BIRD COMMUNITIES AND WHITE SPRUCE SUCCESSION ON THE KENAI PENINSULA, ALASKA.

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Whether effected by natural forces such as floods, insect outbreaks, avalanches, and fire, or by man's activities including timber harvesting, agriculture, and controlled burning, habitat changes are accompanied by changes in bird communities (Lack 1933; Haapanen 1965; Bock and Lynch 1970; Balda 1976). The U.S. Forest Service plans to burn 22,000 acres of the Chugach National Forest on the Kenai Peninsula to improve moose winter-range. This represents roughly 9 percent of the forested land in this area (U.S.D.A. 1978). Such a large scale habitat alteration will unquestionably affect the bird populations of the Kenai Peninsula, but minimal information on the sorts and extent of changes to be expected is available. The birds of the Kenai Peninsula have received little scientific attention beyond determinations of species occurrence, relative observ-ability, and scattered nesting records. Yet birds are an important component of forest ecosystems and highly valued by the general public. Thus, in evaluating and planning the prescribed burning program, information on the effects of controlled burning on bird species and populations is needed. The objective of this study was to determine what changes occur in bird communities of white spruce (*Picea glauca*) forests following fire and throughout succession. As the controlled burning program has just begun, this study was conducted in forest stands burned by wildfire at various times in the past.

STUDY AREA

This study was conducted in the Chugach National Forest on the Kenai Peninsula, Alaska. Five study plots were chosen to represent different successional stages of white spruce forest following fire. A 9 year old and a 20 year old burn represent the early successional stages, while 3 stands of trees aged at 40 - 50, 100 - 120, and 150 - 200 years comprise the mature forests studied. Study plots were up to 15 miles apart but the elevation, and latitude and longitude were approxi-imately the same: 154 m (500 ft), and 60 30' N, 149 40' W. General descriptions of each plot are presented here, however further information has been collected and is being analyzed by Joan Foote of the Institute of Northern Forestry. Tables 1 and 2 summarize tree and sapling densities in each of the study plots, excepting the 150 - 200 year old stand. Locations of the study plots are shown in Figures 1, 2, and 3.

<u>Study site 1 - 9 year old burn</u>: This site is near the edge of a 1011 ha (2570 acre) area burned in 1969 by the "Russian River Fire." Started by an unattended campfire, this fire burned hot through many areas but swept quickly over ridges burning only the understory vegetation. The study plot was located in a heavily burned area near the base of a west-facing slope. Fire killed all trees in the plot and most remain standing at an estimated density of 467 trees/ha (184/acre). Spruce (*Picea glauca*) snags dominate the area with birch snags second in predominance.

Table 1. Tree composition of bird study plots as determined using technique described by Cottam and Curtis (1956). Information on tree composition of the 100-150 year old stand is not yet available.

	9 year old burn	20 year old burn	40-50 year old burn	100-150 year old burn
Average density live trees*/ha	None	None	410.81	784.6
Spruce <u>Picea glauca</u>	----	----	257.7** 67.1%	536.3 68.4%
Birch <u>Betula papyrifera</u>	----	----	37.8 9.2%	168.8 21.5%
Aspen <u>Populus tremuloides</u>	----	----	----	9.93 1.3%
Cottonwood <u>Populus trichocarpa</u>	----	----	5.3% 1.3%	----
Hemlock <u>Tsuga heterophylla</u>	----	----	91.6 22.3%	69.5 8.8%
Average density dead trees/ha	467.3	194.5	8.9	10.5
Spruce	338.8 72.5%	92.4 47.5%	5.1 57.1S	5.2 50%
Birch	105.1 22.5%	4.9 2.5%	1.27 14.3%	5.2 50%
Aspen	----	----	----	----
Cottonwood	----	----	1.27% 14.3%	----
Hemlock	23.4 5.%	97.3 50.%	1.27 14.3%	---- ----

* A tree is at least 2.5 cm in diameter at breast height (3.1 m)?.

** Spruce trees in the 40-50 year old stand are a hybrid between <u>Picea glauca</u> and <u>Picea sitchensis</u> (Joan Foote pers. comm.)

Table 2. Sapling densities found in bird study plots using techniques of Cottam and Curtis (1956). Information on the 150-200 year old stand is not yet available.

	9 year old burn	20 year old burn	40-50 year stand	100-120 year stand
Density of saplings* per/ha	129.4	798	114.6	6.5
Spruce <u>Picea glauca</u>	----	229.4 (28.8)	49.3 (43)	3.5 (54)
Birch <u>Betula papyrifera</u>	122 94.3)	558.6 (70)	----	----
Aspen <u>Populus tremuloides</u>	714	----	----	----
Cottonwood <u>Populus trichpcarpa</u>	---- ----	10 (1.3)	----	----
Hemlock <u>Tsuga heterophylla</u>	----	----	65.3 (57)	3.0 (54)

* A sapling is at leat 1.3 m tall and less than 2.5 cm diameter at breast height (1.3m).

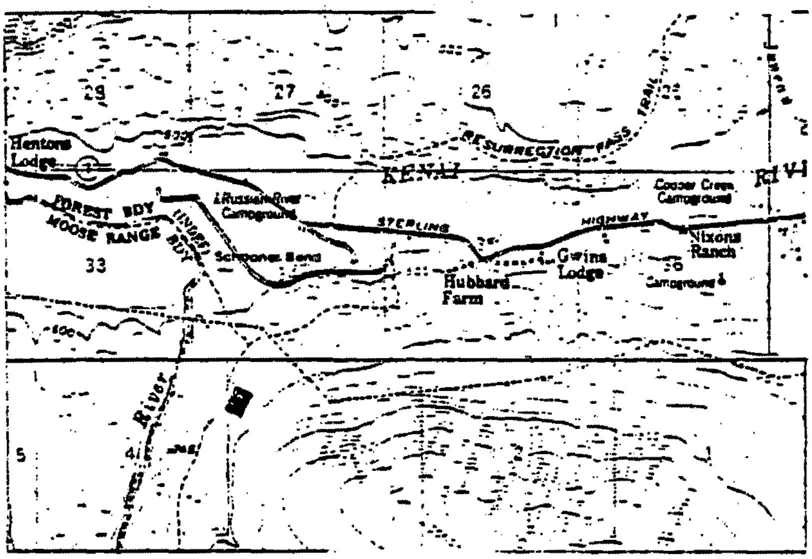

Fig. 1. Location of the 9 year old burn bird study plot, 1 mile down the Russian Lakes Trail, Chugach National Forest, Kenai Pennisula, Alaska.

Shrub vegetation has regrown sparsely. Birch (Betula papyrifera) saplings are the largest regrowth vegetation and occur at a density of 122 saplings/ha (48/acre). Spruce regrowth is barely underway; the few seedlings present are only a few cm tall. Other predominant woody regrowth includes (in order of predominance): Willow (Salix scoulariana), spirea (Spirea beauverdiana), menziesia (Menziesia ferruginea), and rose (Rosa acicularis). Major ground vegetation is moss (Polytrichum spp.) and fireweed (Epilobium angustifolium).

Study site 2 - 20 year burn: In 1958, 1260 ha (3200 acres) of mature spruce-hemlock forest were burned by the Kenai Lake Fire. While pockets of mature forest finger up the hillside from Kenai Lake, most of the eastern slope of Cooper and Stetson mountains were heavily burned by the fire. The study plot again was placed in a well burned potion to avoid the influence of mature forest islands. Previous to the fire, the plot was a white spruce stand with some hemlock and birch intermingled. Most of the deciduous tree trunks have fallen and decayed but standing spruce and hemlock snags occur at a density of 194 trees/ha (76/acre). Fallen timber throughout the area makes foot travel difficult and hazardous. Moose use the burn extensively and have had a strong influence on the character of the vegetation. Vegetation within a moose exclosure erected soon after the burn has reached much greater density and height than occurs throughout the burn, mainly because moose browse down their preferred food plants: aspen (Populus tremuloides), willow, and birch. Alder is the predominating regrowth plant. Willow and Elderberry (Sambucus callicarpa) are second and third in predominance of shrubs. Birch saplings predominate in the largest regrowth vegetation category, but spruce saplings also occur at a density of 229/ha (90/acre); the largest spruce saplings show only 10 growth rings. Major herbaceous growth includes moss (Polytrichum spp.), fireweed, and low bush cranberry (Vaccinium vitus-idaea).

Study site 3 - 40-50 year old forest: This plot is located at 335 m (1100 ft) elevation on a west facing slope. Mixed spruce, birch, aspen, cottonwood, and hemlock occur throughout the stand. Spruce and hemlock dominate the overstory. Fifteen core samples 5 each of spruce, birch, and aspen showed 38 to 52 growth rings, mean 44.5 years, standard deviation of 4.5.

Ten or more years may pass before a young tree is large enough for growth rings to develop so this area probably burned 50 to 60 years ago. Signs of fire including a few standing snags and some burnt and decaying fallen logs occur throughout the plot. Dead trees, important to cavity nesting, and timber drilling and gleaning birds occur at a density of 8.9 trees/ha (3.5/acre). Visibility throughout the plot is poor because of well developed sapling and shrub growth, primarily sruce and hemlock. Menziesia, alder and raspberry are the primary low shrubs. Low herbaceous vegetation is primarily dewberry (Rubus Pedatus) and twinflower (linnea borealis).

This site is the wettest of the study sites; two small streams (about .5 m wide and .25 m deep) traverse the plot. Additionally, a muskeg bog cuts into the northeast corner of the plot.

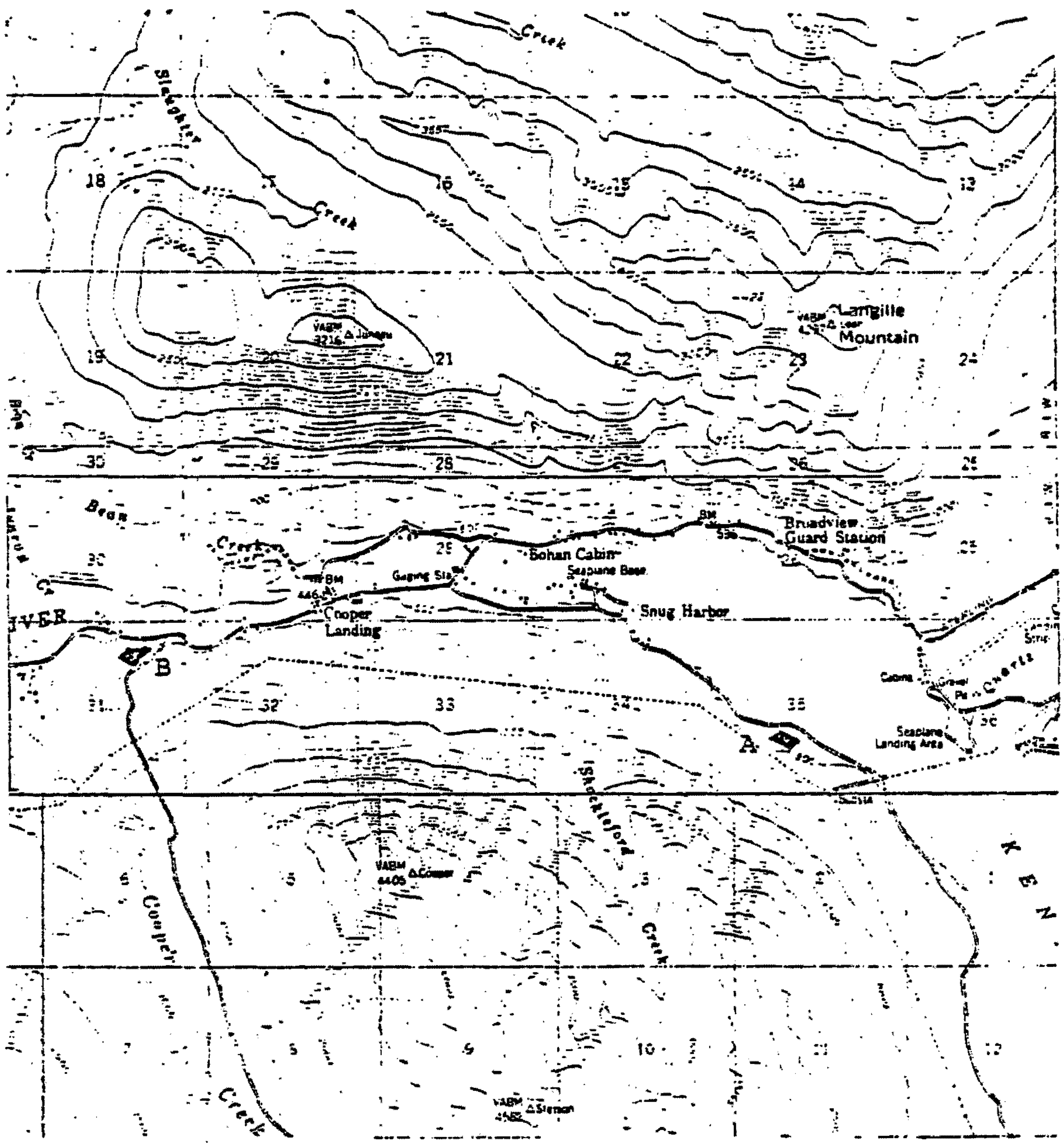

Fig. 2. Location of the 20 year old burn, bird study plot (A), and the 10-120 year old forest study plot (B), in the Chugach National Forest, Kenai Pennisula, Alaska.

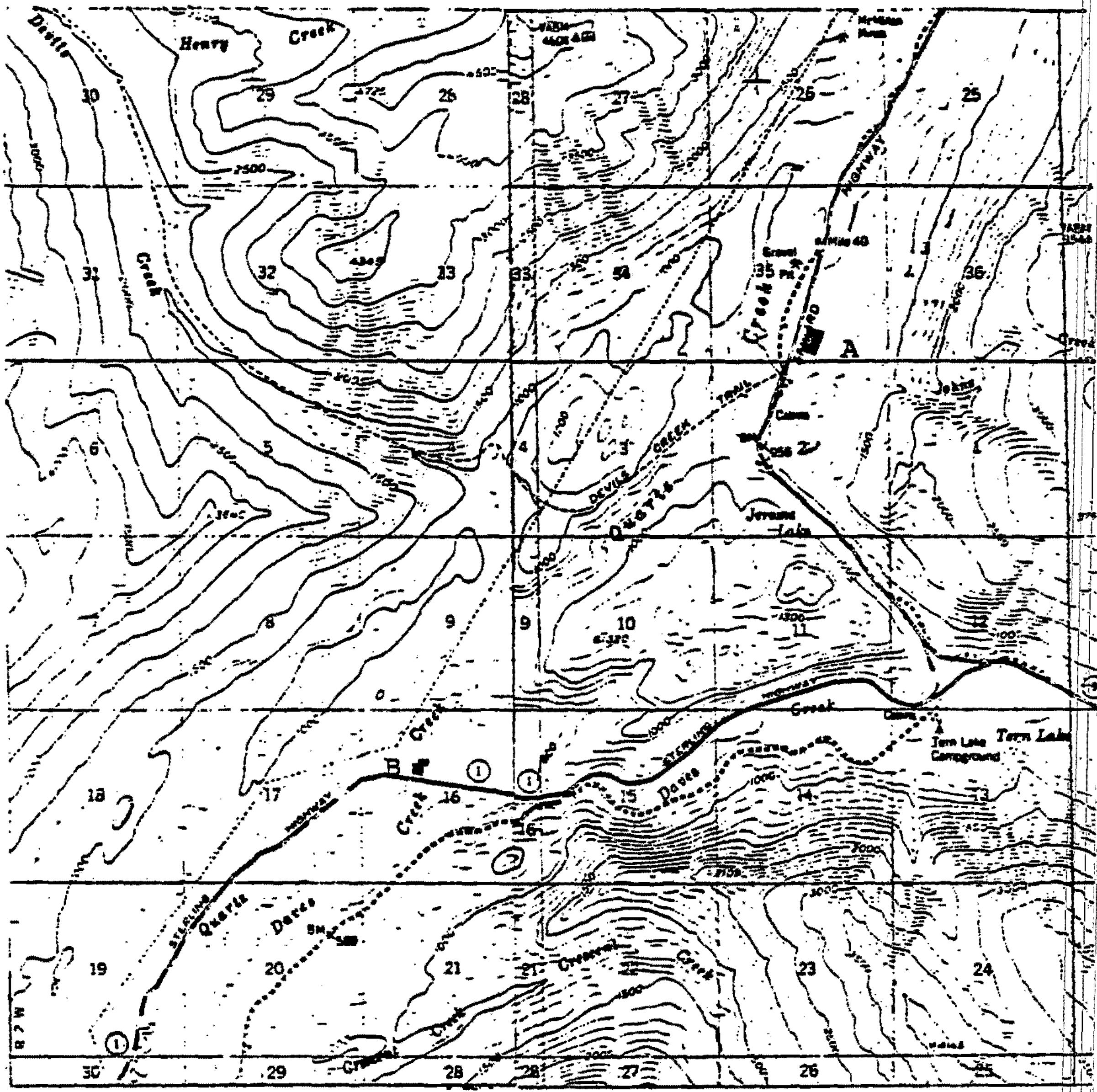

Fig. 3. Location of the 40-50 year old forest bird study plot (A), and the 150-200 year old forest plot in the Chugach National Forest on the Kenai Pennisula, Alaska.

Study site 4 - 100 year old stand: Tree density (785/ha; 308/acre) in this mature white spruce forest is about two-thirds greater than in the 40-50 year stand. However, the stand appears more open as saplings and shrubs occur at very low densities (see Table 2). Spruce and hemlock saplings occur at densities of only 3.5 and 3.0/ha. Shrubs are quite scarce but rose, high bush cranberry (*Viburnum edule*), and menziesia occur in scattered pockets. Dead trees occur at a density of 10.5/ha (4.1/acre). Major ground vegetation is moss (*Hylochomium spp*. and *Pleurozium spp*), low bush cranberry (*Vaccinium vitus-idaea*, and crowberry (*Empetrum nigrum*). The general aspect of the plot is northeast. Ten core samples of spruce trees in the site averaged 114 years, standard deviation of 8.16.

Study site 5 - 150-200 year stand: This site was chosen as one of the oldest forest areas on the Kenai but its history is related more to floodplain geography than fire. Also cottonwood (*populus trichocarpa*) and spruce are of equal importance in the overstory.

While the plot was surveyed to avoid contact with Quartz Creek, there is a riparian influence on the vegetation and bird composition. The stand is quite open as many trees have succumbed to insects and decay. Additionally, the stand appears to have been thinned for cabin logs many years ago. No estimates of tree density are available. Understory consists of alder and scattered regrowth spruce and cottonwood. Raspberry is the major small shrub. Herbaceous growth consists of tall grasses (unidentified species), horsetails (*Equisetum arvense*), and a wide variety of dicots. Spruce trees cored had 120 to 170 growth rings. Several cottonwoods were cored but all had decayed centers so growth rings could not be counted. Others have aged cottonwoods in the stand at up to 300 years old.

METHODS

Bird censuses were conducted according to the Spot-Mapping Method as recommended by the International Bird Census Committee (Svensson 1970). (See Appendix I for advantages and disadvantages of this technique.) A grid system of points was surveyed at each study site using a forester's compass, jake staff, and plastic meter tape. Plastic flagging was used to mark points at 23 m intervals throughout the plots. (While committee recommends 50 m intervals, the density of vegetation and topography required more extensive marking to avoid confusion.) Svensson (1970) recommends 10 ha as a minimum size for a plot. The 9 year old burn plot could not be enlarged beyond 7 ha, nor the 150-200 year old plot beyond 5 ha without encountering substantially different habitat.

Between 15 May and 15 July 1978, each plot was visited a minimum of 8 times during the hours of 0300 to 0930. Censuses were not made on windy mornings, but the wet season and time restraints required census work on rainy days. Only heavy rain seemed to affect bird activity. Additional censuses were made at other times of the day in plots with dense vegetation. On each visit the observer walked the grid system stopping for 2-5 minutes at 46 m intervals to listen and observe birds. Locations of singing males in particular were noted but the location, species, activity, and sex (when possible) of all birds seen or heard were noted on a visit map. Two letter abbreviations were used to denote species and other symbols were used in accordance with Svensson (1970). The observer took special care to note the locations of 2 or more males singing simultaneously and territorial disputes. Nest locations were also noted when possible. Each observation was also listed separately and when possible the vegetation species and height used by the bird was noted.

Following each census the observations were sorted and recopied on to separate species maps. After all census were completed, "clusters of observations" or territories were delineated and counted to obtain the number of territorial males on the census plot. This data was then converted to obtain the number of breeding pairs per 40 ha (100 acres) a commonly used standard in bird census studies.

Information from the censuses in each plot were compiled to obtain total species observed in each plot, the total number of breeding species, number of breeding pairs, mean number of species observed per visit, and mean number of bird observations per visit.

Diversity indexes were calculated using the Shannon-Weaver formula:

$$H = \sum_{i}^{n} \frac{N_i}{N} \times \ln \frac{N_i}{N}$$

where H is species diversity, N_i is the number of individuals of the i^{th} species, and N is the total number of individuals of all species (Shannon and Weaver 1949). This diversity index was chosen as it is the most commonly used diversity index in bird population studies (Balda 1975). Diversity indexes show the relation between the number of species and the number of individuals belonging to each species. Thus, a stand supporting 50 birds, 48 belonging to 1 species and 2 belonging to another species would have a diversity index of .168. Another stand supporting the same number of birds, but with each species represented by 25 individua would have a diversity index of .693. Thus diversity indexes may be used to compare the variety of species occurring in different systems.

Vegetation of each stand (excepting the 150-200 year old) was examined by Joan Foote of the Institute of Northern Forestry. Tree densities were determined using plotless point-center quarter methods as described by Cottam and Curtis (1956). Other vegetational analysis was done using the techniques of Ohmann and Ream (1971), however, data analysis has not been completed at this time.

RESULTS AND DISCUSSION

Bird Communities and Succession

Thirty-nine species of birds were observed in the study plots between 15 May and 15 July. Thirty of these were considered breeding species in at least one of the plots. Table 3 summarizes the breeding bird populations of each plot in numbers of breeding pairs.

Table 3. Species composition and densities of birds in each study site. Densities are expressed as number of breeding pairs per 40 ha (100 acres). "P" indicates the species had a territory partially with the study plot but nested in a different habitat type. "V" indicates the species observed in the plot but was not a breeding species. "N" indicates the species nested in the habitat type but was not found breeding in the study plot.

Bird Species	9 year old burn	20 year old burn	40 year old forest	100 year old forest	150 year old forest
Bald Eagle		V			
Red-Tailed Hawk		V			
Spruce Grouse	4		4		4
Great Horned Owl		V			V
Common Flicker		2			
Downy Woodpecker	V				
Hairy Woodpecker	P	2			
Northern Three-toed Woodpecker	2	2	2	2	2
Alder Flycatcher		4			
Olive-sided Flycatcher	P	2			
Western Wood Pewee	P				
Tree Swallow	6	16	V	V	V
Gray Jay	V	V	4	4	V
Common Raven	V	V	V	V	V
Black-capped Chickadee				4	V
Boreal Chickadee	V		4	6	8
Brown Creeper	6		V	4	8
American Robin	2	4	2	2	4
Varied Thrush		V	18	16	20
Hermit Thrush	V	6	6	2	8
Swainson's Thrush	6	4	14	30	20
Gray-cheeked Thrush	V				
Ruby-crowned Kinglet			16	8	8
Golden-crowned Kinglet			V	N	
Bohemian Waxwing	V	P	V	V	
Orange-crowned Warbler	2	24	8	4	8
Yellow Warbler			V		
Yellow-rumped Warbler	V	V	14	18	16
Townsen's Warbler			40	28	64
Blackpoll Warbler			V		V
Norther Waterthrush					P
Wilson's Warbler	N		8	V	V
Pine Grosbeak	V		2	4	
Common Redpoll					V
Pine Siskin	V	V	4	4	V
White-winged Crossbill			V	8	
Savannah Sparrow	12	8	V		
Dark-eyed Junco	12	24	20	4	8
White-crowned Sparrow	12	12			
Golden-crowned Sparrow		14			

Table 4. Summary of number of breeding species observed in each plot, number os breeding species number of breeding pairs per lo ha number of breeding birds per 40 ha, and indexes of diversity in each study plot.

Bird Species	9 year old burn	20 year old burn	40 year old forest	100 year old forest	150 year old forest
Number of species observed in plot	24	24	25	22	23
Number of breeding species*	10	15	16	17	13
Numbers of breeding pairs/10 ha (25 acres)	16	31.5	41.5	37	44.5
Number of breeding birds/40 ha (100 acres)	128	252	332	296	356
Shannon-Weaver Index of Diversity	2.11	2.27	2.41	2.38	2.13

* Species designated as P or N in Table 3 are no included as breeding species.

Comparison of these numbers with values obtained elsewhere is difficult as many factors influence bird populations including vegetation type, latitude, species composition, and as shown by this study, forest age. However, review of the few studies done on birds in the north indicates that the values obtained for mature forests in this study are similar to estimates of other reasearchers. Spindler (1976) found 21 species breeding at a density of 132 pairs /40 ha in mature white spruce forest near Fairbanks, Alaska. Noble (1977) found 9 species breeding at a density of 187 pairs /40 ha in old growth forest of Southeast Alaska. Buckner et al (1975) estimated that old growth hemlock forest of British Columbia supported 10 species at a density of 84 pairs /40 ha. Wiens (1975) generalizing from census data in the literature estimated a mean of 14.5 $\pm$ 3.9 species and 93.2 $\pm$ 43.1 breeding pairs /40 ha for northern boreal forests. These figures are comparable to estimates obtained in this study of 16, 18, and 12 species breeding at densities of 168, 150, and 180 pairs / 40 ha in the three mature forests examined.

While examination of Table 3 shows that similar numbers of species were observed in each plot, the number of breeding species generally increased with the age of the forest. The 9 year old burn site had the fewest breeding species, 10. The maximum number of breeding species, 17, occurred in the 100-120 year old forest. The oldest stand, 150-200 year old had the second lowest number of breeding species, 13.

Similarily, the number of breeding birds per 40 ha increased with succession Breeding density in the 9 year old burn was 50-60 percent less than densities found in mature forest. Density in the 20 year old burn was only 10-20 percent lower than in mature forest. The 40-50 year old stand supported a slightly higher density of birds than the 100-120 year old stand, but the highest density of breeding birds occurred in the oldest forest.

Diversity, as calculated by the Shannon-Weaver formula, also increased with succession, from 2.1 in the 9 year old burn to 2.4 in the 100-120 year old forest. The oldest forest had a diversity index similar to that found in the 9 year old burn. A definite increase in diversity is observed between the 20 year old burn and the 100 year old forest, however the change is small and probably not statistically significant.

Overall, the number of breeding species, density of breeding birds, and species diversity increase with the age of the stand. Few studies have been done on the relation between fire and bird communities, but as fire merely sets back succession, studies of the relation of plant succession to avian communities are comparable. Several such studies have been done throughtout the U.S. and many researchers obtained results in agreement with the findings of this study: Kendeigh (1948) in cedar forests of northern Michigan, Odum (1950) in hemlock forest of North Carolina, Johnston and Odum (1956) in oak-hickory forests of Arkansas, and Meslow and Wight (1975) in Douglas fir forests of Oregon and Washington, all found higher numbers of breeding, species, densities of breeding birds, and indexes of diversity in mature forest stand than in early successional stages.

Other researchers have compared bird communities of virgin forests to those of cut-over forest. Hagar (1960) studied the effects of logging on birds in Douglas-fir forests of northern California. He found that virgin forests supported more species of birds than cutover areas. Also, virgin forests supported slightly more breeding birds than logged areas in his study. Franzreb (1977) found higher numbers of species, higher breeding densities, and greater species diversity in unlogged than in logged coniferous forests of Arizona. In southeastern Alaska, Noble (1977) found similar numbers of breeding birds, but higher diversity and more species in old growth forest than in a 9 year old forest.

These results can be at least partially explained by the changes in vegetation that occur during succession. MacArthur and MacArthur (1961) found an extremely high correlation between bird species diversity and "foliage height diversity". Foliage height diversity is the "amount of vegetation in area of leaves per unit volume of space, which lies in each of 3 horizontal layers corresponding to herbs, shrubs, and trees over 25 ft. tall" (MacArthur and Mac Arthur 1961). As succession occurs, new layers of vegetation are added until the climax stage, when all three layers are present. Thus, mature forests could be expected to have more bird species than shrubland, and shrubland more than an open field. According to MacAuthur the number of breeding bird species will be greatest when the three vegetation layers have equal amounts of foliage. Several other researchers have also concluded that bird species diversity is closely related to foliage height diversity and/or percent vegetative cover (Cody 1968; Recher 1969; Willson 1975; Balda 1975).

This relationship also explains the results of some other studies that found higher numbers of breeding birds, species, and diversities in intermediate stages of succession. Bock and Lynch (1970) and Webb et al (1977) studied early successional stages that contained habitat "islands of mature trees ". Thus a third vegetation layer was available and mature forest birds, in addition to early successional species were recorded.

Clearly, vegetation complexity plays an important role in determining bird species diversity and partially explains the increase in species numbers, density of breeding birds, and diversity that occurs with succession (Balda 1975). Other factors such as plant species diversity, tree heights, snag densities, and proximity to water also affect bird communities. That these and other factors are important is shown by the studies of Conner and Adkisson (1977) and Buckner et al (1975). These researchers found higher numbers of species, densities, and diversity in early successional plots with mature forest islands, than in mature forest.

In general, however, as this study shows, early successional stages support fewer species, lower densities, and lower diversities of breeding birds than mature forest. This study indicated that on white spruce forest of the Kenai Peninsula, these numerical values may not return to mature forest levels for 20-40 years following wildfire.

Species composition and forest succession

Changes in species composition that occur between early and late succession stages are dramatic. Fig. 4 shows that in the early successional stages (the 9 and 20 year old burns) 67 to 74 percent of the breeding birds and 50 percent of the species are ground-bush foraging birds such as sparrows and thrushes. Another 20 percent of the birds (25 percent of the species) are flycatching, while the remaining are tree-drilling or tree gleaming (woodpeckers and creepers). None are tree foliage searching, for obvious reasons. In mature forest, ground-bush foraging species still constitute 30 percent of the species, but only 40 percent of the breeding birds. Tree-foliage searching species (warblers, kinglets, chickadees) make up 50 percent of the individual birds, and 30 to 50 percent of the species.

In terms of nesting habits, the changes are even greater. As shown in Fig. 5, early successional stages support primarily ground-nesting species. Species nesting in low bushes make up only 16-17 percent of the individual birds. Cavity nesters are the second largest group making up 19-27 percent of the species and 15 to 30 percent of the breeding birds in the burned areas. In mature forests, tree-nesting species dominate, constituting 30-50 percent of the species and 57 to 64 percent of the breeding birds. Ground nesters make up only 13 to 23 percent of the species and only 6-13 percent of the individuals. Cavity nesters form 13 to 25 percent of the species.

Clearly, major changes in bird communities are associated with plant succession in white spruce forests of the Kenai. Since every bird species requires different habitat features, each species reacts differently to habitat change. On the basis of the information collected in this study some generalization can be made about the effects of wildfire on the populations of each breeding bird species in the area. Table 5 categorizes the species to benefit or be adversely affected by fire.

Eleven species of bird benefit from the early successional stage habitat created by wildfire. Six of these are species which nested only in the burned study plots: Common Flicker, Alder Flycatcher, Tree Swallow, Savannah Sparrow, White-crowned Sparrow, and Golden-crowned Sparrow. Four species are edge species, birds that require an opening in the forest for feeding, but nest in mature forest. Hairy Woodpeckers, Olive-sided Flycatchers, Western Wood Pewees, and Bohemian Waxwings established territories partially within the burns and used them for feeding areas. No nests of these species was found. Hairy Woodpeckers, Olive-sided Flycatchers, Western Wood Pewee, and Bohemian Waxwings (Gabrielson and Lincoln 1959) normally nest in live trees. Since no live trees occur within the burned study plots, these species probably nested in nearby mature forest. Other studies indicate Hairy Woodpeckers may only utilize burned areas as long as some trees retain their bark (Kilham 1965; Conner et al 1975). Hairy Woodpeckers were observed regularly only in the 9 year old burn. Few trees in the 20 year old burn retained any bark. Thus, this species may benefit from fire only for a period less than 20 years.

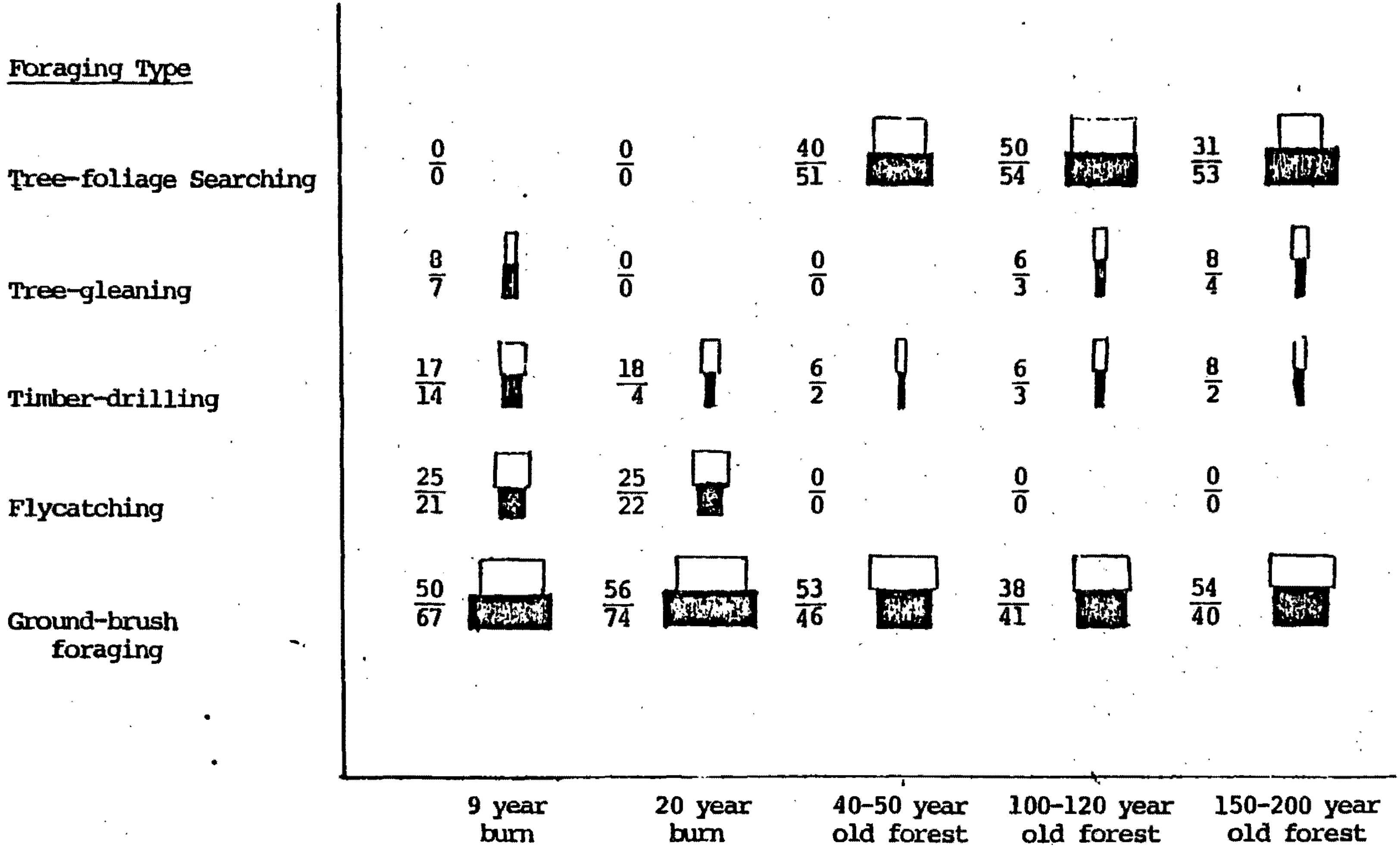

Fig. 4. Percentage distribution of breeding birds according to foraging type in 5 successional stands of white spruce. Solid areas show percentage of breeding birds in each foraging type; open areas show percentage of breeding species in each foraging type. Numbers are actual percentages.

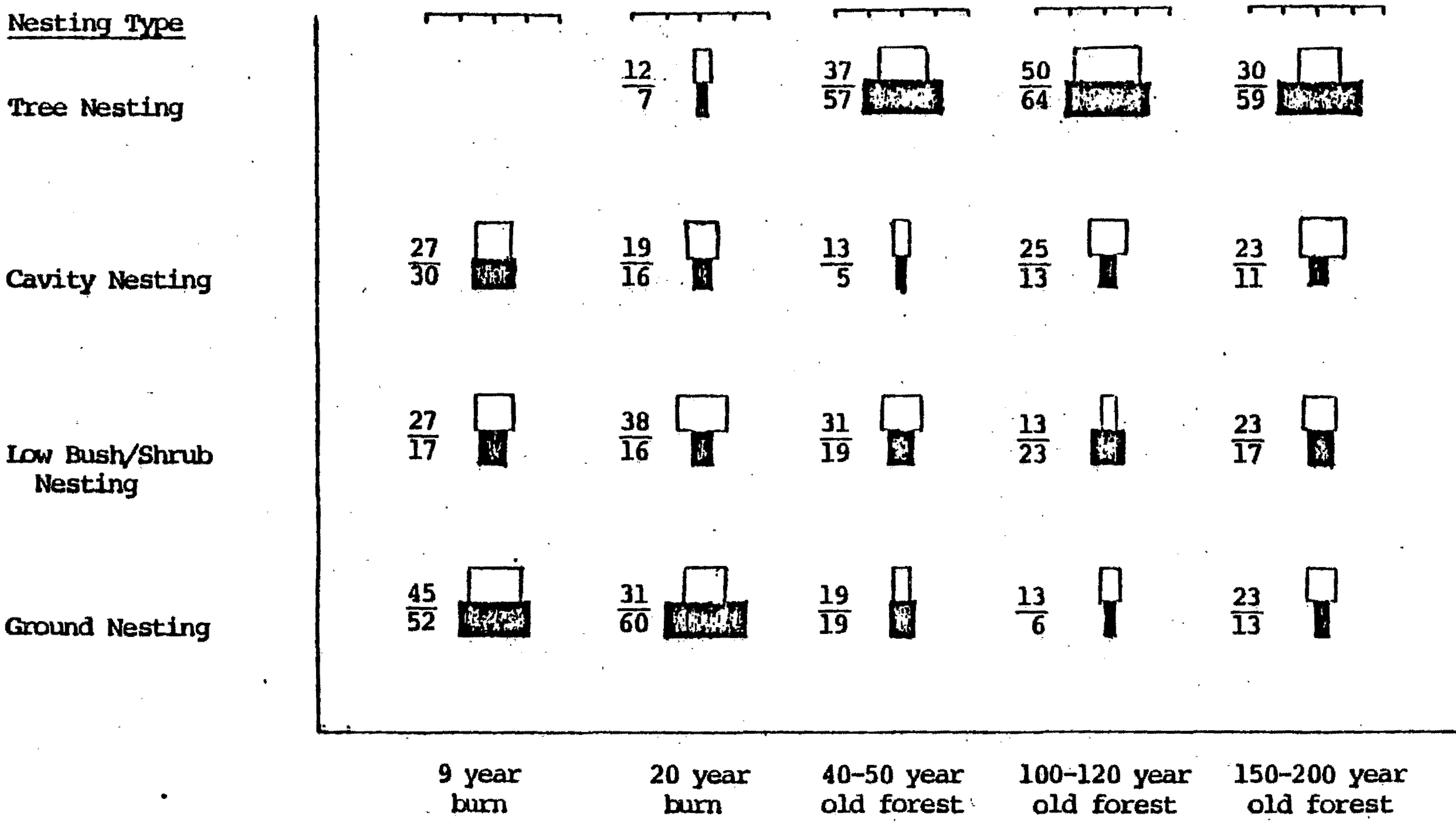

Fig. 5. Species composition of 5 successional white spruce stands as described by nesting habits. Solid areas show percentage of breeding birds in each nesting category; open areas show percentage of breeding species in each nesting category. Numbers are actual percentages.

Finally, 2 species, Orange-crowned Warbler and Dark-eyed Junco, bred in all age stands, but nested at the highest densities in the burned study plots (Table 3).

Fourteen species of birds prefer mature conifer forest and were adversely affected by wild fire through loss of habitat. Eleven of these are species which nested only in mature forest: Gray Jay, Black-capped Chickadee, Boreal Chickadee, Varied Thrush, Ruby-crowned Kinglet, Golden-crowned Kinglet, Yellow-rumped Warbler, Townsend's Warbler, Wilson Warbler, Pine Siskin, and White-winged Crossbill. Swainson's Thrush nested in burned areas, but occurred at a much greater density in mature forest.

Brown Creepers, dependent on dying trees for the insect food they harbor and on trees with loose dead bark for nest sites are also primarily dependent on mature forest. One pair attempted to nest in the 9 year old burn, however, burns are not entirely detrimental to this species. This pair built a nest between the trunk and its burnt bark. In the 20 year old burn, very few trees had bark still attached to the trunk and none of the trees within the study plot has sufficient bark attached for Brown Creepers to nest. Thus, while burns may not exclude Brown Creepers from nesting for the first 10 years, the area will not be available to the species after the burnt bark falls away—apparently this is a period shorter than 20 years. In contrast, a mature forest would continue to provide new nest sites for 50 to 100 years.

Spruce grouse nested in 2 of the mature forest plots and in the 9 year old burn. In each case only one nest was found so the effects of burning are unclear. Ellison (1975) found a 60 percent decrease in spruce grouse densities following fire in white spruce forest on the Kenai Peninsula. Other references indicate spruce grouse prefer mature forest (Bent 1932: Gabrielson and Lincoln 1959) so this species was considered to be adversely affected by fire.

Four bird species nested at similar densities in both burned and unburned areas: Northern Three-Toed Woodpecker, American Robin, Pine Brosbeak, and Hermit Thrush. Until further information is available, these species are assumed to neither gain nor lose habitat through wildfire.

This study was not refined enough to determine what age of forest each mature forest bird species prefers or requires. Several habitat variables other than forest age such as aspect, tree, shrub, or herb density and composition, or proximity to water probably affect species occurrence and densities within the mature forest. Additionally, differences in clutch size, nesting success, territory size, or other variables might indicate more clearly the value of a given age stand to a particular species. But, based on the densities of each species in the various aged stands, Black-capped Chickadees, Boreal Chickadees, Brown Creepers, Swainson's Thrushes, Golden-crowned Kinglets, and White-winged Crossbills appear to prefer white spruce forest 100 years or older.

Hawks and owls were not found breeding in any of the plots, partly because field work was begun in mid-May when most raptors would be near completion of nesting. Four raptors known to occur in the Kenai area are forest species: Sharp-shinned Hawk, Goshawk, Saw-whet Owl, and Boreal Owl. Larger species such as Great Horned Owls, Great Gray Owls, and Red-tailed Hawks utilize forest openings for feeding. Burning may be detrimental to the former species and beneficial to the latter, but concrete information on these species is needed. Since raptorial bird species maintain large territories and require large areas for hunting, these species would be among those most likely to be affected by the moose-fire program.

Wildfire Versus Controlled Burns

The results of this study are not directly applicable to the successional changes which will follow a controlled burn. Successional patterns following a forest fire are generally similar but the length of time required to reach any given stage of succession will vary between sites. Pre-fire vegetative composition, aspect, soil types, drainage patterns, and the intensity of the fire all influence the vegetative succession that will follow a fire. Bird species and densities are largely determined by vegetative structure and diversity (MacArthur 1964). Thus, while the succession of bird communities observed in this study may be approximated following any fire, large differences in species composition and density may occur.

Preparation of control burn sites to insure the desired fire intensity will also affect bird community succession. In order to burn an area on the Kenai to mineral soil in a controlled burn, a fuel source near the ground is needed. This problem has been met by felling all or most of the coniferous trees on a burn site. The effects of this site preparation on bird succession following a fire may be substantial. Indeed, the actual changes in bird composition may more closely resemble those found following a clearcut than those found following a fire.

Cavity nesters made up 20-30 percent of the species and 15-30 percent of the birds in burn areas. All of these species are dependent on standing snags for nest sites, and with the exception of tree swallows, for foraging areas. Tree swallow utilize old woodpecker holes for nest sites, so their occurrence is dependent on woodpecker occurrence. Wood peckers will excavate nest holes in deciduous tree snags, but all active and inactive nest cavities found in burn sites during this study were in dead spruce trees. Hogstad (1978) noted that 98 percent of his 305 observations of Northern Three-toed Woodpeckers were standing dead spruce trees. If coniferous snags are preferred by some species, as this information suggests, felling of all coniferous trees may decrease woodpecker use of burns. Ahlen (1975) noted that Northern Three-toed Woodpeckers could use clearcut areas only if some dead standing trees are left or the surrounding forest contains dead trees. Conner et al (1975) found that Downy and Hairy Woodpeckers do not readily use clear-cut areas for nesting. Thus, massive reduction in standing dead trees could affect the occurrence and density of cavity nesting species that utilize burn sites.

The removal of standing conifers may also affect the occurrence and density of other bird species using burns. Many birds require songposts; perches elevated above most of the surrounding vegetation or at least providing a view of much of the territory and an opportunity for song to carry some distance (Verner 1975). Songposts have been suggested as critical in habitat selection for a wide variety of species (Kendeigh 1945). In the burn sites studied on the Kenai, Olivesided Flycatchers, Western Wood Peewees, American Robins, Hermit Thrushes, Swainson's Thrushes, Orange-crowned Warblers, Pine Grosbeaks, Savannah Sparrows, Dark-eye Juncos, White-crowned Sparrows, and Golden-crowned Sparrows extensively used standing snags of songposts. Standing snags may also be important to woodpeckers as drumming posts (Bendell 1974). Perhaps of note, all drumming woodpeckers observed in this study were using dead standing spruce. Standing snags are also used as resting posts and hawking or hunting post by flycatchers and raptors. Clearly, felling of all coniferous trees before burning may seriously alter the value of a burned area to birds.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Controlled burning will affect bird population on the Kenai. Although the effects of fire on the habitat of a particular species can be predicted, as a whole, fire can not be said to have a good or bad effect upon the bird populations of the Kenai. The openings in forest stands and variety in age class and forest type created by fire provide habitat for a wider variety of birds than could exist in extensive stands of even-aged or mature forest (Weins 1975). Thus in some cases bird species diversity is increased over a large area by burning and fire is considered beneficial (Kelsall et al 1977). However, some bird species depend on mature forest. Reduction of their habitat will result in reductions in their populations. Further, while fragmentation of a forest may result in higher species diversity forest-wide, maximum diversity may be obtained at the expense of uncommon or rare species that depend on large expanses of mature forest (Balda 1975; Wiens 1975).

In planning the moose-fire program attention should be given to balancing the beneficial and detrimental effects of controlled burning on bird populations. Table 5 lists the alternative habitats used by each species beneficially or adversely affected by fire. These alternative habitat assignments are tenative as little information has been gathered on bird use of various habitats on the Kenai. However, assignments were carefully made on the basis of the investigator's observations in the area, and on information given in Gabrielson and Lincoln (1959), Williamson and Peyton (1962), Isleib and Kessel (1973), Spindler (1975) and Noble (1977).

As shown, most of the species benefiting from fire have several alternative habitats--primarily areas returned to early successional stages through various forms of disturbance including floods, avalanches, powerline and road right-of-ways, windfalls, and logging. Black spruce forests and subalpine areas are also major alternative habitats for those species benefited by fire. Those species benefiting the most from fire are

Table 5. Summary of the species benefitting from and adversely affected by habitat changes caused by wildfire. Alternative habitat listings indicate other habitats in which the species are known or thought to breed. Assignments were made on the basis of the investigators observations in the Kenai Lake area and information given in Gabrielson and Lincoln (1958), Williamson and Peyton(1962), Isleib and Kessel (1963), Spindler (1975) and Noble (1977). Alternative habitats are as follows: 1) Any early successional stage caused by avalanches, powerlines, logging, wildfire, earthquakes, other; 2) marsh or lake margins; 3) floodplains; 4) stream margins; 5) subalpine meadows and alder patches; 6) seral birch or aspen stands; 7) mature Black Spruce forest; 8) mature Sitka Spruce forest; 9) mature forest in parklike stand.

Species benefitting from wildfire		Alternative Habitats	Species adversely affected by Wildfire		Alternative Habitats
Breed only in burned areas	Common Flicker	3,9	Breed only in mature forest	Gray Jay	6,7,8,9
	Alder Flycatcher	1,2,4,5,6,		Black-capped Chickadee	6,8,9
	Tree Swallow	3,4		Boreal Chickadee	6,7,8,9
	Savannah Sparrow	1,2,3,5		Varied Thrush	6,8,9
	White-crowned Sparrow	1,5,7,9		Ruby-crowned Kinglet	6,7,8,9
	Golden-crowned Sparrow	1,5,7,9,		Golden-crowned Kinglet	8
				Yellow-rumped Warbler	6,7,8,9
Breed at highest densities in burned areas	Orange-crowned Warbler	1,2,4,6,9		Townsend's Warbler	7,8,9
	Dark-eyed Junco	1,2,3,6,7		Pine Siskin	7,8,9
				White-winged Crossbill	8
			Breed at highest densities in mature forest	Spruce Grouse	6,8
Edge species	Hairy Woodpecker	3,9		Brown Creeper	8
	Olive-sided Flycatcher	2,4,6,7,9		Swainson's Thrush	6,8,9
	Western Wood Peewee	2,4,6,9			
	Bohemian Waxwing	7,8,9			

those which have few alternative habitats: Common Flicker, Hairy Woodpecker, Western Wood Peewee, and Tree Swallow. While wildfires create or improve habitat for 11 species of birds, only 4 are heavily dependent on burned areas.

On the other hand, those species typical of mature spruce forests and adversely affected by fire, generally have few alternative habitats. The major alternative habitats for most are other forms of mature forest (i.e. Sitka Spruce, Black Spruce, or open, park-like stands of mature forest). Seral birch and aspen stands are also valuable to some species. Eight mature forest species seem to be entirely dependent on some form of mature forest. Six of these (Black-capped Chicadee Boreal Chickadee, Golden-crowned Kinglet, White-winged Crossbills, Brown Creepers and Swainson's Thrushes) occurred at higher densities in the 100 and 150 year old stands than in the 40-50 year old stand. White-spruce forest covers more area on the Chugach National Forest (Kenai Peninsula) than black spruce and Sitka spruce combined (Table 6). Thus 8 species are primarily dependent on mature white spruce forest, and 6 of these are probably dependent on old growth stands.

With this information in mind, two primary goals of bird management in relation to the moose-burn should be:

1) Maintain adequate habitat for those bird species dependent on mature forest.

2) Maximize the value of the control-burn areas to early successional bird species, particularily those with few alternative habitats.

Minimizing the Effects on Mature Forest Species

Of these goals the former is the most difficult with which to deal. How large an area is required to support year-round a single breeding pair of any of the species is unknown. Further, no information on the minimum number of breeding pairs required to maintain a species or a population is available (Verner 1975). Finally, we have little information on the extent of mature forest habitats on the Kenai now.

Information collected in this study shows the number of breeding pairs of each mature forest species which 40 ha of 40-50, 100-120, and 150-200 year old forest might support. With only a single years data, and only 10 ha site in each age stand examined, the estimates are decidedly rough. Four species occur at densities of 4 breeding birds per 40 ha. To insure that adequate habitat was preserved to support 1000 breeding pairs of these species, at least 10,000 ha (25,000 acres) would be required. Likewise, for those species found at densities of 6 pairs per ha, 6600 ha (16,700 acres) would be needed. In considering these figures one should remember that the estimates of density are based on only one years data and even if applicable refer only to the breeding season. Schoener (1968) found evidence that territory size varies seasonally (Welty 1962). Eight of the 14 species found to depend on mature forest are year-round residents. In most cases, their winter territories are probably larger than their breeding territories.

Table 6. Estimated extent of various habitat types and land forms on National Forest Land on the Kenai Pennisula. The estimates are based on the percentage of 8487 photo points in each habitat as determined by Timber Inventory Crews in Seward. The areas indicated for each forest species represent all age classes, mature forest probably comprizes 50 to 80 percent of the area.

	Acres	Ha	% of forested land	% of total area
Total area of National Forest land on the Kenai Pennisula	1,216,814	482,637	—	100%
Forested Area	212,620	86,080	100%	17%
White Spruce	61,360	24,840	29%	5%
Hemlock-Spruce	53,330	21,590	25%	4%
Sitka Spruce	13,050	5,280	6%	1%
Black Spruce	5,600	2,270	.6%	.4%
Black Cottonwood	13,620	5,510	6%	1%
Birch	13,050	5,280	6%	1%
Aspen	12,760	5,160	6%	1%
Mountain Hemlock	37,850	15,320	18%	3%
Western Hemlock	2,000	810	.9%	.2%
Brushland	182,520	73,890	—	15%
Pure Alder	60,840	24,630	—	5%
Pure Willow	7,300	2,950	—	.6%
Recurrent Snowslide	36,500	14,780	—	3%
Alpine	266,699	107,790	—	22%
Snowfield	6,080	2,460	—	.5%
Glacier	161,840	65,520	—	13%
Rocks	267,699	108,380	—	22%
Riverfill	3,650	1,470	—	.3%
Roads	240	100	—	.02%

Raptorial species would also require much larger areas per breeding pair (Schoener 1969). Virtually nothing is known of the densities of any raptor species on the Kenai. Habitat alteration without fore-knowledge of the habitat needs of raptorial species can have serious consequences as evidenced by the plight of the Spotted Owl in Washington and Oregon. This endangered species requires 118-236 ha (300-600 acres) of old dense forest (Zarn 1974). Clearly, large areas of mature forest habitat are needed to maintain populations of some birds.

Not suprisingly, those species that occur at low density are the ones biologists know least about. As these species would be the most likely to be affected by the moose-burn project, further research, both through literature review and field studies, on year-round territory size and habitat requirements is needed. Birds of particular concern include: Red-breasted nuthatch, Sharp-shinned Hawk, Coshawk, Boreal Owl, Saw-whet Owl, Gray Jay, Golden-crowned Kinglet, White-winged Crossbill, and Brown Creeper.

Another stumbling block to insuring that adequate habitat is maintained for mature forest birds is lack of information on the extent and locations of mature forest habitat now available. Table 6 presents very rough estimates of the extent of various habitat types on the Kenai Peninsula within the Chugach National Forest. The information was calculated on the basis of 8,486 photo points analyzed by Timber Inventory crews in Seward. The percentage of photo points in a particular habitat type was converted to area based on an estimate of 492,637 ha (1,216,814 acres) for total Chugach National Forest Land on the Kenai Peninsula. In examining Table 6, one must keep in mind that not all acreage in a particular forest type is mature. Figures on the age of forest for all photo points was not readily available so no distinction was possible between seed-sapling and old-growth stages. An aged sample of commercial forest photo points (those areas having or likely to have marketable timber) indicates that 20 to 50 percent of each forest type may be inan early successional stage. These figures point out that while 22,000 acres of forested land represents only 9 percent of the forested acreage, unless controlled burning sites are carefully chosen some mature forest habitat types could be drastically reduced. Black spruce habitat is particularily scarce comprising only .6 percent of the forested area. Black cottonwood makes up only 6 percent of the habitat. Some stands of this species such as the 100-150 year old site examined in this study are quite old. As these forests would be paricularly slow to regow after a fire, they should be selected for burning only after careful consideration.

Certainly large tracts of mature forest (of all apecies) should be identified an set aside (to the exclusion of any habitat alteration) as mature forest preserves. Since different species may depend on different aged stands, large tracts of variously aged forests should be chosen. Zeedyk and Evans (1975) recommend that some mature stands of at least 31 ha (80 acres) be maintained. Verner (1975) however, recommends that areas of suitable habitat set aside for any species should be as large as possible as "an arithmetic reduction in utilizable space results in geometric decline in its value as a preserve." The latter recommendation seems especially appropriate considering how little is known of some species requirements.

An additional action that would minimize the impact of controlled burning on mature forest species is maintenance of habitat corridors between tracts of mature forest. MacClintock et al (1977) clearly showed that the value to birds of small acreages of mature forest increases dramatically when habitat corridors from larger woodlands are available. Such corridors allow colonization of small tracts by species which would otherwise be limited to more extensive forests. "Buffer strips" of mature forest planned to protect streams and to isolate burn sites from public view will, in many cases, serve as habitat corridors. However, special attention should be given to insuring such corridors are available to birds.

Maximizing the Value of Controlled Burn Sites to Birds

The second goal of non-game bird management in relation to the moose-fire program should be to maximize the value of burned areas to birds--particularilly those species heavily dependent on burned habitat. As previously discussed, the value of controlled burn sites to birds, if all coniferous trees are slashed, will probably be substantially less than that of an area burned by wildfire. Nearly one-third of the species using burned areas in this study require dead trees for nesting and one-fifth require dead trees for the insect food they harbor. Further nearly all species occurring in the burned areas used standing snags for songposts, hawking, hunting, or resting sites. While leaving the deciduous trees standing will be greatly beneficial, selected coniferous trees also should be left standing to increase the value of controlled burn sites to birds. In prescribed burn sites that are dominated by coniferous trees, this would be particularily valuable.

Snags that are already in use by cavity nesting species or contain nest cavities should be left standing. Bent (1939), and Conner and Crawford (1974) indicate that some woodpeckers will re-use old nest trees when the surrounding trees are removed. Secondary cavity nesters, such as Tree Swallow would benefit also, as they depend on previously excavated holes for nesting.

Trees infected by heart rot should also be selected. Heart rots are fungal infections which soften the inner wood of a tree. Development of heart rot is necessary before woodpeckers are able to excavate cavities (McClellan and Frissell 1975; Conner et al 1976). Since heart rot fungi enter trees via broken off tops of broken dead branches (Conner et al 1976), trees with broken tops or large broken off branches might be chosen to be left standing.

Some percentage of all coniferous trees on a site should also be left. Conner et al (1975) found that hairy and downy woodpeckers could nest in trees, respectively, 30-46 and 20-30 cm in diameter at breast height. Thus preference might be given to trees larger than 20 cm dbh. Smaller snags would not be of value as nest trees, though they might be valuable as foraging or drumming posts for woodpeckers. They would also meet the requirements for songposts and hawking posts.

Nest boxes placed in the burned areas would benefit secondary cavity nesters such as Tree Swallows. However, nest boxes are not suitable replacements for standing snags, as snags are important to many species for several purposes as previously discussed.

SUMMARY

The relation between white spruce forest succession and bird communities was studied by examining 5 areas burned at various times in the past. These included a 9 and 20 year old burn, and 3 mature forests aged at 40-50, 100-120, and 150-200 years. The area burned 9 years ago supported only half the number of breeding species, and 60 percent fewer breeding birds than found in mature forests. The area burned 20 years ago supported a similar number of species and only 20 percent fewer breeding birds than mature forests. A slight drop in the number of breeding species and species diversity was noted in the oldest stand studied.

Changes in species composition were more dramatic and of greater importance in terms of management. The burned study area supported primarily ground-foraging and ground nesting species. One-third of the species in burned areas were cavity nesting and one-fifth timber-drilling; these two portions of the bird community are dependent on standing snags. In mature forest, tree-foliage searching, and tree-nesting species dominate the avian community.

Eleven bird species benefit from the habitat changes caused by fire. Fourteen species prefer mature forest and temporarily lose habitat through fire. Burned over areas may not be suitable for mature forest birds for a period greater than 20 and less than 50 years following fire. Species dependent on the oldest aged forests may be unable to re-invade burned areas for 100 or more years following fire.

The majority of species nesting in burned areas on the Kenai breed in several other habitats. Other early successional stage areas created by avalanches, powerline and road right-of-ways, insect outbreaks, windfalls, or floods; subalpine meadows and alder patches, and black spruce forests are the primary alternate habitats. Mature forest species, in contrast, have few alternative habitats.

If all coniferous trees are slashed on control burn sites, the effects of prescribed burning on bird communities may differ significantly from the effects of wildfire. Standing snags are important as nest sites for cavity nesters, foraging areas for woodpeckers, hawking stations for flycatchers, hunting posts for raptors, and as songposts to most other birds.

In relation to the moose-fire program, management for non-game birds in the Chugach National Forest should be centered around two goals:

1) Insuring that adequate mature forest habitat is maintained for those species adversely affected by fire.

2) Maximizing the value of prescribed burn areas to birds, particularily those species which have few alternative habitats.

In regards to the first goal, better information on species habitat requirements are needed. Accurate determination of the amount of habitat necessary to maintain forest bird populations are not available. Rough calculations based only on breeding season information indicate that at least 25,000 acres (not necessarily continuous) would be needed to support 1000 breeding pairs of some species. Since winter territories are probably larger, and forest raptor species would require larger areas this estimate is certainly too small. Since even the extent of mature forest habitat now available on the Chugach National Forest is not accurately known, the effects on bird populations of burning 22,000 acres can not be accurately predicted. Thus, to meet the first objective, large tracts of mature forest stands should be set aside to serve as preserves for mature forest species.

Special attention should be given to obtaining more information, both from the literature and through field work, on the breeding biology and habitat requirements of those forest birds that occur at low densities on the Kenai.

Attention should also be given to providing habitat corridors to maximize bird use of mature forest islands and fragments created by the moose-burn program.

In regards to the second goal, selected conifers should be left standing if they already contain nest cavities, or if they have broken tops or large branches broken off. Additionally, some percentage of spruce trees should be left standing to encourage woodpecker foraging in burn area, and for use as songposts, hawking, hunting, and resting posts for other species.

CONCLUSION

The Chugach National Forest's habitat management program to create winter range for moose is compatible with non-game bird management. Areas burned for moose will provide habitat for a wide variety of birds that are unable to use mature forests, and they will provide a diversity in forest age and type in the future. However, some species will be adversely affected by the burning program, so attention must be given to maintaining habitat for these species. Attention to maximizing the value of prescribed burn sites to birds will insure that the burns are useful to some species of woodpeckers that now occur only in low numbers on the Kenai.

NEEDS FOR FURTHER STUDY

1) One year of study of any bird population can not be considered adequate. Bird populations may vary up to 40 percent from year to year (Balda 1975). Further, using the spot-mapping techniques and available personne, only one site in each successional stand could be studied. Thus, no estimate of within year variance could be obtained. Also, as many factors including the aspect, wetness, exposure, and vegetative profile, may affect bird species composition and density, a single plot may not accurately represent a particular successional stage. At least one more year of study in each of the successional plots now established should be conducted. Also, alternative plots representing each successional stage should be selected and censused.

2) Other aged stands should be included in future studies. of particular importance would be a stand of trees showing 20-30 growth rings—mixed spruce and hardwoods. This would result in a clearer picture of the continum of bird communities as succession progresses. Without study of such stands, the length of time required for forest species to return to burned areas can not be estimated within 10 years error. From this years information all that can be said is that a period longer than 20 and less than 50 years is required.

3) As mentioned in the section on controlled burns versus wildfire, controlled burns are substantially different from wildfires when all coniferous trees are slashed. Breeding bird census plots should be established and run in the areas burned in 1978 and years following to determine what differences, if any, exist between the effects of controlled burns and the effects of wildfire.

4) Information on the extent of available habitat seems of paramount importance in determining how the controlled burning for moose will affect songbird populations. The rough estimates provided in Table 6 are useful only because they are the only thing available. Mapping and habitat typing of all Forest Service Lands on the Kenai would be invaluable in placing burns so as to maintain sufficient mature forest habitat and in maintaining corridors between mature forest habitats.

5) Surveys of other habitat types on the Kenai including Sitka Spruce, Mountain Hemlock, and Black Spruce would be valuable in ascertaining the amount of habitat actually available to any particular species. Currently there is hardly any information on bird populations of these habitats on the Kenai.

6) No information on the densities of raptorial species was obtained in this study. As low density species are the most likely to be affected by the burning program, future bird studies should be planned so as to encompass the breeding season of these species.

APPENDIX I.

The spot-mapping method was chosen after careful consideration of several methods for bird censusing for the following reasons:

1) Spot-mapping techniques provide the best estimate of the actual density of breeding birds (Snow 1965; Svensson 1974; Dickson 1978).

2) Variability between observers has less effect on the reliability of this method than on other methods such as the strip transect method (Emlen 1971; Franzreb 1976). Snow (1965) states "the least experienced observers produced results which compared very favorably with those of the most experienced."

3) The spot-mapping method requires few statistical assumptions, whereas the coefficient of detectability used in the strip-transect method incorporates many assumptions which are difficult to meet under varying conditions of weather, time species, and observers (Franzreb 1971).

4) Spot-mapping is considered much more accurate in dense forest and with secretive species than other methods (Franzreb 1971).

4) Finally, spot-mapping is used widely and is considered a reliable method. Though very little work has been done on passerines in Alaska, Spindler (1976), Noble (1977) and MacDonald (pers. comm.) Have used or are using this technique in their studies of Alaskan birds. Thus, this study will be more useful and comparable if the same technique is used.

The disadvantages of the spot-mapping method are:

1) The time required is much more than that of other methods. Eight to 10 visits are required to obtain worthwhile results (Svensson 1970). Such time restraints often do not allow study of enough plots for statistical analysis.

2) Territorial but non-breeding males are counted as a breeding pair. (The same is true of other techniques however.)

3) Difficulties may arise in mapping territories of high density species.

4) This method is not usable except in the breeding season.

5) Spot-mapping does not take re-nests, or changes in territory size over season into account (Hall 1964).

6) Non-territorial birds (redpolls and Bohemian Waxwings, for example) can not be evaluated in the same manner as territorial species.

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ABSTRACT

This study was undertaken to determine the effects of fire on the bird communities of the Chugach National Forest on the Kenai Peninsula, Alaska. Bird communities were studied in five successional stages of white spruce (picea glauca) forest including a 9 and 20 year old burn, and a 40-50, a 100, and a 150 year old forest. Birds were censused between 15 May and 15 July 1978, using spot-mapping techniques. Number of breeding bird species, density of breeding birds, and bird species diversity increased with the age of the successional stage. A slight drop in the number of breeding species and diversity was observed in the oldest forest. The burned study plots harbored mainly ground-foraging and ground-nesting species. One third of the species were cavity nesting species. In mature forest, tree-foliage searching and tree-nesting species dominate the avian community.

Because of site preparations including slashing of all coniferous trees, prescribed burn sites may be less valuable to birds than areas burned by wildfire.

Two major goals for management of non-game birds in relation to the moose burn program should be: 1) insure that adequate mature forest habitat is maintained for those species adversely affected by fire; 2) maximize the value of prescribed burn areas to birds, particularily those species which have few alternative habitats.

LITERATURE CITED

Ahlen, I. 1975. Forestry and the bird fauna of Sweden. Ornis Fennica 52: 39-44.

Balda, R.P. 1975. Vegetation structure and breeding bird diversity. Pages 57-80 in Proc. Symp. on Manage. of Forest and Range Habitats for Non-game Birds. U.S.D.A. Forest Service; Gen. Tech. Report WO-1.

Bendell, J.F. 1974. Effects of fire on birds and mammals. Pages 73-138 in Fire and Ecosystems. (T.T. Koslowski and C.E. Ahlgren, eds.) Academic Press. New York: 542 p.

Bent, A.C. 1932. Life histories of North American gallinaceous birds. Bull. U.S. Nat. Muns. No. 162. 490 p.

_____. 1939. Life histories of North American woodpeckers. Bull. U.S. Nat. Mus. No. 174. 334 p.

Best, L.B. 1975. Interpretational errors in the mapping method as a census technique. Auk 92: 452-460.

Bock, C.E. and J.F. Lynch. 1970. Breeding bird populations of burned and unburned conifer forest in the Sierra Nevada. Condor 72: 182-189.

Buckner, C.H., A.J. Erskine, R. Lidstone, B.B. McLeod, and M. Ward. 1975. The breeding bird community of coast forest stands on northern Vancouver Island. Murrelet 56(3): 6-11.

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

Conner, R.N. and C.S. Adkisson. 1975. Effects of clearcutting and the diversity of breeding birds. J. Forestry 73(12): 781-785.

Conner, R,N. and H.S. Crawford. 1974. Woodpecker foraging in Applachian clearcuts. J. Forestry 72(9): 564-566.

Conner, R.N., R.G. Hooper, H.S. Crawford, and H.S. Mosby. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. J. Wildl. Manage. 39(1): 144-150.

Conner, R.N., O.K. Miller, and C.S. Adkisson. 1976. Woodpecker dependence on trees infected by fungal heart rots. Wilson Bull. 88(4): 575-581.

Cottam, C. and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 36: 451-460.

Dickson, J.G. 1978. Comparison of breeding bird census techniques. American Birds 32(1): 10-13.

Ellison, L.N. 1975. Density of Alaskan Spruce Grouse before and after fire. J. Wildl. Manage. 39(3): 468-471.

Emlen, J.T. 1969. Habitat selection by birds following a forest fire. Ecology 51(2): 343-345.

Franzreb, K. 1976. Comparison of variable strip transect and spot map methods for censusing avian populations in mixed coniferous forest. Condor 78:260-262.

_____. 1977. Bird population changes after timber harvesting of a mixed coniferous forest in Arizona. U.S.D.A. Forest Service Res. Pap. RM-184. 26 p.

Gabrielson, I.N. and F.C. Lincoln. 1959. Birds of Alaska. Stackpole Co. Harrisburg, Penn. 922 p.

Gashwiler, J.S. 1977. Bird populations in four vegetative types in central Oregon. U.S. Dept. Interior. Fish and Wildlife Serv. Spec. Sci. Rept. Wildl. No. 205. 20p.

Haapanen, A. 1965. Bird fauna of the Finnish forest in relation to forest succession. Annu. Zool. Fenn. 2:153-196.

Hagar, D.C. 1960. Inter-relationships of logging, birds, and timber regeneration in the douglas-fir region of the northern California. Ecology 41(1): 116-125.

Hogstad, O. 1978. Sexual dimorphism in relation to winter foraging and territorial behaviour of the three-toed woodpecker - Picoides tridactylus and three Dendrocopus species. Ibis 120: 198-203.

Isleib, M.E. and B. Kessel 1973. Birds of the north gulf coast - Prince Willaim Sound region, Alaska. Univ. Alaska Biol. Pap. No. 14. 0.

Johnston, D.W. and E.P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37: 50-62.

Karr, J.R. 1968. Habitat and avian diversity on strip-mined land in east central Illinois. Condor 70: 348-357.

Kelsall, J.P., E.S. Telfer, and T.D. Wright. 1977. The effects of fire on ecology of the boreal forest with particular reference to the Canadian north: a review and selected bibliography. Canadian Wildl. Ser. Occ. Pap. No. 32. 58 p.

Kendeigh, S.C. 1945. Community selection by birds on the Helderberg Plateau of New York. Auk 62: 418-436.

_____. 1948. Bird populations and biotic communities in northern low Michigan. Ecology 28: 101-114.

Lack, D. 1933. Habitat selection in birds with special reference to the affects of afforestation on the Breckland avifauna. J. Anim. Ecology. 2: 239-262.

MacArthur, R.H. 1964. Environmental factors affecting bird species diversity. American Nat. 98: 387-397.

MacArthur, R.H. and J.W. MacArthur. 1961. On bird species diversity. Ecology 42: 594-598.

MacClintock, L., R.F. Whitcomb, and B.L. Witcomb. 1977. Evidence for the value of corridors and minimization of isolation in preservation of biotic diversity. Amer. Birds 31(1): 6-12.

McClellan, B.R. and S.S. Frissell. 1975. Identifying forest snags useful for hole-nesting birds. J. Forestry 73: 414-417.

Meslow, E.C. and H.M. Wight. 1975. Avifauna and succession in Douglas-fir forests of the Pacific Northwest. Pages 266-287 in Proc. symp. manage. forest and range habitats for non-game birds. U.S.D.A. Forest Serv. Gen. Tech. Rept. WO-1. 342 pp.

Noble, R.E. 1977. Breeding bird populations in hemlock-spruce old-growth and clearcuts, Prince Wales Island, Alaska. U.S. Forest Service Report, Tongass National Forest, Ketchikan, Alaska. 73 p.

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

Ohman, L.F. and R.R. Ream. 1971. Wilderness ecology: a method for plant community classification. U.S.D.A. Forest Service Res. Pap. NC-49. North Central For. Exp. Sta. St. Paul, Minn. 14 p.

Recher, H.F. 1969. Bird species diversity and habitat diversity in Austrailia and North America. Amer. Natur. 103: 75-80.

Schoener, T.W. 1968. Sizes of feeding territories among birds. Ecology 49:123-141.

Shannon, C.E. and W. Weaver. 1949. The mathematical theory of communications. Univ. Illinois Press, Urbana. 125 p.

Shugart, H.H. and D. James. 1973. Ecological succession of breeding bird populations in north western Arkansas. Auk 90:62-77.

Snow, D.W. 1965. The relationship between census results and the breeding population of birds on farmland. Bird study 12:287-304.

Spindler, M.A. 1976. Ecological survey of the birds, mammals, and vegetation of the Fairbanks Wildlife Management Area. M.S. Thesis. Univ. Alaska. 257 p.

Svensson, S. 1970. An international standard for a mapping method in bird census work recommended by the International Bird Census Committee. Aud. Field Notes 24(6): 722-726.

United States Department of Agriculture. 1978. Environmental statement Chugach Moose-Fire Management Program. U.S.D.A. FS-R10-FES (ADM) 77-07. 146 p.

Verner, J. 1975. Avian behavior and habitat management. Pages 39-58 in Proc. symp. on management of forest and range habitats for non-game birds. U.S.D.A. Forest Service Gen. Tech. Rept. WO-1.

Webb, W.L., D.F. Behrend, and B. Saisorn. 1977. Effects of logging on songbird populations in northern hardwood forests. Wildl. Monog. 55. 35p.

Welty, J.C. 1962. The life of birds. W.B. Saunders Company. Philadelphi Penn. 546 p.

Wiens, J.A. 1969. An approach to the study of ecological relationships among grassland birds. Amer. Ornithol. Union Monog. 8. 93 p.

_____. 1975. Avian communities, energetics, and functions in coniferous forest habitats. Pages 226-265 in Proc. symp. on management of forest and range habitats for non-game birds. U.S.D.A. Forest Service Gen. Tech Rept. WO-1.

Williamson, F.S.L. and L.J. Peyton. 1962. Faunal relationships of birds in the Iliamna Lake area, Alaska. Univ. Alaska Biol. Pap. No. 5 73 p.

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

Zarn, M. 1974. Habitat management series for unique and endangered species, rept. no. 10. Spotted Owl, Strix occidentalis. Bureau of Land Manage. U.S. Dept. Interior. 22 p.

Zeedyk, W.D. and K.E. Evans. 1975. Silvicultural options and habitat values in deciduous forests. Pages 115-127 in Proc. symp. on management of forest and range habitats for non-game birds. U.S.D.A. Forest Service Gen. Tech. Rept. WO-1.