.52	0.64	1.74	-0.37	-0.73
Factor 2	-0.43	0.05	-0.41	-0.52	-0.42	-0.77	-0.90
Factor 3	0.97	0.66	-1.76	-0.77	-0.12	2.46	-0.01
Trees 24 - 44 cm DBH	6.00	16.00	65.00	13.00	15.00	0.00	0.00
Trees < 24 cm DBH	183.00	364.00	113.00	167.00	604.00	124.00	4.00
Shrubs 50 - 150 cm tall	1928.00	808.00	48.00	224.00	728.00	7224.00	1504.00
No. saplings	68.00	72.00	20.00	16.00	32.00	32.00	16.00
No. seedlings	1040.00	6400.00	160.00	80.00	40.00	80.00	240.00
No. snags	25.00	25.00	19.00	11.00	32.00	19.00	0.00
% of plot burned	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% canopy closure	24.50	70.50	45.00	31.00	59.00	17.20	0.20
Mean canopy depth (meters)	6.23	7.38	10.06	7.83	9.55	2.36	0.86
% cover - grasses & sedges	22.50	11.80	3.00	11.20	2.10	33.20	40.00

	BURNED						
Plot number	1	2	3	4	5	6	7
Factor 1	-0.49	-0.42	-0.01	0.01	-0.26	-1.07	-1.10
Factor 2	0.38	0.87	1.16	-0.09	2.95	-0.32	-0.28
Factor 3	-0.61	0.81	1.45	0.05	-0.42	-0.73	-0.08
Trees 24 - 44 cm DBH	3.00	2.00	9.00	12.00	9.00	0.00	0.00
Trees < 24 cm DBH	39.00	45.00	54.00	97.00	87.00	3.00	2.00
Shrubs 50 - 150 cm tall	736.00	1744.00	3472.00	2808.00	1240.00	624.00	2352.00
No. saplings	8.00	56.00	72.00	12.00	4.00	0.00	0.00
No. seedlings	2960.00	8040.00	6200.00	680.00	18720.00	320.00	0.00
No. snags	53.00	52.00	112.00	39.00	360.00	4.00	0.00
% of plot burned	100.00	94.50	100.00	72.00	79.50	100.00	100.00
% canopy closure	13.50	7.50	9.20	29.30	16.50	0.50	0.20
Mean canopy depth (meters)	3.77	2.55	6.28	6.04	4.56	0.60	0.44
% cover - grasses & sedges	12.60	10.70	3.10	18.70	2.20	33.80	26.40

Table 3.--Factor scores for bird species.

Species (code)	Factor 1	Factor 2	Factor 3	Number territories
Alder Flycatcher (ALFL)	0.0931	-0.1498	1.2255	7.5
Brown Creeper (BRCR)	0.4900	1.2293	0.3025	3.0
Black-backed Three-toed Woodpecker (BTWO)	-0.1769	2.3538	0.2003	1.5
Cape May Warbler (CMWA)	1.1510	0.1942	0.3266	22.0
Nashville Warbler (NAWA)	0.4335	0.0274	0.4434	39.0
Ovenbird (OVEN)	0.8609	0.1386	-0.0883	33.0
Savannah Sparrow (SASP)	-1.0686	-0.3196	-0.7346	3.0
Slate-colored Junco (SCJU)	0.1510	1.0649	-0.0884	13.0
Swamp Sparrow (SWSP)	-0.3254	-0.4421	1.0933	9.5

to invade an area when the resident species change the habitat so the residents cannot effectively compete with invaders. Actual stages of plant succession might or might not coincide with distinct bird communities as birds respond to structure.

In a study in the Algonquin Provincial Park in Ontario, Martin (1960) reported that birds occurred when their niche requirements were satisfied. Martin pointed out that you could list a group of birds for each forest type in the park, but most species overlapped into several plant community associations. He also showed that bird species were found in different vertical strata in the different plant communities.

On the Apostle Islands of Wisconsin, distinctive patterns of hemlock, pine, aspen, red oak, sugar maple, and percentage of understory contribute to the bird species diversity (Beals 1960). The lack of pattern for spruce and fir could reflect the important difference of associated tree species according to Beals. This lack of pattern is particularly true of the northeastern and north central forests. Kendeigh's 1948 study on the northern lower peninsula of Michigan shows that plant communities there have a very non-uniform structure. In that study, aspen--red maple forests contain two bird communities and red pine--aspen, a mingling of three bird communities. This information, he points out, is an indication that bird species do not directly recognize the same seral stages as plant communities.

Most workers find that avian species and diversity increase through progressive successional communities toward climax vegetation (Johnson and Odum 1956, Shugart and James 1973). These results are similar in both deciduous and coniferous forests. Karr (1968) notes a slight decline in bird species and in density in late forest stages. Bond (1957) used a vegetation continuum index devised by Curtis and McIntosh (1951) to correlate populations of breeding birds to tree species composition. This study in southern Wisconsin has obvious relationships to community succession. It also shows how bird species and diversities change in different stages of succession.

Logging and fire are two forms of habitat destruction to which succession can be related. Fire historically serves as an important factor in the regeneration of forests of the north central region. Following fire an area generally reverts to an early stage in succession. Adams (1908) shows the importance of fire in maintaining open areas on Isle Royale, Michigan. Niemi (1978) shows that bird species, especially small passerines, decrease following fire in northern Minnesota. The study at the Seney National Refuge indicates that some bird species are attracted to burned areas and others leave the disturbed areas (Table 4).

Table 4.--Bird species on Seney National Wildlife Refuge significantly affected by the 1976 fire.

Increased following fire:
Eastern Kingbird
Brown Creeper
Cedar Waxwing
White-throated Sparrow
Song Sparrow
Decreased following fire:
Veery
Black-and-white Warbler
Magnolia Warbler
Cape May Warbler
Chestnut-sided Warbler

These data, developed by means of an analysis of variance test, show that 10 species of birds are affected by the fire. In addition, in the mixed forest the Alder Flycatcher, Black-throated Green Warbler and Nashville Warbler are common in the unburned area, while the Yellow-rumped Warbler, American Robin, Lincoln's Sparrow, Killdeer and Black-backed Three-toed Woodpecker are observed most frequently in the burned forest.

The bog forest has American Redstart, Black-and-white Warbler, Canada Warbler, Nashville Warbler and Swamp Sparrow, which are not found in the burned bog area. The only species found in the burned bog area and not in the unburned area are Savannah Sparrow and Brewer's Blackbird.

Birds moving into burned areas are probably attracted by features such as snags which attract woodpeckers and bark-foraging species and perches for insect hawking species. Succession following a fire can increase the diversity of birds as the shrub layer thickens below the burned snags, and seedlings and shrubs develop rapidly in the area. Heinselman (1973) stated that the entire biota of the Boundary Waters Canoe Area of Minnesota are adapted to periodic fire. Succession resulting from fire restructures the entire system.

Bird species diversity on the Seney Refuge was higher on the burned plots than on the unburned plots. Species such as the Black-backed Three-toed Woodpecker, Brown Creeper and Slate-colored Junco, which were

uncommon in burned areas, were found in the burned habitat. Very few species were found exclusively in the unburned habitat although the populations found in dense forests were lower than in the burned habitat.

Clearcutting, on the other hand, destroys segments of the forest creating open areas with much debris on the ground. When whole forests are destroyed, as occurred in northern Minnesota and Wisconsin in the early part of the century, the avian community changes.

In a study on five stands of northern hardwood forest in the Adirondack Mountains of northeastern New York, breeding bird census sites were established to verify the effect of logging. None of the bird species were eliminated by logging, but some were recorded only in logged stands (Webb *et al.* 1977). They found that in this 10-year study the number of species and the species diversity index increased in the logged areas and were correlated positively with logging. Hagar (1960), in a study of Douglas fir (*Pseudotsuga taxifolia*) in California, found that little change occurred in the number of species immediately following logging. He indicated that a change occurred in the species composition 3 years following logging.

Natural succession should be considered in nongame bird management. Total diversity can be maintained at a higher level when forests consist of different successional seres. Habitat change can be planned around the forest succession sequences and the nongame bird communities.

MEASUREMENT OF CHANGE IN BIRD COMMUNITIES

It is important to be able to measure the changes in bird communities as they occur in a forest.

Diversity. A bird species diversity index (BSD) can be one means of measuring change. Diversity is measured by counting the number of individuals and the number of species, then noting the distribution of individuals among the species. Thus communities with low BSDs tend to have large numbers of birds in one or a few species and very few individuals in other species. Communities with high BSD have a more or less uniform distribution of individuals in all species. To use diversity indices it is important to have comparative figures. Thus the BSD of different successional seres might be compared. Diversity before and after disturbance can be used. MacArthur and MacArthur (1961) show how BSD increases with the diversity of the vegetation in the three different layers (foliage height diversity - FHD) they use. Habitats with more uniform distributions of tree, shrub and ground layers contain higher bird species diversities. Willson (1974) cautions about using such indicators after finding a lack of correlation between BSD and FHD.

Wildlife managers, however, can use the diversity concept to maintain nongame bird communities. By measuring BSD in a forest and maintaining important habitat factors correlated with key species, it is possible to maintain diverse communities. Habitat diversity is an approach that can be contrasted with single species management of game or endangered species.

Care should be taken in using the diversity techniques as all bird species contribute to the diversity. Thus, some less desirable species, such as Starlings and House Sparrows, or highly adaptable species such as Gray Catbirds and Cardinals, are able to substitute for some of the more specialized species of forest birds. Studies should be made on carefully delineated communities. The clue is to establish a habitat for the bird community desired and use diversity as one of the tools of measurement.

Indicator Species. Species that characterize a community are indicator species. While it is difficult to define this term because there are so many species in a community, it is possible to identify major bird assemblages with each successional sere. The changes that occur as succession proceeds in a forest make it possible for us to look at different birds that are found in different community types. Bird species frequently overlap between two plant seres so bird communities do not always coincide with plant communities. However, by managing for the selected bird species found in each seral stage we can attract an entire community. We must still be sure that minor or endangered populations are not lost because of our effort. It is important to realize that management for indicator species means managing for the whole community. It is also possible to use one of the lesser or endangered populations as an indicator.

Data from the Seney National Wildlife Refuge and data from Martin's (1960) study in Ontario, Canada, are used to show key indicator species in bog, boreal forest and deciduous forest communities (Table 5).

NONGAME BIRD MANAGEMENT IN THE NORTH CENTRAL FORESTS

Managers have a number of techniques available to them for managing nongame communities.

Table 5.--Common birds of bog, boreal forest and deciduous forest in north central United States (source, Martin 1960 and Anderson unpublished data).

Bog	Boreal Forest	Deciduous Forest
Eastern Kingbird	Spruce Grouse	Eastern Wood Pewee
Tree Swallow	Golden-crowned Kinglet	White-breasted Nuthatch
Common Yellowthroat	Ruby-crowned Kinglet	Wood Thrush
Red-winged Blackbird	Cedar Waxwing	Veery
Lincoln's Sparrow	Magnolia Warbler	Red-eyed Vireo
Swamp Sparrow	Myrtle Warbler	Ovenbird
Song Sparrow	Northern Waterthrush	Scarlet Tanager
	White-throated Sparrow	Rose-breasted Grosbeak

Fire. Much of the north central forest region was periodically affected by fire before white man. Fire largely determined the composition and structure of the presettlement vegetation in such areas as the Boundary Waters Canoe Area, the Upper Peninsula of Michigan, and a good portion of northern Wisconsin and Minnesota. These fires burned in irregular patterns throughout the area, opening up the understory, creating additional edge, and thereby creating habitat for many bird species.

Some species, such as the Kirtland's Warbler, are dependent on fire for periodically opening habitat. A number of other species, including Upland Sandpiper, Mourning Dove, Common Nighthawk, Common Flicker, Eastern Kingbird, Black-capped Chickadee, House Wren, Brown Thrasher, Eastern Bluebird, Nashville Warbler and Vesper Sparrow, are reported by Pinkowski (1977) to receive benefits from jack pine burns in Michigan. Studies by Heinselman (1973) and Niemi (1978) also demonstrate the effect of fire on birds in the north central region.

A small prescribed burn can be used to clear the understory or some of the ground litter and allow ferns and aspens to spring up to provide seed and other food for birds. Larger burns can be used to actually change the structural component of the vegetation. A very intense fire could destroy the entire forest and set the area back to the earliest stages of succession. Intense fires are much more common in the western United States.

Clearing Vegetation. Selective logging, clearing understory and removing small stands of timber all have major impacts on the avian community. They all serve to increase bird diversity in the north central forest. They attract edge species and provide a temporary mixture of both forest specialists and edge generalists. Flycatchers can hawk in the open area and woodpecker activities increase on the more exposed tree and snag branches. Clearing the understory allows some species to move into forested areas previously unavailable to them because of dense vegetation. This technique is particularly effective when the habitat requirements of bird communities are considered for each successional sere.

Edge. A number of studies have shown the value of edge to birds. Lay (1938) indicated that wildlife increased in a mixed Texas forest where small clearings were established. Hagar (1960) found that logging in a western Douglas fir forest increased the bird population density along the edge within 3 years after cutting. Johnson (1947) believed that the forest edge was a distinct community because it was inhabited by species that in part displayed adjustments to the particular niche available only in forest edge. Kendeigh (1946) documented the high species diversity in the deciduous-coniferous forest ecotone.

Managers can use the edge concept to maintain the diversity of the north central forest birds. Another paper in this Workshop addresses the dangers of introducing edge into forest interior situations and discusses the minimum edge-free area required to support different species of forest interior birds. This very important feature should be considered when deciding whether to manage avian communities by increasing edge. Increased edge can actually reduce the number of nongame species if the forest becomes fragmented into small isolated units.

Using these guidelines, one should consider edge between forest and field or edge created by human disturbances such as logging, transmission-line corridors and roadways. These cuts are continuing to increase the amount of edge and reduce the size of unbroken forested area. A study in an east Tennessee deciduous forest shows that transmission-line corridors reduce the area for nesting migratory bird species but

increase the nesting potential for resident birds (Anderson in press). The additional open area brings in some gallinaceous birds, as well as the raptors and other predators, which can hunt along these transmission lines.

Snags. Snags or dead trees are considered undesirable by many land managers and are viewed with mixed emotions by wildlifers. We now are aware of some 85 species of North American birds that excavate nesting holes or use holes created by other species in dead or deteriorating trees (Scott *et al.* 1977). Since the majority of all cavity nesting birds are insectivorous, they play a valuable role in the forest ecosystem. Maintenance of snags does benefit hole-nesting species (Haapanen 1965).

The great majority of hole-nesting species are permanent residents or short distance migrants (owls, woodpeckers, chickadees, nuthatches, wrens and bluebirds). Another paper in this Workshop will address some problems associated with leaving snags standing throughout a forest.

Nest boxes can be substituted for snags to draw more cavity nesters or increase their nesting success. Game biologists attract wood ducks, mergansers and a few other species by properly placing nest boxes. Experiments with some species of chickadees show population increases when nest boxes are placed in wooded areas with insufficient nesting cavities. We need to conduct studies on the behavior of species using nesting boxes to determine how far apart they should be placed for maximum utilization.

Habitat Diversity. Very few areas have extensive uniform avian habitat; rather, small islands of forest are found around fields and forests are segmented by roadways and clearcuts. Succession can also vary due to slope, exposure, climate and historical use. Uniform forests such as those found on tree farms often have a lower bird species diversity than those with a mixed age class. Forests having a diversity of structure generally attract the largest bird diversity.

Planned Management. Effective management for nongame birds requires a plan based on desired goals and specific methods.

Once the area to be managed is selected and the purpose for management established, employable methods to fulfill that purpose must be chosen. One management possibility could involve allowing the area to proceed toward natural succession and climax--a policy of let nature take its course. The result is likely to be an increase in diversity and changes in the bird species much as would occur in a climax vegetation. The population or diversity of birds is highest in the near climax communities. If a large region is allowed to reach climax forest, total diversity and species composition will be reduced. Second, the area can be maintained for diversity by special techniques, such as clearcutting the understory, prescribed burns, or some profitable form of logging. Management of an area under these principles really is the development of a sustained yield plan or a plan that alters the different areas at different times. Third, single species management might be instituted for important species, endangered species or others. Finally, selective techniques discussed in this paper might be used to maintain nongame bird communities in habitats managed for other purposes, such as timber harvest.

The manager must consider the size of the habitat that is being managed and the natural successional sequence. In addition, unusual species must be considered. It is difficult to attract rare or unusual species to a forest habitat by selective management. Knowledge of the habitat requirement of the avian community and major species make for the most effective management of the north central forests for nongame birds.

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APPENDIX 1

Common Name	Scientific Name
Killdeer	*Charadrius vociferus*
Barred Owl	*Strix varia*
Downy Woodpecker	*Picoides pubescens*
Black-backed Three-toed Woodpecker	*Picoides arcticus*
Great Crested Flycatcher	*Myiarchus crinitus*
Alder Flycatcher	*Empidonax alnorum*
White-breasted Nuthatch	*Sitta carolinensis*
Red-breasted Nuthatch	*Sitta canadensis*
Brown Creeper	*Certhia familiaris*
Gray Catbird	*Dumetella carolinensis*
American Robin	*Turdus migratorius*
Starling	*Sturnus vulgaris*
White-eyed Vireo	*Vireo griseus*
Yellow-throated Vireo	*Vireo flavifrons*
Warbling Vireo	*Vireo gilvus*
Black-and-white Warbler	*Mniotilta varia*
Nashville Warbler	*Vermivora ruficapilla*
Cape May Warbler	*Dendroica tigrina*
Yellow-rumped Warbler	*Dendroica coronata*
Black-throated Green Warbler	*Dendroica virens*
Kirtland's Warbler	*Dendroica kirtlandii*
Ovenbird	*Seiurus aurocapillus*
Canada Warbler	*Wilsonia canadensis*
American Redstart	*Setophaga ruticilla*
House Sparrow	*Passer domesticus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Cardinal	*Cardinalis cardinalis*
Savannah Sparrow	*Passerculus sandwichensis*
Slate-colored Junco	*Junco hyemalis*
Chipping Sparrow	*Spizella passerina*
Lincoln's Sparrow	*Melospiza lincolnii*
Swamp Sparrow	*Melospiza georgiana*