FEDERAL AID
INTERIM PERFORMANCE REPORT

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
PO Box 25526
Juneau, AK 99802-5526

COOPERATIVE ENDANGERED SPECIES CONSERVATION FUND

STATE: Alaska **GRANT AND SEGMENT NR.:** E-6-CC

PROJECT NR.: 1.0

WORK LOCATION: Fairbanks

PROJECT DURATION: 1 January 2002 – 31 December 2003

PROJECT REPORTING PERIOD: 1 January 2002 – 31 December 2002

PROJECT TITLE: Distribution and Abundance of Neotropical Migratory Landbirds in Interior Alaska Forests

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Project Objectives:

OBJECTIVE 1: Initiate studies to determine the abundance of landbirds in each of the habitats found within the Tanana Valley forest.

OBJECTIVE 2: Initiate studies to determine specific habitats and habitat characteristics selected by landbird species during the early summer nesting season in the Northwest Interior Forest BCR, particularly Alaska "Species of Special Concern" and Boreal Partners in Flight "Priority Species for Conservation."

Summary of Project Accomplishments:

From 5-28 June 2002, 423 points were surveyed for birds following the Off-road Point Count protocol using variable circular plots. Points were randomly located in 3 white spruce sites with differing historical and anticipated future logging; and in aspen forest managed to enhance ruffed grouse habitat and unmanipulated aspen forest. Detailed vegetation and habitat data were collected at each survey point. A second field season is scheduled for June 2003.

Interim Project Costs: Federal share $36,951 + state share $28,660 = total $ 65,611

Prepared By: John Wright, Wildlife Biologist III

Date: April 10, 2003

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DIVISION OF WILDLIFE CONSERVATION
PO Box 25526
Juneau, AK 99802-5526

COOPERATIVE ENDANGERED SPECIES CONSERVATION FUND

STATE: Alaska **GRANT AND SEGMENT NR.:** E-6-CC
PROJECT NR.: 1

WORK LOCATION: Interior Alaska

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Project Objectives:

The objectives of this project were to initiate studies to determine:

1) the abundance of landbirds in each of the habitats found within the Tanana Valley forest; and

2) specific habitats and habitat characteristics selected by landbird species during the early summer nesting season in the Northwest Interior Forest BCR, particularly Alaska "Species of Special Concern" and Boreal Partners In Flight "Priority Species for Conservation."

Summary of Project Accomplishments:

1. Bird species were recorded using variable circle point counts in 3 white spruce sites and 2 aspen sites. A total of 5976 individual birds of 57 species were detected in visits to 426 points in 2002 and 421 points in 2003. Differences in species abundance and diversity between logged or manipulated sites and control sites were minimal. Swainson's thrush, Townsend's warbler, yellow-rumped warbler, and dark-eyed junco were most frequently detected in spruce forest. Dark-eyed Junco, yellow-rumped warbler, Swainson's thrush, Hammond's flycatcher, and hermit thrush were the common species in aspen forest. Mean abundance (birds per point) ranged from 7.2 to 9.9 in spruce forest, and from 4.6 to 5.8 in aspen forest.

2. Spruce forests had more individuals and greater species diversity than aspen. Within spruce forests, abundance and diversity were highest in older and mature mixed forests, and mature spruce-dominated forests. Townsend warblers preferred sites with taller white spruce trees, steeper slopes, lower forb cover, and more bare ground in understory. Varied thrush preferred taller birch trees, steeper slopes, and greater moss cover. More information is included in the attached report, "Distribution and abundance of landbirds in the Tanana Valley State Forest, Alaska 2002–2003," a final report prepared by Hannah, K.C., A.R. Ajmi and T.R. Walker, with the Alaska Bird Observatory, Fairbanks.

Project Costs: Federal share $73,901 + state share $21,020 + Ruffed Grouse Society Share $8,050 = total cost $ 102,971

Prepared By: John Wright

Date: March 23, 2004

Distribution and Abundance of Landbirds in the Tanana Valley State Forest, Alaska 2002-2003.

Kevin C. Hannah, Amal R. Ajmi, and Timothy R. Walker.
Alaska Bird Observatory, P.O. Box 80505, Fairbanks, AK 99708.

December 2003

EXECUTIVE SUMMARY

We examined the distribution, abundance, and habitat associations of breeding passerine birds in the Tanana Valley State Forest between Nenana and Fairbanks, Alaska. The goals of the study were: 1) to compare the abundance and distribution of breeding passerine birds between a mature undisturbed aspen (*Populus tremuloides*) forest and one treated (stem/sapling stage) to enhance habitat for Ruffed Grouse (*Bonasa umbellus*) populations, and 2) to identify bird-habitat associations for species known to associate with older, white spruce (*Picea glauca*) forests.

We randomly selected points within three white spruce forest sites at Bonanza Creek, West Site, and Rosie Creek, and two aspen sites at Nenana Ridge. Bird species were recorded using variable circular points, and vegetative information was recorded within a 50 m radius circle at 426 points in 2002, and 421 points in 2003.

We detected 5976 individuals of 57 species at unlimited distance during the two year period; a total of 4130 in the three spruce sites and 1846 in the two aspen sites. In the unmodified aspen site (hereafter "control"), Dark-eyed Junco (27%), Yellow-rumped Warbler (*Dendroica coronata*) (24%), Swainson's Thrush (*Catharus ustulatus*) (9%), Hammond's Flycatcher (*Empidonax hammondii*) (8%), and Hermit Thrush (*Catharus guttatus*) (6%) were the most frequently detected species at unlimited distance. In the modified aspen site, Dark-eyed Junco (21%), Yellow-rumped Warbler (18%), Swainson's Thrush (8%), Hammond's Flycatcher (6%), and Alder Flycatcher (8%) (*Empidonax alnorum*) were the most frequently detected species at unlimited distance. In the spruce sites, Swainson's Thrush (18%), Townsend's Warbler (13%) (*Dendroica townsendi*), Yellow-rumped Warbler (12%), and Dark-eyed Junco (12%) were the most frequently detected species at unlimited distance. Mean abundance (individual birds per point) was 4.6 birds at Nenana Ridge Control, 5.8 at Nenana Ridge Treatment, 9.9 at Bonanza Creek, 7.8 at Rosie Creek, and 7.2 at West Site.

Differences in species abundance and diversity (mean ± S.D.) between the Nenana Ridge control and treatment sites were not markedly different when comparing data for both years combined. However, differences between sites were significant between years. In 2002, mean bird abundance was significantly higher in the treatment (6.5 ± 3.3) than in the control (3.7 ± 2.3). Mean species diversity (number of species per point) was also significantly higher in the treatment (4.1 ± 1.9) than in the control (2.6 ± 1.3) in 2002. In 2003, mean bird abundance was not significantly different between the treatment (5.2 ± 4.6) and the control (5.2 ± 2.9). Mean species diversity was also not significantly different between the treatment (3.3 ± 2.0) and the control (3.3 ± 1.5) in 2003. Using Shannon diversity and evenness indices, the two communities appeared to be relatively similar. Species composition varied between the two sites with Horned Grebe, American Wigeon, Northern Shoveler, Lesser Yellowlegs, Solitary Sandpiper, Hairy Woodpecker, Three-toed Woodpecker, Western Wood-Pewee, Tree Swallow, Bank Swallow, Yellow Warbler, Wilson's Warbler, Savannah Sparrow, Lincoln's Sparrow, White-crowned Sparrow, and Pine Siskin detected exclusively in the treatment. The following species were detected exclusively in the control: Wilson's Snipe, Olive-sided Flycatcher, and Bohemian Waxwing.

The bird community in spruce forests had more individuals and greater species diversity than those in aspen forests. Within these spruce forests, both abundance and diversity were highest in older and mature mixed spruce forests, and in mature spruce-dominated forests. Using logistic regression, higher amounts of bare ground, lower forb cover, taller white spruce trees, and steeper slopes characterized sites where Townsend's Warblers were present. For the Varied Thrush, taller birch trees, greater moss cover, and steeper slopes characterized points where this species was present.

While results from this study may provide important baseline information for improved habitat and species management, validation of these results through more detailed population studies seems warranted. In this regard, assessments of productivity or habitat quality are essential in directing future management plans.

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INTRODUCTION

In recent decades, declines in many passerine birds have been linked to increased habitat fragmentation, leading to reductions in the amount of high quality habitat for certain species (Hagan and Johnston 1992). Forest harvesting can result in increased edge (Whitcomb et al. 1981, Yahner 1988), reductions in the amount of interior forest (Rich et al. 1994), changes in vegetation structure (Ranney et al. 1981, Fraver 1994), and degradation and isolation of remaining habitat (Robinson et al. 1995).

In Alaska, expansive floodplain forests along the Yukon and Tanana River valleys contain a large proportion of the highest volume white spruce timber in the Interior. As a consequence, large-scale industrial logging has been proposed in the Tanana Valley State Forest. While at a much larger scale, industrialized logging has taken place over much of North America's boreal region, often with unknown consequences for regional avifauna (Schmiegelow et al. 1997, Hobson and Bayne 2000). Studying forest systems, their component species, and incorporating active adaptive management strategies will help to ensure the conservation and maintenance of healthy bird populations in this region (Song 2002).

Habitat enhancement for Ruffed Grouse (*Bonasa umbellus*) populations is generally accomplished through the creation and maintenance of patchy, early successional broadleaf forest (Dessecker and McAuley 2001, Wiggers et al. 1992). While the creation and maintenance of this habitat may be beneficial to grouse and other early-successional species, of particular importance is how this habitat management technique impacts non-target species. Although evidence is limited, species richness does not appear to decline following the creation of patches of early-successional habitat from mature forest; however, community similarity becomes increasingly divergent over time (Yahner 1984). Maintaining large areas of early-successional habitat on the landscape is known to adversely affect area sensitive or interior species (Yahner 1984).

Many bird species throughout Alaska's boreal forest region utilize coniferous forests dominated largely by older white spruce (*Picea glauca*) (Spindler and Kessel 1980, Paton and Pogson 1996). In many regions, forests dominated by older white spruce often have the most diverse bird communities (Machtans and Latour 2003). As well as being an ecologically rich resource, older white spruce forests are also economically valuable. Consequently, older white spruce forests are generally harvested preferentially over younger, deciduous dominated forests (Schmiegelow et al. 1997). Older white spruce forest in interior Alaska represents important habitat for the Townsend's Warbler (*Dendroica townsendi*), and the Varied Thrush (*Ixoreus naevius*) (Matsuoka et al. 1997a, Beck and George 2000), both of which have been identified as conservation priority species in interior Alaska (Boreal Partners in Flight Working Group 1999). By identifying important habitat attributes for these species within older spruce forests, it may be possible to reduce or even ameliorate the negative consequences of forest harvesting through informed adaptive management practices.

The goals of this study were to: 1) Compare the relative abundance and diversity of selected passerines in treated aspen stands with undisturbed stands at Nenana Ridge (Aspen study); and 2)

Determine the relative abundance and identify important habitat characteristics of priority bird species in mature white spruce forests (Spruce study).

STUDY AREA

The study areas lie within the Tanana Valley State Forest between Fairbanks and Nenana (Figure 1).

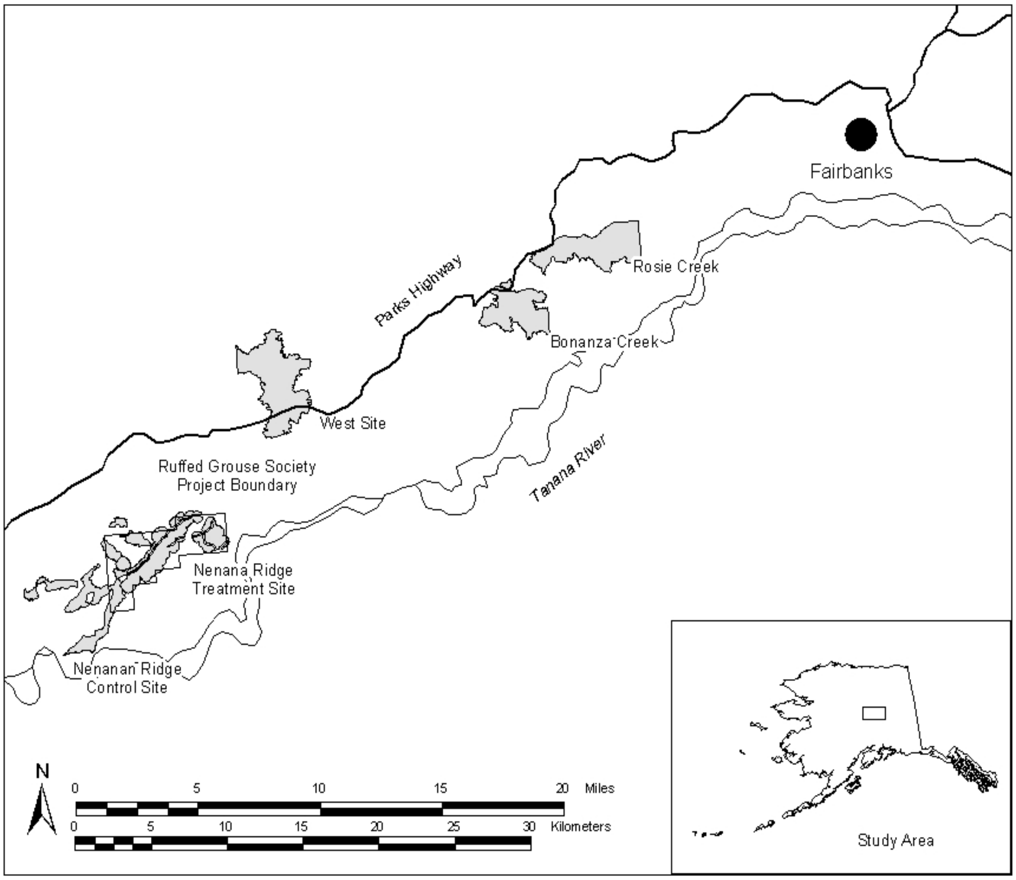
1. Aspen study.

We selected two study sites in the Nenana Ridge Ruffed Grouse Project area, approximately 42 miles southwest of Fairbanks, to investigate passerine use of forests manipulated to enhance Ruffed Grouse habitat. Grouse habitat treatments in this area included felling or burning of quaking aspen (*Populus tremulodies*), and harvest of paper birch (*Betula papyrifera*). Our treatment study site, encompassing 1241 ha, included all the treatment units and the surrounding untreated areas. The control site consisted of 1095 ha of unmodified quaking aspen stands adjacent to and southwest of the Nenana Ridge Ruffed Grouse Project area.

2. Spruce study.

We selected three replicate sites to investigate habitat associations by passerines in white spruce forests. Two of the sites have had or are likely to have logging take place within them while the third has had a limited amount of logging, with additional logging unlikely to occur in the near future. The sites within logging areas included 1282 ha in the vicinity of Rosie Creek, 16 miles southwest of Fairbanks; and 1658 ha north of Nenana Ridge on the north and south sides of the Parks Highway near milepost 323, which we called the West Site. The third site, with limited logging, encompassed 981 ha within the Bonanza Creek Experimental Forest, 18 miles southwest of Fairbanks.

Figure 1- Location of study sites within the Tanana Valley.



METHODS

Sampling Techniques

We allocated 110 random points for the Nenana Ridge Treatment site and 109 random points for the Nenana Ridge Control site. In the spruce study sites (Bonanza Creek, Rosie Creek and West Site), we allocated 83 random points for each site. Each point was identified based on UTM coordinates (see Appendix 1). We conducted point counts with unlimited distance estimation (variable circular plots, VCP; Reynolds et al. 1980, Ralph et al. 1995) from 5 to 28 June 2002 and 4 to 24 June 2003. Each point was surveyed between 02:30 and 09:30 hrs to ensure that sampling coincided with the peak period of bird detectability. Survey crews located random points using a Global Position System (GPS) unit. At each point observers recorded all birds detected within 8 min, subdivided into the first 5 min and the last 3 min. We recorded all birds detected within 100m of the point at 10m intervals, between 100 and 150m of the point at 25m intervals and all those detected beyond 150m of the point as >150m. Points were located a minimum distance of 250m apart, and at least 50m from dirt roads and 100m from paved roads. Because Common Redpoll (*Carduelis flammea*) and Hoary Redpoll (*Carduelis hornemanni*) are difficult to differentiate during point counts, they were grouped as a single species, denoted as Redpoll species. Thrushes (*Catharus* spp.) and woodpeckers (*Picoides* spp.) can also be difficult to differentiate when they are not vocal, so we added these two additional species categories to accommodate this potential detection bias.

At each point, a second crewmember collected site-specific vegetation and landscape data within a 50m radius of each point. This included aspect, slope, weather conditions, presence of water, disturbance, percent standing dead trees, height and percent cover of species in the tree and shrub layers, percent cover and species of herbs, and percent cover of moss, lichen, litter, and bare ground.

Study Site Selection and Descriptions

Selection of the study sites were based on prior knowledge of the area and Alaska Department of Natural Resources, Division of Forestry Geographic Information System (GIS) coverages. We used the GIS coverages and attribute files to identify and quantify the vegetation strata available to birds. The GIS coverages were mapped at a 1:31,680 scale using enlarged NASA high-altitude color infrared photography flown between 1979 and 1984. Ninety-one types with six modifiers were used to map land cover and were further grouped into 29 vegetative strata. Land cover types were not described because of their large number and lack of data to describe them, and because the 29 strata suited the needs for forest management (USDA Soil Conservation Service, Forest Service and Alaska DNR 1984).

1. Aspen study.

The treatment site on Nenana Ridge is a fragmented aspen forest. We defined this fragmented forest site as all of the treatment units buffered by 250m from the treatment edge. The specific treatment units were held on separate GIS coverages, so these were added to the study's vegetation coverage. We assigned a strata code for felling units, burn units, and the birch sale units.

The available GIS coverages did not differentiate between paper birch (*Betula papyrifera*) and quaking aspen; however, most south slope facing birch-aspen forests in the Tanana Valley are aspen stands. At this site, much of the treatment area has a south-facing orientation, and thereby consisted largely of aspen. The study site also contained some additional forest cover types. The vegetative stratum for most of this area is delineated as birch-aspen forest, which is described in two ways: birch-aspen saw and pole timber stands (strata code 7) and birch-aspen forests with the descriptors sapling and burned (strata code 24). Most of the area surrounding the felling units is stratum 24. During the surveys, however, we found these two strata at Nenana Ridge to be quite similar. By definition, pole-size hardwoods are 13-23 cm diameter breast height (dbh); sapling size trees are less than 13 cm dbh (diameter breast height), but over 6 m height and can be of young or mature seral stage; trees in burn areas are saplings less than 6 m height and usually less than 15 years old. Stands of strata code 24 in Nenana Ridge may therefore be quite variable. The treatment area also includes a few north-facing birch stands. These stands are on the north side of the upper roads and in the vicinity of the birch sale units. The treatment site includes 62.3% birch-aspen stands, 14% felling units, 2.2% burn units and 3.7% birch sales (Table 1). The remaining 17.8% is mostly mixed forest, with very small areas of shrubland and white spruce forests. The treatment units consisted of burned units (n = 6, range 1.5 – 12.0 ha, mean = 4.7 ha) and felled units (n = 40, range 0.6 – 9.7 ha, mean = 4.4 ha) and was treated in 1995 – 2001. The felling units consist of aspen forests that have been felled, with material remaining on site, resulting in dense woody material. Most of the area surrounding the treatment units is closed-canopy aspen forest.

The control site at Nenana Ridge is composed of 60.7% birch-aspen saw and pole timber (stratum 7), and 39.3% birch-aspen sapling and burn descriptors (Table 2). As with the treatment site, we found both stratum 7 and 24 to be similar enough to use for our study.

2. Spruce study.

To study passerines in spruce forests, we identified areas with a relatively high proportion of mature white spruce that were fairly accessible. Due to the patchwork mosaic of interior Alaskan forests, large continuous monotypic forests are unusual; therefore our study sites also included a small proportion of forest cover types other than spruce. The Bonanza Creek site contains the highest proportion of white spruce saw timber (22.8%) (Table 3). Ninety-one percent of the study site contains saw or pole timber white spruce represented by four different vegetative strata. The Rosie Creek site contains 4.7% white spruce saw timber and 54% of the study area contains saw or pole size white spruce represented by five different vegetative strata (Table 4). The West site contains 7.1% saw timber white spruce and 62.1% of the study area contains saw or pole white spruce represented by six vegetative strata (Table 5).

Standard Creek was considered as an alternative site to the West Site but was not used because the GIS coverage showed only a limited amount of delineated uncut mature white spruce. The Chena River Recreation Area, a riparian white spruce site, was considered as an alternative site to the Bonanza Creek Experimental Forest; however, detailed GIS coverages were not available for this area.

Within these three study sites, several polygons were not distinguishable from the GIS coverages. These polygons were associated with logging areas and encompassed many logging units on a separate GIS coverage. It appears that these areas may not have been interpreted because they had been or were slated to be logged, and therefore interpretation was not important for future forest management. These polygons were labeled as stratum 0. Since these areas occurred within the boundaries of our study sites and were likely to contain spruce forests, they were also sampled. Logging units were not included in the vegetation coverages and were not part of the strata scheme. The logging units were subsequently added to the vegetation coverage and defined as strata code 99.

Statistical Analyses

1. Aspen study.

Our intent was to compare the entire bird community, based on detections at unlimited radius from the sampling point. Given the patchiness and variability of the vegetative strata, however, there was some potential to sample individuals from beyond the desired vegetative strata or habitat type (treatment or control). Where possible, we present data from both the 50 m and unlimited radius separately in order to minimize the effects of sampling outside of the desired habitat type.

We used the Shannon Diversity Index (H) to compare species diversity and evenness (E_H) between the two communities using the following equations:

$$H = \sum_{i=1}^{S} p_i \ln p_i \qquad \text{and} \qquad E_H = H / H_{max} = H / \ln S$$

where S equals the total number of species, p_i equals proportion of S made up of the ith species, and H_{max} equals $\ln$ S. As the value of H increases, so does species diversity. Shannon evenness measures the equitability of the distribution of individuals among species within the community. Evenness ranges from 0 to 1, with high evenness indicating that individuals in a given community are equitably distributed among species and between sampling units (points). Shannon Index is relatively easy to use and is frequently used to compare community diversity, and was used to compare species richness between treated and control areas in this study.

While Shannon Diversity Indices are widely used, interpretation is often less quantitative than more conventional statistical analyses. Therefore, we also compared the total abundance and diversity of birds between treatment and control areas using univariate *t*-tests. While this analysis is not a comparison of the overall bird community between the two habitats, it does compare the overall mean difference in species abundance and diversity detected at each sampling point.

2. Spruce study.

Since this component of the study lacked an experimental design, our comparisons were largely qualitative. In all cases, our abundance and diversity comparisons were between vegetative strata grouped by replicate sites. Given our inability to effectively sample these strata exclusively, largely as a result of the patchy nature of stand boundaries and the potential inaccuracy of the stand boundaries on GIS coverages, we present results from both the 50 m and unlimited sampling radii.

The second component of this study was to evaluate habitat variables that are important to species inhabiting older white spruce forests. Since vegetation sampling was limited to the inner 50m sampling radius of each point count, only birds detected within this 50 m radius were included when determining species-habitat associations.

Habitat variables were examined using Spearman rank correlations and descriptive statistics. Any habitat variables for which fewer than 10 observations were made were eliminated. To further reduce habitat variables, we assessed the potential ecological significance of highly correlated variables ($r > 0.50$), and eliminated correlated variables that appeared to be redundant. For instance, there was a strong correlation between the canopy cover of a tree species and the height of the tree. Since tree height is easier to quantify in the field, and may be more ecologically meaningful, we eliminated the canopy cover variable. We retained 13 habitat variables for analysis.

Habitat data used to determine habitat associations of species in forests dominated by white spruce was analyzed using a stepwise logistic regression procedure. We used a binary dependent variable, which represented the presence or absence of a species at a particular point. The criterion for entry into the regression model was a score statistic of $\alpha = 0.10$, and for removal, we used a log-likelihood ratio statistic of $\alpha = 0.15$ (Hosmer and Lemeshow 1989, Norusis 1994). We selected to use a total of 100 stepwise logistic regression iterations in determining each model (Matsuoka et al. 1997b). Since the presence of each species at a sampling point was somewhat variable each year, we developed a model for each species in each year separately. As a means of evaluating the yearly models, we developed a third model using data averaged from points where each species was present in both years. Townsend's Warbler presence was more consistent at individual points between years than in the Varied Thrush, which greatly reduced sample sizes for analysis in the latter species.

In all analyses, we considered a $P \leq 0.05$ to be significant, however, $0.05 \leq P \leq 0.10$ was considered to be marginally significant. All data were tested for normality and homoscedasticity prior to analysis. Unless otherwise stated, values given are mean ± SD. All analyses were performed using SPSS (Version 11.5.0) (SPSS 2002).

Table 1 - Vegetation cover types and number of random points in the Nenana Ridge treatment area.

Strata Code	Vegetation Strata Description	Area (ha)	Percent Area	Number of Random Points Generated	Number of Random Points Surveyed
1	White Spruce; Saw Timber	1	0.1	0	0
7	Birch - Aspen; Saw and Pole Timber	385	31.0	35	28
8	White Spruce, Birch and Aspen; Saw Timber	13	1.0	0	0
9	White Spruce, Birch and Aspen; Pole Timber	139	11.2	13	13
10	Black and White Spruce, Birch and Aspen; Saw & Pole Timber	21	1.7	2	2
22	Other Coniferous Stands; Dwarf, Sapling, Burned	6	0.5	2	2
24	Birch-Aspen; Sapling, Burned	388	31.3	30	23
26	Black and White Spruce, Birch and Aspen; Dwarf, Sapling, Burned	22	1.8	1	0
30	Tall Shrubland	4	0.3	0	0
32	Low Shrubland	15	1.2	1	1
70	Felling Unit	174	14.0	17	13
80	Burn Unit	27	2.2	5	5
90	Birch Sale	45	3.7	4	4
Total		1241	100.0	110	91

Table 2 - Vegetation cover types and number of random points in the Nenana Ridge control area.

Strata Code	Vegetation Strata Description	Area (ha)	Percent Area	Number of Random Points Generated	Number of Random Points Surveyed
7	Birch-Aspen; Saw and Pole Timber	665	60.7	68	57
24	Birch-Aspen; Sapling, Burned	430	39.3	41	25
Total		1095	100.0	109	82

Note – an additional point was sampled in strata code 24 in 2003, making a total of 83 points sampled.

Table 3 - Vegetation cover types and number of random points in Bonanza Creek.

Strata Code	Vegetation Strata Description	Area (ha)	Percent Area	Number of Random Points Generated	Number of Random Points Surveyed
0	Vegetation Strata Not Defined	13	1.3	1	2
1	White Spruce; Saw Timber	223	22.8	19	18
8	White Spruce, Birch and Aspen; Saw Timber	475	48.5	42	41
9	White Spruce, Birch and Aspen; Pole Timber	157	16.0	15	15
10	White Spruce, Birch and Aspen; Saw & Pole Timber	41	4.2	4	4
22	Other Coniferous Stands; Dwarf, Sapling, Burned	61	0.6	2	2
99	Cutting Unit	65	6.6	1	1
Total		1035	100.0	84	83

Table 4 – Vegetation cover types and number of random points at the Rosie Creek Site.

Strata Code	Vegetation Strata Description	Area (ha)	Percent Area	Number of Random Points Generated	Number of Random Points Surveyed
0	Vegetation Strata Not Defined	106	8.2	5	5
1	White Spruce; Saw Timber	60	4.7	6	6
3	Black and White Spruce; Saw and Pole Timber	2	0.1	0	0
7	Birch-Aspen; Saw and Pole Timber	189	14.7	13	13
8	White Spruce, Birch and Aspen; Saw Timber	290	22.6	19	19
9	White Spruce, Birch and Aspen; Pole Timber	326	25.4	24	24
10	Black and White Spruce, Birch and Aspen; Saw & Pole Timber	15	1.2	0	0
21	Black and White Spruce; Dwarf, Sapling, Burned	4	0.3	0	0
22	Other Coniferous Stands; Dwarf, Sapling, Burned	56	4.4	2	2
24	Birch-Aspen; Sapling, Burned	50	3.9	4	4
26	Black and White Spruce, Birch and Aspen; Dwarf, Sapling, Burned	4	0.3	0	0
30	Tall Shrubland	16	1.2	2	2
99	Cutting Unit	165	12.8	8	7
Total		1282	100.0	83	82

Table 5 – Vegetation cover types and number of random points at the West Site.

Strata Code	Vegetation Strata Description	Area (ha)	Percent Area	Number of Random Points Generated	Number of Random Points Surveyed
0	Vegetation Strata Not Defined	84	5.1	3	3
1	White Spruce; Saw Timber	117	7.1	7	7
2	White Spruce; Pole Timber	13	0.8	0	0
3	Black and White Spruce; Saw and Pole Timber	82	5.0	3	3
7	Birch-Aspen; Saw and Pole Timber	4	0.2	0	0
8	White Spruce, Birch and Aspen; Saw Timber	364	22.0	15	15
9	White Spruce, Birch and Aspen; Pole Timber	374	22.6	24	24
10	Black and White Spruce, Birch and Aspen; Saw & Pole Timber	76	4.6	3	2
21	Black and White Spruce; Dwarf, Sapling, Burned	11	0.7	1	1
22	Other Coniferous Stands; Dwarf, Sapling, Burned	185	11.1	9	8
24	Birch - Aspen; Sapling, Burned	39	2.3	2	2
25	White Spruce, Birch and Aspen; Sapling, Burned	64	3.9	3	4
26	Black and White Spruce, Birch and Aspen; Dwarf, Sapling, Burned	92	5.6	7	7
30	Tall Shrubland	11	0.7	0	0
60	Cultural	36	2.2	0	0
99	Cutting Unit	105	6.3	6	6
Total		1658	100.0	83	82

RESULTS

1. Aspen study

A total of 1112 individuals of 36 species were counted at 91 points in the Nenana Ridge treatment area during the two-year period (Table 6). A total of 740 individuals of 24 species were detected in the Nenana Ridge control area (82 points in 2002; 83 points in 2003) (Table 7). In 2002, mean bird abundance was significantly higher in the treatment (6.5 ± 3.3) than in the control (3.7 ± 2.3) ($t = 6.6$, $P < 0.001$). Mean species diversity was also significantly higher in the treatment (4.1 ± 1.9) than in the control (2.6 ± 1.3) in 2002 ($t = 6.0$, $P < 0.001$). In 2003, mean bird abundance was not significantly different between the treatment (5.2 ± 4.6) and the control (5.2 ± 2.9) ($t = 0.1$, $P = 0.95$). Mean species diversity was also not significantly different between the treatment (3.3 ± 2.0) and the control (3.3 ± 1.5) in 2003 ($t = 0.1$, $P = 0.95$).

The abundance and diversity of species per point in each of the treatment and control was highly variable between vegetation strata. Of these strata, stands of saw- and pole-aged birch and aspen (strata 7), and sapling-aged birch and aspen (strata 24) were common to both the treatment and control sites. Within these strata, bird abundance was higher at points in the treatment (strata 7: 5.1 birds per point; strata 24: 5.2 birds per point; Table 6) than in the control (strata 7: 4.6 birds per point; strata 24: 4.2 birds per point; Table 7). Within these strata, species diversity was also greater in the treatment (strata 7: 5.1 species per point; strata 24: 5.2 species per point) than in the control (strata 7: 4.6 species per point; strata 24: 4.7 species per point). Within the treatment, several other vegetation strata contained highly abundant and diverse bird communities. For instance, bird abundance in each vegetation strata ranged from an average of 5.1 to 15.5 birds per point and species diversity ranged from an average of 5.0 to 14.0 species per point. Within the treatment, the most productive habitats were the low shrubland (strata 32) followed by the birch sale units (strata 90). The following species were detected exclusively in the treatment: Horned Grebe, American Wigeon, Northern Shoveler, Lesser Yellowlegs, Solitary Sandpiper, Hairy Woodpecker, Three-toed Woodpecker, Western Wood-Pewee, Tree Swallow, Bank Swallow, Yellow Warbler, Wilson's Warbler, Savannah Sparrow, Lincoln's Sparrow, White-crowned Sparrow, and Pine Siskin (Table 8). The following species were detected exclusively in the control: Wilson's Snipe, Olive-sided Flycatcher, and Bohemian Waxwing (Table 9).

In the treatment, the high diversity of bird species detected was largely a result of high structural diversity and complexity. Having structural components similar to the control (strata 7), along with several early- and mid-successional stands, there were many more unique habitats present in the treatment. For instance, Hairy and Three-toed Woodpeckers were present in the burned and felling units (strata 24, 70, and 90), likely as a result of an increased availability of standing snags. Several mid-successional species, such as Western Wood-Pewee, Yellow Warbler, and Wilson's Warbler were attracted to pole-stage mixedwood forest stands (strata 9). Early successional species such as Savannah Sparrow and Lincoln's Sparrow were attracted to stands defined as low shrubland (strata 32). Additional species diversity, in the form of waterfowl and shorebirds, was largely in response to several large areas of standing water in the treatment plot. In the control plot, the single Olive-sided Flycatcher that was detected may have been attracted to an area of deciduous saplings, although with only a single detection it may not be prudent to suggest a habitat association.

Using the Shannon Diversity Index (*H*), species diversity was consistently higher in the treatment (2.64) than in the control (2.22) (Table 10). In 2002, species diversity was considerably higher in the treatment (2.82) than in the control (1.96). In 2003, species diversity was only marginally higher in the treatment (2.62) than in the control (2.26). Using the Shannon evenness index (E_H), species were equally represented or distributed in the treatment (0.74) and the control (0.70). As with diversity, species within the two communities were more evenly or equitably distributed between the treatment and the control in 2003 (0.80 vs. 0.77) than in 2002 (0.81 vs. 0.71).

The distance an individual bird is from an observer can often dictate whether that bird will be detected on a survey (Scheick 1997). While we did not make any rigorous quantitative comparisons of the detection distances of particular species, we did compare the overall detection distances of all birds. Between the treatment and the control, individuals were detected in similar proportions at each distance (Table 11), with the majority of detections (40% treatment; 37% control) within the 50-100 m range. At both sites, the fewest detections of individuals were at >150 m from the observer.

2. Spruce study.

A total of 247 points were sampled in the three replicate spruce sites (83 in Bonanza Creek, 82 in each of Rosie Creek and the West Site) in 2002 and 2003. Across all sites for both years combined, 4520 individuals of 51 species were detected at unlimited distance (Table 12). At Bonanza Creek, 1634 individuals of 34 species were detected. At Rosie Creek, 1442 individuals of 36 species were detected. Finally, at the West Site, 1444 individuals of 37 species were detected.

The purpose of the second component of this study was to determine habitat associations for several species known to prefer older white spruce forest. Given the difficulty in determining distances of birds beyond 50 m accurately (Machtans and Latour 2003), we summarize in detail only those individuals detected within the 50 m radius. At Bonanza Creek, a total of 429 individuals of 21 species were detected within the 50 m radius (Table 13). At Rosie Creek, a total of 510 individuals of 25 species were detected (Table 14). Finally, at the West Site, a total of 393 individuals of 23 species were detected (Table 15).

Between spruce plots, individual birds were detected in similar proportions at each distance (Table 16), with the majority of detections in the 50-100 m range. In contrast to deciduous forest, the fewest bird detections of individual birds were between 100-150 m from the observer.

In general, within white spruce dominated forests, species diversity and abundance were greatest in older forests (strata codes 1 and 8). Younger spruce forests, generally of pole-aged timber (strata code 9), also contained a relatively diverse and abundant bird community. For spruce specialists, such as Townsend's Warbler, these three vegetative strata accounted for 189 out of 221 (85%) detections. A total of 28 out of 33 (84%) Varied Thrush detections were made within these three vegetative strata. For both species, at all sites, the majority of detections were in older white spruce, birch, and aspen forests (strata code 8). Within this vegetative stratum, a total of 93 (42% of all detections) Townsend's Warblers, and 14 (42% of all detections) Varied Thrushes, were detected for both years across all sites.

In 2002, shorter birch trees and taller black spruce trees characterized points where Townsend's Warblers were absent. This model was highly significant ($\chi^2 = 13.2$, $P < 0.01$, $r^2 = 0.08$). This model failed to correctly classify any of the points where Townsend's Warbler were present; however, it did correctly classify 100% of points where they were absent, for an overall correct classification rate of 67%. In 2003, points with taller birch trees, taller white spruce trees, and steeper slopes characterized where Townsend's Warblers were present. This model was highly significant ($\chi^2 = 29.8$, $P < 0.01$, $r^2 = 0.18$). This model correctly classified 17% of points where Townsend's Warbler were present, and correctly classify 95% of points where they were absent, for an overall correct classification rate of 75%. Using a combined model with data for both years, points where Townsend's Warblers were present were characterized by more bare ground, lower forb cover, taller white spruce trees, and steeper slopes (Table 17). This model was highly significant ($\chi^2 = 38.0$, $P < 0.01$, $r^2 = 0.28$). This model correctly classified 10% of points where Townsend's Warbler were present, and correctly classified 100% of points where they were absent, for an overall correct classification rate of 89%. Given that Townsend's Warblers associated with areas containing taller white spruce trees and steeper slopes in two of the three models, then this is likely a meaningful result.

In 2002, too few Varied Thrushes were detected to enable us to correctly classify vegetation at points where birds were present or absent. In 2003, taller birch trees, greater moss cover, and steeper slopes characterized points where Varied Thrushes were present (Table 18). This model was significant ($\chi^2 = 14.4$, $P < 0.01$, $r^2 = 0.14$). This model correctly classified only 5% of points where Varied Thrushes were present; however, it did correctly classify 100% of points where they were absent, for an overall correct classification rate of 92%. Using combined data from both years, we also failed to develop a model to correctly classify vegetation at enough points. The inability of these models to correctly classify the presence of Varied Thrushes makes it difficult to identify habitat associations for this species. By looking at points where the species was absent, however, may provide some meaningful information on the types of habitat attributes that the species may avoid (see Table 18).

Table 6 – Number of individuals detected at unlimited radius at Nenana Ridge Treatment in 2002-2003 (see full species descriptions in Appendix I).

Nenana Treatment 2002			Nenana Treatment 2003
Species	Abundance		Species
Horned Grebe	1	1	Horned Grebe
American Wigeon	1		
Northern Shoveler	7		
Sharp-shinned Hawk	1		
		1	Lesser Yellowlegs
Solitary Sandpiper	1	3	Solitary Sandpiper
Northern Flicker	3	3	Northern Flicker
		2	Hairy Woodpecker
Three-toed Woodpecker	2		
Picoides Species	1		
Western Wood-Pewee	1		
Alder Flycatcher	39	54	Alder Flycatcher
Hammond's Flycatcher	35	33	Hammond's Flycatcher
Gray Jay	27	8	Gray Jay
Common Raven	3	2	Common Raven
Tree Swallow	2		
		2	Bank Swallow
Black-capped Chickadee	14	5	Black-capped Chickadee
Boreal Chickadee	8	5	Boreal Chickadee
Ruby-crowned Kinglet	2	2	Ruby-crowned Kinglet
Swainson's Thrush	62	24	Swainson's Thrush
Hermit Thrush	13	34	Hermit Thrush
Catharus Species	1		
American Robin	30	9	American Robin
Orange-crowned Warbler	14	28	Orange-crowned Warbler
Yellow-rumped Warbler	132	51	Yellow-rumped Warbler
Townsend's Warbler	6	7	Townsend's Warbler
Yellow Warbler	3	1	Yellow Warbler
Wilson's Warbler	1		
Savannah Sparrow	1	2	Savannah Sparrow
Lincoln's Sparrow	2	2	Lincoln's Sparrow
White-crowned Sparrow	37	9	White-crowned Sparrow
Dark-eyed Junco	134	111	Dark-eyed Junco
White-winged Crossbill	2	18	White-winged Crossbill
Pine Siskin	1	13	Pine Siskin
Redpoll Species	11	84	Redpoll Species
33 Species	**598**	**514**	**26 Species**

Table 7 – Number of individuals detected at unlimited radius at Nenana Ridge Control in 2002-2003.

Nenana Control 2002			Nenana Control 2003
Species	Abundance		Species
Sharp-shinned Hawk	1		
		2	Wilson's Snipe
Northern Flicker	2		
Picoides Species	2		
		1	Olive-sided Flycatcher
		1	Alder Flycatcher
Hammond's Flycatcher	26	35	Hammond's Flycatcher
Gray Jay	11	3	Gray Jay
Common Raven	3		
Black-capped Chickadee	9	16	Black-capped Chickadee
Boreal Chickadee	4		
Ruby-crowned Kinglet	3	3	Ruby-crowned Kinglet
Swainson's Thrush	31	35	Swainson's Thrush
Hermit Thrush	16	32	Hermit Thrush
		1	*Catharus* Species
American Robin	10	13	American Robin
		5	Bohemian Waxwing
		18	Orange-crowned Warbler
Yellow-rumped Warbler	95	82	Yellow-rumped Warbler
Townsend's Warbler	1	5	Townsend's Warbler
		1	Blackpoll Warbler
Dark-eyed Junco	92	105	Dark-eyed Junco
		14	White-winged Crossbill
Redpoll Species	5	57	Redpoll Species
16 Species	**311**	**429**	**19 Species**

Table 8 - Number of individuals detected at unlimited radius of point by vegetative strata at Nenana Ridge Treatment in 2002-2003.

	Strata Code									
Species	**7**	**9**	**10**	**22**	**24**	**32**	**70**	**80**	**90**	**Total**
Dark-eyed Junco	59	31	4	8	56	2	51	22	12	245
Yellow-rumped Warbler	54	32	5	6	46		24	13	3	183
Redpoll Sp.	27	29	8		18		10		3	95
Alder Flycatcher	13	4			20	3	36	7	10	93
Swainson's Thrush	27	18	3	4	15		12	1	6	86
Hammond's Flycatcher	25	6			21		4	8	4	68
Hermit Thrush	15	5	1		19	1	5	1		47
White-crowned Sparrow	7	7			3	1	13	1	14	46
Orange-crowned Warbler	15	2			6	2	9	3	5	42
American Robin	17	8	2		6		2	3	1	39
Gray Jay	8	5		6	8	2	2	2	2	35
White-winged Crossbill	1	3		3	4		3		6	20
Black-capped Chickadee	7	3	1		1		3	1	3	19
Pine Siskin	1	3			3			4	3	14
Boreal Chickadee	2			2	3	1	4		1	13
Townsend's Warbler	3	6						1	3	13
Northern Shoveler						7				7
Northern Flicker					2				4	6
Common Raven		3			1			1		5
Lincoln's Sparrow						3			1	4
Ruby-crowned Kinglet	2	1			1					4
Solitary Sandpiper	1						3			4
Yellow Warbler		2			1			1		4
Savannah Sparrow						3				3
Bank Swallow						2				2
Horned Grebe						2				2
Hairy Woodpecker							1		1	2
Three-toed Woodpecker					2					2
Tree Swallow	1						1			2
American Wigeon						1				1
Lesser Yellowlegs						1				1
Sharp-shinned Hawk							1			1
Catharus species					1					1
Western Wood-Pewee		1								1
Wilson's Warbler		1								1
Picoides species	1									1
Total Abundance	286	170	24	29	237	31	184	69	82	1112
Total Diversity	21	20	8	7	22	15	19	16	18	36
Total Number of Points	56	26	4	4	46	2	26	10	8	182
Mean Abundance (Birds/Point)	5.1	6.5	6.0	7.3	5.2	15.5	7.1	6.9	10.1	6.1
Mean Diversity (Species/Point)	5.4	6.5	5.1	6.5	5.0	14.0	5.8	6.0	8.3	5.8

Table 9 - Number of individuals detected at unlimited radius of point by vegetative strata at Nenana Ridge Control 2002-2003.

	Strata Code		
Species	**7**	**24**	**Total**
Dark-eyed Junco	150	47	197
Yellow-rumped Warbler	114	63	177
Swainson's Thrush	47	19	66
Redpoll Sp.	45	17	62
Hammond's Flycatcher	45	16	61
Hermit Thrush	38	10	48
Black-capped Chickadee	19	6	25
American Robin	8	15	23
Orange-crowned Warbler	10	8	18
Gray Jay	11	3	14
White-winged Crossbill	14		14
Ruby-crowned Kinglet	5	1	6
Townsend's Warbler	5	1	6
Bohemian Waxwing	4	1	5
Boreal Chickadee	2	2	4
Common Raven	3		3
Northern Flicker	2		2
Wilson's Snipe	2		2
Picoides species	1	1	2
Alder Flycatcher		1	1
Blackpoll Warbler	1		1
Olive-sided Flycatcher		1	1
Sharp-shinned Hawk	1		1
Catharus species	1		1
Total Abundance	528	212	740
Total Diversity	22	17	24
Total Number of Points	115	50	165
Mean Abundance (Birds/Point)	4.6	4.2	4.5
Mean Diversity (Species/Point)	4.6	4.7	4.6

Table 10 - Shannon Diversity and Evenness Indices for Nenana Ridge Control and Treatment.

Location	Detection Distance	Number of Individuals	Species	H^a	$E_H{}^b$
Nenana Ridge Control (2002 and 2003)	Unlimited	740	24	2.22	0.70
Nenana Ridge Treatment (2002 and 2003)	Unlimited	1112	36	2.64	0.74
Nenana Ridge Control (2002 and 2003)	< 50 m	204	12	1.77	0.71
Nenana Ridge Treatment (2002 and 2003)	< 50 m	270	18	2.34	0.81
Nenana Ridge Control (2002)	Unlimited	311	16	1.96	0.71
Nenana Ridge Treatment (2002)	Unlimited	598	33	2.82	0.81
Nenana Ridge Control (2003)	Unlimited	429	19	2.26	0.77
Nenana Ridge Treatment (2003)	Unlimited	514	26	2.62	0.80
Nenana Ridge Control (2002)	< 50 m	94	10	1.75	0.76
Nenana Ridge Treatment (2002)	< 50 m	134	15	2.29	0.85
Nenana Ridge Control (2003)	< 50 m	110	9	1.65	0.75
Nenana Ridge Treatment (2003)	< 50 m	136	16	2.23	0.80

[a] **Shannon Diversity Index H =-1 *SUM(Pi * lnPi)**

[b] **Shannon Evenness $E_H = H$*ln(species) $^{-1}$**

Table 11 - Detection distances and percent occurrence of birds at Nenana Ridge in 2002-2003.

NR Treatment Distance (Total)	**Number**	**(Percent)**	**(Total)**	**NR Control Distance**	**Number**	**(Percent)**	
0 – 10 m	11	(0.01)		0 – 10 m	16	(0.02)	
10 – 20 m	40	(0.03)		10 – 20 m	22	(0.03)	
20 – 30 m	58	(0.05)		20 – 30 m	39	(0.05)	
30 – 40 m	78	(0.07)		30 – 40 m	64	(0.09)	
40 – 50 m	90	(0.08)	(0.24)	40 – 50 m	64	(0.09)	(0.28)
50 – 60 m	89	(0.08)		50 – 60 m	47	(0.06)	
60 – 70 m	99	(0.09)		60 – 70 m	56	(0.08)	
70 – 80 m	95	(0.09)		70 – 80 m	64	(0.09)	
80 – 90 m	52	(0.05)		80 – 90 m	37	(0.05)	
90 – 100 m	102	(0.09)	(0.40)	90 – 100 m	67	(0.09)	(0.37)
100 – 125 m	91	(0.08)		100 – 125 m	53	(0.07)	
125 – 150 m	60	(0.05)	(0.13)	125 – 150 m	41	(0.06)	(0.13)
> 150 m	107	(0.10)	(0.10)	> 150 m	85	(0.11)	(0.11)
Flyover	140	(0.13)	(0.13)	Flyover	85	(0.11)	(0.11)
Total	**1112**	**(1.00)**	**(1.00)**	**Total**	**740**	**(1.00)**	**(1.00)**

Rosie Creek in 2002-2003.

Species	Bonanza Creek	Rosie Creek	West Site	Grand Total
Swainson's Thrush	278	246	230	754
Townsend's Warbler	211	214	110	535
Redpoll species	121	132	256	509
Yellow-rumped Warbler	200	148	135	483
Dark-eyed Junco	150	151	160	461
Pine Siskin	127	95	103	325
White-winged Crossbill	75	102	67	244
Varied Thrush	104	36	87	227
Gray Jay	61	48	50	159
Ruby-crowned Kinglet	50	18	50	118
Boreal Chickadee	47	32	26	105
Alder Flycatcher	39	34	21	94
Bohemian Waxwing	24	24	25	73
American Robin	17	15	27	59
Hammond's Flycatcher	12	22	15	49
Orange-crowned Warbler	16	21	8	45
Common Raven	21	16	7	44
Black-capped Chickadee	19	21		40
Hermit Thrush	7	19	3	29
Picoides species	5	1	22	28
Three-toed Woodpecker	15	8	2	25
White-crowned Sparrow	15	5	4	24
Hairy Woodpecker	4	5	10	19
Northern Flicker	3	8	1	12
Green-winged Teal			8	8
Lincoln's Sparrow	4	1	2	7
Sandhill Crane	1	4	1	6
Rough-legged Hawk		4		4
Downy Woodpecker		3		3
Red-tailed Hawk	1	2		3
American Wigeon			2	2
Blackpoll Warbler	1		1	2
Mallard			2	2
Northern Goshawk	1	1		2
Olive-sided Flycatcher		1	1	2
Ruffed Grouse		1	1	2
Yellow Warbler			2	2
American Kestrel			1	1
Brown Creeper		1		1
Bufflehead			1	1
Fox Sparrow	1			1
Great Horned Owl			1	1
Lesser Yellowlegs	1			1
Merlin	1			1
Northern Shoveler			1	1
Red-breasted Nuthatch			1	1
Solitary Sandpiper	1			1
Catharus species		1		1
Wilson's Snipe	1			1
Wilson's Warbler		1		1
Yellow-bellied Sapsucker		1		1
Total Abundance	1634	1442	1444	4520
Species Diversity	34	36	37	51

Table 13 - Number of individuals detected within 50 m radius of point by vegetative strata at Bonanza Creek in 2002-2003.

	Strata Code							
Species	**0**	**1**	**8**	**9**	**10**	**22**	**99**	**Total**
Yellow-rumped Warbler		19	40	9	5			73
Swainson's Thrush	2	17	30	17	3	1	1	71
Townsend's Warbler		16	34	15				65
Dark-eyed Junco	2	11	24	10	7		2	56
Boreal Chickadee		6	25		1			32
Gray Jay		11	13	3	3			30
Redpoll Sp.		20	1					21
Ruby-crowned Kinglet		5	10			1		16
Pine Siskin		1	14					15
Black-capped Chickadee		4	5	2	2			13
Varied Thrush		4	8	1				13
Three-toed Woodpecker		3	1	2				6
White-winged Crossbill		3	2	1				6
Orange-crowned Warbler		1	1	3				5
Hammond's Flycatcher			1	3				4
American Robin		1	1	1				3
Bohemian Waxwing		3						3
Hairy Woodpecker			3					3
White-crowned Sparrow			2					2
Hermit Thrush		1						1
Northern Flicker		1						1
Total Abundance	4	127	215	67	21	2	3	429
Total Diversity	2	18	18	12	6	2	2	21
Total Number of Points	4	36	82	30	8	4	2	166
Mean Abundance (Birds/Point)	1.0	3.5	2.6	2.2	2.6	2.0	1.5	2.6

Table 14 - Number of individuals detected within 50m radius of point by vegetative strata at Rosie Creek in 2002-2003.

	Strata Code									
Species	**0**	**1**	**7**	**8**	**9**	**22**	**24**	**30**	**99**	**Total**
Townsend's Warbler	6	11	8	24	29	1	3	2	1	85
Redpoll Sp.	1	2	4	11	17	10		20	5	70
Yellow-rumped Warbler	4	1	12	16	20		2	1	3	59
Swainson's Thrush	5	1	7	14	19		1	1	7	55
Dark-eyed Junco	1	2	12	13	15	2	1	4	3	53
Pine Siskin	2	12	1	1	18	1	2	1	1	39
White-winged Crossbill	2	4		19	3		1		1	30
Boreal Chickadee		2	2	13	3		2		1	23
Gray Jay	1	1	1	1	3	4		1	5	17
Bohemian Waxwing	1		5		5	3				14
Orange-crowned Warbler	1		1	3	5				4	14
Black-capped Chickadee	5		1	5		1				12
Hammond's Flycatcher	3		2		5		1			11
Alder Flycatcher		1							6	7
Ruby-crowned Kinglet		2		3	1					6
Varied Thrush		2		2						4
Hermit Thrush	1		2							3
American Robin		1								1
Brown Creeper				1						1
Common Raven				1						1
Downy Woodpecker	1									1
Northern Flicker					1					1
Olive-sided Flycatcher						1				1
Catharus species				1						1
Picoides species									1	1
Total Abundance	34	42	58	128	144	23	13	30	38	510
Total Diversity	14	13	13	16	14	8	8	7	12	25
Total Number of Points	10	12	26	38	48	4	8	4	14	164
Mean Abundance (Birds/Point)	3.4	3.5	2.2	3.4	3.0	5.8	1.6	7.5	2.7	3.1

Table 15 - Number of individuals detected within 50 m radius of point by vegetative strata at the West Site in 2002-2003.

	Strata Code												
Species	**0**	**1**	**3**	**8**	**9**	**10**	**21**	**22**	**24**	**25**	**26**	**29**	**Total**
Townsend's Warbler	4	4	1	29	21	2	2				1	7	71
Yellow-rumped Warbler	5	7	2	13	23	3	1	5	2		5	5	71
Dark-eyed Junco		1	6	9	14	3	1	14	2		7	5	62
Swainson's Thrush	2	2		18	16		1	5	5		5	2	56
Gray Jay		1		12	8	2		2	1		3	1	30
Boreal Chickadee	1		2	7		6		2			4		22
Ruby-crowned Kinglet			1	4	5	1		2	1		4		18
Varied Thrush		1	2	4	6		1	1				1	16
Hammond's Flycatcher	1				11								12
Alder Flycatcher		1		3							1	4	9
Redpoll Sp.				6	1					1			8
Hairy Woodpecker			1		1							1	3
American Wigeon											2		2
Mallard											2		2
Orange-crowned Warbler				1	1								2
Picoides species		1			1								2
Blackpoll Warbler												1	1
Bohemian Waxwing				1									1
Bufflehead											1		1
Hermit Thrush				1									1
Northern Shoveler											1		1
Red-breasted Nuthatch					1								1
Yellow Warbler					1								1
Total Abundance	13	18	15	108	110	17	6	31	11	1	36	27	393
Total Diversity	5	8	7	13	14	6	5	7	5	1	12	9	23
Total Number of Points	6	14	6	30	48	4	2	16	4	8	14	12	164
Mean Abundance (Birds/Point)	2.2	1.3	2.5	3.6	2.3	4.3	3.0	1.9	2.8	0.1	2.6	2.3	2.4

Table 16 - Detection distance and percent occurrence of birds at Bonanza Creek, Rosie Creek, and West Site in 2002-2003.

Bonanza Creek Distance	**Number**	**(Percent)**	**(Total)**	**Rosie Creek Distance**	**Number**	**(Percent)**	**(Total)**	**West Site Distance**	**Number**	**(Percent)**	
0 – 10 m	13	(0.01)		0 – 10 m	10	(0.01)		0 – 10 m	8	(0.01)	
10 – 20 m	64	(0.04)		10 – 20 m	42	(0.03)		10 – 20 m	41	(0.03)	
20 – 30 m	68	(0.04)		20 – 30 m	103	(0.08)		20 – 30 m	86	(0.07)	
30 – 40 m	151	(0.09)		30 – 40 m	113	(0.09)		30 – 40 m	127	(0.11)	
40 – 50 m	143	(0.09)	(0.27)	40 – 50 m	128	(0.10)	(0.31)	40 – 50 m	110	(0.09)	(0.31)
50 – 60 m	121	(0.07)		50 – 60 m	119	(0.09)		50 – 60 m	90	(0.08)	
60 – 70 m	96	(0.06)		60 – 70 m	118	(0.09)		60 – 70 m	89	(0.07)	
70 – 80 m	109	(0.07)		70 – 80 m	101	(0.08)		70 – 80 m	72	(0.06)	
80 – 90 m	79	(0.05)		80 – 90 m	57	(0.04)		80 – 90 m	44	(0.04)	
90 – 100 m	107	(0.07)	(0.32)	90 – 100 m	94	(0.07)	(0.37)	90 – 100 m	83	(0.07)	(0.32)
100 – 125 m	87	(0.05)		100 – 125 m	78	(0.06)		100 – 125 m	56	(0.05)	
125 – 150 m	52	(0.03)	(0.08)	125 – 150 m	40	(0.03)	(0.09)	125 – 150 m	23	(0.02)	(0.07)
> 150 m	256	(0.16)	(0.16)	> 150 m	134	(0.10)	(0.10)	> 150 m	162	(0.13)	(0.13)
Flyover	288	(0.18)	(0.18)	Flyover	151	(0.12)	(0.12)	Flyover	217	(0.18)	(0.18)
Total	**1634**	**(1.00)**	**(1.00)**		**1288**	**(1.00)**	**(1.00)**		**1208**	**(1.00)**	**(1.00)**

Table 17 – Habitat features at points where Townsend's Warbler was present and absent at points in Bonanza Creek, Rosie Creek, and the West Site in 2002-2003. Values represent mean ± SD.

Variable	Present	Absent
Bare cover	1.16 ± 0.8	1.03 ± 0.2
Birch height	0.75 ± 0.2	0.57 ± 0.3
Dead cover	0.20 ± 0.1	0.20 ± 0.1
Graminoid cover	2.67 ± 0.8	2.66 ± 1.0
Lichen cover	2.05 ± 0.4	2.29 ± 0.6
Litter cover	4.03 ± 0.7	3.77 ± 1.0
Moss cover	3.97 ± 0.9	3.81 ± 1.0
White spruce height	0.89 ± 0.1	0.72 ± 0.3
Black spruce height	0.03 ± 0.1	0.11 ± 0.2
Aspen height	0.28 ± 0.3	0.28 ± 0.3
Slope	14.76 ± 7.6	10.31 ± 7.1
Shrub percent cover	0.44 ± 0.1	0.46 ± 0.2
Tree percent cover	0.68 ± 0.1	0.65 ± 0.1

Table 18 – Habitat features at points where Varied Thrush was present and absent at points in Bonanza Creek, Rosie Creek, and the West Site in 2002-2003. Values represent mean ± SD.

Variable	Present	Absent
Bare cover	1.00 ± 0.0	1.04 ± 0.3
Birch height	0.71 ± 0.2	0.59 ± 0.3
Dead cover	0.20 ± 0.1	0.20 ± 0.1
Graminoid cover	2.17 ± 0.3	2.67 ± 1.0
Lichen cover	2.50 ± 1.0	2.26 ± 0.6
Litter cover	3.50 ± 0.5	3.80 ± 1.0
Moss cover	4.50 ± 0.9	3.82 ± 1.0
White spruce height	0.83 ± 0.1	0.74 ± 0.3
Black spruce height	N/A*	0.10 ± 0.2
Aspen height	0.29 ± 0.3	0.28 ± 0.3
Slope	16.00 ± 8.9	10.77 ± 7.2
Shrub percent cover	0.41 ± 0.1	0.46 ± 0.2
Tree percent cover	0.72 ± 0.1	0.66 ± 0.1

* N/A denotes habitat variable not detected at point.

DISCUSSION

1. Aspen study

The treatment and modification of aspen-dominated forests for Ruffed Grouse did not appear to have a negative impact on breeding songbirds. In fact, based on the relative abundance and diversity of bird species, the treatment site appeared to enhance both the abundance and diversity of the bird community. In general, the opening of aspen forests through logging and burning created a greater diversity of habitats, leading to a richer, more abundant bird community. This was apparent, given that the difference between bird communities in the control and treatment sites was largely due to the presence of early-successional, open-canopy species in the treatment site.

Ruffed Grouse benefit from the creation of shrub-dominated, early-successional forest habitats with high stem densities (Dessecker and McAuley 2001). By directly manipulating habitats, local populations of grouse may reach levels substantially greater than those occupying mature forests (Gullion 1984). Research in central Pennsylvania, encompassing over twenty years of study, has addressed changes in species composition, richness, and distributions of breeding songbirds following Ruffed Grouse habitat manipulations (Yahner 1993, 1997, 2000). In general, detrimental effects to species richness in the long-term are not associated with small-scale forest management practices, and habitat management can and does provide suitable conditions for many breeding bird communities, especially those adapted to edge or brushy conditions (Yahner 1986a, 1986b, 1987, 1991, 1993, 1997). Following habitat modification, guild structure and composition may change; however, there may be no detectable change in the overall richness of the bird community (Crawford et al. 1981, Freedman et al. 1981, and Maurer et al. 1981).

While overall bird community richness and composition did not differ between the treatment and control using data from both years combined, differences were more significant between specific years. In 2002, the bird community in the treatment site was significantly more diverse and contained more individuals than the control site. In 2003, the communities were much more similar and differences were not significant. Given the highly variable nature of bird populations, especially at high latitudes, differences between sites might possibly be attributed to inter-annual variation. Considering that early-successional habitat is much more variable on the landscape, populations of bird species that inhabit these forest types may also be temporally variable. The quality or suitability of the early-successional habitat may have been so ephemeral that this may have resulted in the lack of significant differences in community metrics between the two sites in 2003.

2. Spruce study

Bird communities that inhabit older spruce-dominated forests appear to be remarkably similar between sites in the Tanana Valley State Forest. In general, these communities were very diverse and often contained bird species that were unique to this stand type. Compared to our unmodified aspen site, diversity and abundance in continuous white spruce-dominated stands was substantially higher. While this result is likely meaningful, detectability of birds is lower in aspen stands than white spruce stands (Scheick 1997). Within white spruce-dominated forests, abundance and diversity were consistently highest in stands of saw-class, or older-aged forest.

Our results suggest that Townsend's Warblers were associating with sites that had a greater proportion of exposed bare ground, lower forb cover, taller white spruce trees, and steeper slopes. Based on each of the annual models, taller birch trees may also be important to Townsend's Warblers, though this was not apparent in the combined model. Other research suggests a similar association with mature coniferous and mixed coniferous forests throughout the species' breeding range (Bent 1953, Spindler and Kessel 1980, Mannan and Meslow 1984, Kessler and Kogut 1985, Curson et al. 1994, and Hejl et al. 1995). In Alaska, Townsend's Warbler nest placement was in large white spruce trees (mean of 11.8 in dbh), primarily in areas of high-density large white spruce. Nest-site selection has is known to affect fitness by influencing productivity and survival (Martin and Roper 1988). Increased foliage density, an attribute often found in older white spruce forests, may provide concealment of nests and nestlings, thereby influencing site selection of nesting territories during the breeding season (Martin 1992, Steele 1993, Matsuoka et al. 1997a). Townsend's Warblers also select steeper slopes, since steeper slopes may provide more optimal growing conditions for white spruce (Viereck and Little 1972). Unlike the results of Matsuoka et al. (1997a), we found a positive, albeit weak relationship between spruce tree height and slope ($r_s = 0.04$, df = 245, $P < 0.01$). Steeper slopes may also facilitate easier nest or mate defense, provide a more favorable microclimate for arthropods, or aid in the thermoregulation of adults and nestlings (Matsuoka et al. 1997). Given the concordance of our model results with those of Matsuoka et al. (1997a), especially with regard to taller white spruce trees on steeper slopes, the management of this species in the Alaskan interior warrants the maintenance of these habitat attributes on the landscape. While these results suggest that the management of upland white spruce forests is essential for the maintenance of this species, the ecological value of floodplain white spruce remains unknown. Both Benson (1999) and Johnson (1999) failed to detect Townsend's Warblers in white spruce stands on the floodplain, despite the presence of large-diameter spruce.

Given their relatively low overall abundance and variability between years, we were largely unsuccessful in identifying habitat associations for the Varied Thrush in interior Alaskan spruce forests. Despite low overall predictive power, points with taller white birch trees, denser ground-level moss cover, and steeper slopes were selected for by the Varied Thrush in 2003. We suspect, however, that these results may be spurious and should be interpreted cautiously. The apparent association between the Varied Thrush and ground-level moss cover may be legitimate in that the species has been described as preferring darker, shaded, mossy forests (Grinnell and Miller 1944, Campbell et al. 1997). Our results indicating that the Varied Thrush might be selecting for taller birch trees was difficult to interpret. Beck and George (2000) identified larger diameter coniferous trees as important for the Varied Thrush in California. Despite this association between taller spruce trees and Varied Thrushes in other areas, we failed to find an association between the two in this study. Given the apparent association between steeper slopes and taller spruce in this study, steeper slopes may provide a surrogate measure of taller spruce trees.

CONCLUSIONS

The treatment and modification of aspen-dominated forests for Ruffed Grouse did not appear to have a negative impact on breeding songbirds. In fact, based on the relative abundance and diversity of bird species, the treatment site appeared to enhance both the abundance and diversity of the bird community. In general, the opening of aspen forests through logging and burning created a greater diversity of habitats, leading to a richer, more abundant bird community.

Bird communities that inhabit older spruce-dominated forests appear to be remarkably similar between sites in the Tanana Valley State Forest. In general, these communities were very diverse and often contained bird species that were unique to this stand type. Compared to our unmodified aspen site, diversity and abundance in continuous white spruce-dominated stands was substantially higher. Within white spruce-dominated forests, abundance and diversity were consistently highest in stands of saw-class or older-aged forest.

Our results suggest that Townsend's Warblers were associating with sites that had a greater proportion of exposed bare ground, lower forb cover, taller white spruce trees, and steeper slopes. Despite low overall predictive power, points with taller white birch trees, denser ground-level moss cover, and steeper slopes may be important for the Varied Thrush.

MANAGEMENT CONSIDERATIONS AND RECOMMENDATIONS

General Recommendations

As with most small-scale studies on the effects of habitat modification on bird communities or populations in the boreal forest, responses are often measured using changes in species density or relative abundance. While being logistically and economically feasible, comparisons using only density or relative abundance may be misleading (Van Horne 1983). Certain species often occur at the greatest density or abundance in habitats where they are least reproductively successful (Vickery et al. 1992, Purcell and Verner 1998, Hannah 2000). While results from this study may provide important baseline information for effects of habitat and species management, validation of these results through more detailed population studies seems warranted. In this regard, assessments of productivity or habitat quality are essential in directing future management plans.

Aspen study

In order to better manage for Ruffed Grouse populations and other, non-game species, identifying the optimal habitat enhancement techniques (e.g. burning, felling, or birch sale) would be beneficial. Again, assessments of habitat quality or productivity for grouse should be compared to non-game species to maximize benefits and reduce detrimental effects of certain management techniques. Given the differences in bird communities between years, based on abundance and diversity, a third year of data collection may be warranted. With an additional year of data, we may be able to more accurately identify if these differences are a result of inter-annual variation in bird population numbers or as a function of habitat changes and succession.

Spruce study

The models developed in this study are rather crude, given that they associate habitat variables with species presence at an accuracy of 50 m. Habitat variables within the 50 m radius are averaged, resulting in fairly crude habitat associations. Given that habitat selection can often function at the scale of the individual tree, results from this study, while potentially accurate, may be misleading. Future studies should identify habitat variables first, based on their ecological function, and secondly, measuring directly the actual habitat that is used. For instance, identifying habitat used for nesting or foraging and measuring it directly, compared to random points, would be a more valuable tool in assessments of habitat quality or suitability (Matsuoka et al. 1997b). While results from this study are not definitive, they complement existing knowledge on the distribution, abundance, and habitat associations of forest birds in interior Alaska.

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Appendix I

List of species observed in the Tanana Valley Forest 2002-2003.

Horned Grebe (*Podiceps auritus*)
Green-winged Teal (*Anas crecca*)
Mallard (*Anas platyrhynchos*)
Northern Shoveler (*Anas clypeata*)
American Wigeon (*Anas americana*)
Bufflehead (*Bucephala albeola*)
Sharp-shinned Hawk (*Accipiter striatus*)
Northern Goshawk (*Accipiter gentilis*)
Red-tailed Hawk (*Buteo jamaicensis*)
Rough-legged Hawk (*Buteo lagopus*)
American Kestrel (*Falco sparverius*)
Merlin (*Falco columbarius*)
Ruffed Grouse (*Bonasa umbellus*)
Sandhill Crane (*Grus canadensis*)
Lesser Yellowlegs (*Tringa flavipes*)
Solitary Sandpiper (*Tringa solitaria*)
Wilson's Snipe (*Gallinago delicata*)
Great Horned Owl (*Bubo virginianus*)
Northern Flicker (*Colaptes auratus*)
Yellow-bellied Sapsucker (*Sphyrapicus ruber*)
Downy Woodpecker (*Picoides pubescens*)
Hairy Woodpecker (*Picoides villosus*)
Three-toed Woodpecker (*Picoides tridactylus*)
Olive-sided Flycatcher (*Contopus cooperi*)
Western Wood-Pewee (*Contopus sordidus*)
Alder Flycatcher (*Empidonax alnorum*)
Hammond's Flycatcher (*Empidonax hammondii*)
Tree Swallow (*Tachycineta bicolor*)
Bank Swallow (*Riparia riparia*)
Gray Jay (*Perisoreus canadensis*)
Common Raven (*Corvus corax*)
Black-capped Chickadee (*Poecile atricapilla*)
Boreal Chickadee (*Poecile hudsonicus*)
Red-breasted Nuthatch (*Sitta canadensis*)
Brown Creeper (*Certhia americana*)
Ruby-crowned Kinglet (Regulus calendula)
Swainson's Thrush (*Catharus ustulatus*)
Hermit Thrush (*Catharus guttatus*)
American Robin (*Turdus migratorius*)
Varied Thrush (*Ixoreus naevius*)
Bohemian Waxwing (*Bombycilla garrulus*)
Orange-crowned Warbler (*Vermivora celata*)
Yellow Warbler (*Dendroica petechia*)
Yellow-rumped Warbler (*Dendroica coronata*)
Townsend's Warbler (*Dendroica townsendi*)
Blackpoll Warbler (*Dendroica striata*)
Wilson's Warbler (*Wilsonia pusilla*)
Savannah Sparrow (*Passerculus sandwichensis*)
Fox Sparrow (*Passerella iliaca*)
Lincoln's Sparrow (*Melospiza lincolnii*)
White-crowned Sparrow (*Zonotrichia leucophrys*)
Dark-eyed Junco (*Junco hyemalis*)
White-winged Crossbill (*Loxia leucoptera*)
Pine Siskin (*Carduelis pinus*)