
Breeding Bird Communities in the Forests of the Liard River Valley, Yukon

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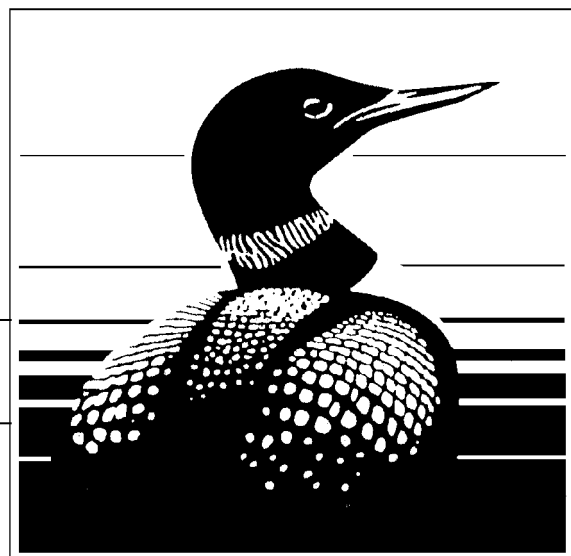
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ABSTRACT

The goals of this study were: 1) to identify avian communities associated with forested habitats in the Liard River Valley, and 2) to identify specialist species which exhibit restricted habitat use and are therefore most threatened by alterations to the natural landscape. We used fixed-radius point counts (75 metre radius) to survey breeding bird communities in six different forested habitats and cutblocks in the Liard River Valley, Yukon. A total of 1375 detections of 51 species were made during 294 point counts at 147 census points. Some of the most common species were Yellow-rumped Warbler (195 detections), White-winged Crossbill (179 detections), Chipping Sparrow (102 detections), Dark-eyed Junco (99 detections), Swainson's Thrush (68 detections) and Boreal Chickadee (62 detections). We found that different habitat types in the Liard River Valley are characterized by distinct and different avian communities. Mature White Spruce forest, which is the habitat most threatened by logging, is important for cavity nesters as well as Golden-crowned Kinglets. Riparian forests in the valley are very rich and diverse, and support most of the habitat specialists identified in the area. Cutblocks support lower densities and diversity of birds than any forest type. The current management regime is likely to have negative impacts on habitat specialists associated with White Spruce forest. Our recommendations direct forest managers to: 1) Establish a network of protected areas within the Liard River Valley, representing all forest types. 2) Revise timber management guidelines to recognize the value of the full range of riparian types, and require larger harvest-free treed buffers. 3) Since old-growth forest appears to support so many specialist species, while cutblocks do not appear to provide rich bird habitat, management practices should be altered to incorporate old-growth reserves, a much longer rotation as well as alternatives to clear-cut logging, such as selection logging.

RESUME

L'étude faisant l'objet du présent rapport visait un double objectif : 1) identifier les communautés aviennes peuplant les habitats forestiers de la vallée de la rivière Liard et 2) identifier les espèces spécialisées qui utilisent un habitat restreint, et qui sont par conséquent le plus menacées par l'altération du paysage naturel. Nous avons effectué des dénombrements des oiseaux nicheurs à des endroits déterminés, sur 75 mètres de rayon, dans six habitats forestiers différents, ainsi que dans des parterres de coupe du bois, dans la vallée de la rivière Liard, au Yukon. Au total, nous avons réalisé 294 dénombrements à partir de 147 points, de qui nous a permis de recenser 1 375 individus appartenant à 51 espèces. Voici quelques-unes des espèces les plus communes : Paruline à croupion jaune (195 individus), Bec-croisé bifascié (179), Bruant familial (102), Junco ardoisé (99), Grive à dos olive (68), Mésange à tête brune (62). Nous avons constaté que, dans la vallée de la rivière Liard, différentes communautés d'oiseaux distinctes occupent différents types d'habitat. La forêt d'épinettes blanches arrivées à maturité, soit l'habitat le plus menacé par l'exploitation, est un habitat important pour les espèces qui nichent dans des cavités ainsi que le Roitelet à couronne dorée. Les forêts riveraines, qui présentent une grande richesse et une grande diversité, accueillent la plupart des espèces spécialisées observées dans la région. C'est dans les parterres de coupe que la densité et la diversité de l'avifaune sont les moins élevées. Le régime d'aménagement forestier actuel aura vraisemblablement des répercussions négatives sur les habitats des oiseaux spécialisés associés à la forêt d'épinettes blanches. Nous faisons les recommandations suivantes aux aménagistes forestiers : 1) Créer dans la vallée de la Liard un réseau de zones protégées représentant tous les types de forêt. 2) Réviser les lignes directrices concernant la gestion des matières ligneuses, de manière à reconnaître la valeur de l'ensemble des types d'habitats riverains et à préserver de plus vastes zones tampon boisées contre l'exploitation. 3) Puisque la vieille forêt semble accueillir un si grand nombre d'espèces spécialisées, alors que les parterres de coupe ne semblent pas fournir un habitat riche en oiseaux, il faudrait modifier les pratiques d'aménagement afin d'intégrer les vieux peuplements, allonger sensiblement le cycle d'exploitation de la forêt et trouver d'autres modes d'exploitation que la coupe à blanc, notamment la coupe sélective.

INTRODUCTION

Much of the Yukon's richest forests are found in the Liard River Valley in the southeastern part of the territory. The forest habitats along the Liard River and its tributaries are among the territory's most productive for birds, wildlife and plant species, many of which are not found elsewhere in the territory. In the Yukon there is considerable public concern for the effect of industrial forestry on wildlife communities. Increased logging activity in the Liard River Valley has resulted in significant alterations to the natural landscape in the form of clearcuts and new roads with little understanding of the effects on bird, wildlife and plant communities. At present, mature White Spruce (*Picea glauca*) forests account for most of the harvest. In areas managed for timber production it is critical to identify the avian communities and specialist species associated with natural forest habitats. While some generalist forest bird species can meet their habitat requirements across a variety of habitats, specialist species tend to be strictly limited by the availability of particular habitat types and may entirely disappear from an area when their required habitats are lost. Väisänen and co-workers (1986) indicated that human-caused habitat alterations in boreal regions can dramatically affect local bird populations; natural bird communities are lost while generalist species sometimes extend their ranges by colonizing new habitats.

To date, there has not been a systematic study of the association between bird communities and forested habitats in the Liard River Valley. The goals of this study were: 1) to identify avian communities associated with forested habitats in the Liard River Valley, and 2) to identify specialist species which exhibit restricted habitat use and are most likely to be threatened by alterations to the natural landscape. Without careful planning, the Liard River Valley's unique natural complex of habitats and associated bird communities may be lost. Resource managers who recognize that a different avian community is associated with each habitat and understand the habitat requirements of specialist species, can implement management practices which maintain a region's natural avian diversity.

METHODS

Study Area

Our study focused on the forests of the Liard River Valley in southeastern Yukon. The area lies within the traditional territory of the Kaska First Nation and is part of the Liard Basin Ecoregion of the Boreal Cordilleran Ecozone (Ecological Stratification Working Group 1995; Ellis and Peepre 1995). Our surveys were conducted between Watson Creek (60° 07'N/128° 57'W) and the Meister River (60° 20'N/129° 30'W) area along the Liard River, and along the lower Rancheria River from 60° 13'N/129° 18'W to the Liard River (Figure 1). The area supports some of the Yukon's most productive forests, as well as diverse and abundant bird life (Appendix A and Appendix B), wildlife (Appendix C) and plant communities (Appendix D). The forests are dominated by White Spruce (*Picea glauca*), Black Spruce (*Picea mariana*), Trembling Aspen (*Populus tremuloides*), Lodgepole Pine (*Pinus contorta*), and Balsam Poplar (*Populus balsamifera*). Other less common tree species are White Birch (*Betula glandulosa*), Larch (*Larix laricina*), and very rarely fir (*Abies* sp.). The area is highly valued by a variety of users including First Nations, trappers, fishers, campers, wildlife viewers, and hunters. While there has been some logging in the area for many years, over the last ten years industrial forestry operations have increased greatly resulting in intense pressure on the mature White Spruce forests.

Habitat Types

We surveyed seven habitat types including four habitats characterized by a dominant tree species (basal area > 60% of total): mature *White Spruce*, *Lodgepole Pine*, *Trembling Aspen*, and *Balsam Poplar*. In addition, we surveyed mature *Mixed* forests which are characterized by a mix of co-dominant tree species, as well as *Riparian* forests which are characterized by complex forested habitats and shrubs directly adjacent to rivers. We also surveyed recently logged *Cutblocks*. Specific survey sites were chosen based on how the forest appeared to conform to our seven habitat types. The choice of survey sites was limited by accessibility.

To better document variation in riparian bird communities we classified our 26 Riparian census points into three riparian types: 1) *Large streams* (>5 metres wide) which included 10 points along the main channel of the Liard River and 2 points along the Meister River; 2) *Small streams* (<5 metres wide) which included 8 points along a small creek flowing into the Rancheria River; 3) *Back-channel* which included 6 points on very slow flowing (or non-flowing) back-channels

off of the Liard River. We used the timber management guidelines for the Yukon (Forest Resources 1995) to define “large” and “small” streams, and added the third category, back-channel which was not specifically recognized by Forest Resources (1995) timber management guidelines.

Bird Surveys

We established 147 census points in the seven habitat types (see Tables 1 and 2). Census points were established along transects and were at least 150 metres apart and at least 75 metres from the nearest edge or major habitat break. We used 10 minute point counts during which the observer stood at the point and recorded all birds detected by sight or sound within 75 metres. All counts were conducted by C. Eckert and P. Sinclair between 5:00 am. and 9:30 am., and each point was visited twice between 29 May and 29 June 1994. The two observers were switched between points for the second set of counts to control for observer bias.

Birds that did not exhibit a direct association with the surveyed habitat (e.g. birds flying well above the canopy) were excluded from further analysis but included in Appendix A. As well, other groups of species such as grouse, ducks, raptors, shorebirds and swallows which are not effectively surveyed using point counts were recorded on counts, but excluded from further analyses and discussion.

For each species in each habitat type, we determined the “mean maximum” number of birds per point by taking the greater number of detections from the two counts at each point, and calculating the mean of these maxima. Values for the “mean number of birds per point” in the tables, figures, and text are based on the “mean maximum”. The “total” number of birds (all species) at each point was defined as the sum of the higher count for each species. Thus the “total” gives an indication of the total number of birds at the point, including birds detected on both counts. We used these values to calculate the mean “total” number of birds per point for each habitat (Table 1, Table 3). The “high count” of all species at each point was defined as the greater number of birds detected at the point during one of the two counts. Thus the “high count” is the maximum number of birds recorded at the point during one count (Table 1, Table 3). We excluded White-winged Crossbill detections from our calculations of the total number of birds per point and “high count”. This was done because relatively large flocks of White-winged

Crossbills which were recorded at some census points significantly altered the resulting totals for the corresponding habitat type.

We used the data presented in Table 1 to calculate the relative proportion of detections which occurred in each habitat type for each species. To do this we divided the mean number of birds per point by the sum of the mean number of birds per point across habitats (Table 2). Since these values are based on detections per point they are not affected by the number of census points in each habitat. Values for “total” do not include White-winged Crossbill detections.

We use the terms “generalist” and “specialist” to describe the occurrence of species across our broad habitat types. We used the data presented in Table 2 to identify “specialist species”, which we defined as species for which at least 0.70 of detections were within one or two habitat types.

Vegetation Surveys

In order to generally describe the vegetation characteristics associated with each habitat type we established three 10 metre x 10 metre vegetation sampling quadrats at 102 of the 147 census points (see Table 4). Quadrats were arranged with one quadrat at the centre (using the centre of the census point as a corner point for the quadrat) and the other two placed 40 metres from the centre in a randomly chosen primary compass direction (either north, south, east or west). Figure 2 shows one possible configuration of the basic sampling design.

Within each quadrat we counted the number of live trees and standing dead trees (snags) of each species and the number of seedlings and saplings (< 2cm DBH) for each tree species. We recorded the diameter at breast height (DBH) for every live tree and snag with a DBH of at least 7 cm. Trees with a DBH of at least 2 cm but less than 7 cm were counted but the DBH was not recorded. We visually estimated the percent cover of bare ground, litter, herb, moss/lichen, dwarf shrub (<0.5m), low shrub (0.5-2m), and tall shrub (>2m). We also recorded dominant plant species for each cover type.

One side of each quadrat was randomly selected for a 10 metre coarse woody debris transect. The diameter was recorded for each piece of coarse woody debris lying on the transect.

We used the DBH for each tree with a minimum DBH of 7 cm and the quadrat area (100 m²) to calculate the basal area per hectare ($BAH=m^2/ha$) for each tree species. Means and standard errors were calculated for all habitat parameters for each point and then for each habitat type. To calculate the percent of the basal area that each tree species contributed to the total we pooled the quadrats for each point and then calculated means.

We used K-means cluster analysis for vegetation data (percent basal area and mean DBH for each tree species) to support the assignment of each sampled point to one of four forest types (Balsam Poplar, Lodgepole Pine, White Spruce and Mixed Forest). Riparian points were defined by their immediate proximity to a river, creek or back-channel and Cutblock points were defined by the fact that the forest had recently been clearcut.

RESULTS

Vegetation Characteristics of Habitat Types

Table 4 summarizes the means and standard errors for all vegetation parameters measured for each habitat type. Dominant plant species (herbs, mosses, lichens and shrubs) recorded at each plot are summarized by habitat type in Appendix D.

Bird Observations

A total of 1375 detections of 51 species were made during 294 point counts at 147 census points (Table 1). Some of the most common species were Yellow-rumped Warbler (195 detections), White-winged Crossbill (179 detections), Chipping Sparrow (102 detections), Dark-eyed Junco (99 detections), Swainson's Thrush (68 detections) and Boreal Chickadee (62 detections). Table 1 and Figure 3 (a-ad) summarize the mean maximum number of birds per point with standard errors for each species by habitat type. We graphed (Figure 3a-ad) only those species with at least 5 detections. The total number of detections for 11 species which are poorly surveyed using point counts (1 falcon, 1 swallow, 1 raven, 2 grouse, 4 sandpipers and 2 ducks) are included at the bottom of Table 1 but were not analyzed by habitat or included in further data summaries. The total number of species detected in a particular habitat type ranged from 13 species in Cutblocks to 31 species in Riparian (Table 1); and the mean total number of birds detected per point (the sum of the maximum value of the two counts for each species) ranged from 3.3 birds

per point in Cutblocks to 9 birds per point in Balsam Poplar forest (Table 1). Table 2 summarizes the relative proportion of detections accounted for by each habitat type, for each species.

Appendix A lists common and scientific names for 104 species observed in the study area during our study (29 May to 27 July 1994), and Appendix B provides field accounts of four rare species (Solitary Vireo, Winter Wren, Lark Sparrow and Eastern Kingbird) observed during our study.

Bird Communities and Vegetation Characteristics across Habitat Types

Trembling Aspen

Vegetation Characteristics: Trembling Aspen forests were on relatively dry upland sites while Balsam Poplar forests were on wet floodplains in lowland areas, and as such we did not group Trembling Aspen and Balsam Poplar as one “deciduous” forest type. Trembling Aspen forests had a greater mix of other tree species than the other “species defined” habitat types surveyed (White Spruce, Balsam Poplar and Lodgepole Pine). Trembling Aspen forests (basal area) were composed of Trembling Aspen (64 ± 5 %), Lodgepole Pine (20 ± 6 %), and spruce species (5 ± 3 %). Trembling Aspen forests were similar to Lodgepole Pine forests in that Low Shrub cover (7.0 ± 1.3 %) and Tall Shrub cover (2.6 ± 0.6 %) were relatively low. Trembling Aspen forests had the highest total stem counts (2840 ± 249 stems/ha).

Bird Community: The total density of birds (5.1 ± 1.1 birds per point) was relatively low in Trembling Aspen; only Cutblocks had fewer birds per point. While Chipping Sparrows were found in most habitats, the density of this species in Trembling Aspen was at least 2.2 times higher than the densities recorded in other habitats (Fig.3w). Also the complete absence of Chipping Sparrows from Balsam Poplar forests highlights the different character of the bird communities associated with these two deciduous forest types. Trembling Aspen forests had the second highest density of Yellow-bellied Sapsuckers (Fig.3a). The relatively high mixture of spruce and Lodgepole Pine may have contributed to the presence of three species, Ruby-crowned Kinglet (Fig.3k), Boreal Chickadee (Fig.3h), and Pine Siskin (Fig.3ad) which are generally considered to be coniferous dwelling species. Other species found in Trembling Aspen forests included Yellow-rumped Warbler (Fig.3r), Warbling Vireo (Fig.3p), Dark-eyed Junco (Fig.3y), and Swainson’s Thrush (Fig.3l). One of the two Hairy Woodpecker detections occurred in Trembling Aspen forests (Table 1, Table 2).

Balsam Poplar

Vegetation Characteristics: Balsam Poplar forests are riparian, typically growing in the very moist flood plain and delta areas of the Liard River Valley. Balsam Poplar trees accounted for 89.7 ± 7 % of the basal area and had the largest diameter (max DBH=85cm) of any species that we measured. The mean diameter of Balsam Poplars found in these forests was 29.5 ± 2.0 cm. This forest type was characterized by the highest Low Shrub cover (67.4 ± 5.0 %) and Tall Shrub cover (36.3 ± 5.8 %) which provides birds with a very different vegetation structure than that of Trembling Aspen forests. Only White Spruce and Balsam Poplar seedlings and saplings were recorded in Balsam Poplar forests, with much higher counts for White Spruce seedlings (38 ± 33 stems/ha versus zero) and saplings (142 ± 56 stems/ha versus 14 ± 10 stems/ha). As well, White Spruce accounted for 10% of the basal area. White Spruce will likely succeed Balsam Poplar in these forests.

Bird Community: Balsam Poplar forests were characterized by the highest total density of birds (9.0 ± 1.0 birds per point). Species found in Balsam Poplar were Least Flycatcher (Fig.3e), Warbling Vireo (Fig.3p), American Redstart (Fig.3t), Northern Waterthrush (Fig.3u), Magnolia Warbler (Fig.3s), Varied Thrush (Fig.3n). The only woodpecker species recorded in Balsam Poplar forest, Yellow-bellied Sapsucker (Fig.3a), had its highest density in these forests. Hammond's Flycatchers occurred at relatively high densities with densities only slightly higher in Riparian forests (Fig.3f). Least Flycatcher was recorded only in Balsam Poplar and Riparian forests (Fig.3e). Other species found in Balsam Poplar forests were Yellow-rumped Warbler (Fig.3r), Swainson's Thrush (Fig.3l), White-throated Sparrow (Fig.3z), Gray Jay (Fig.3g), and Tennessee Warbler (Fig.3q). Our single observation of a Hermit Thrush was in Balsam Poplar forest (Table 1, Table 2).

Mature Lodgepole Pine

Vegetation Characteristics: Lodgepole Pine forests were found on the dry upland sites, often in association with Trembling Aspen forests. Lodgepole Pine forests (basal area) were composed of Lodgepole Pine (82.5 ± 4 %), Black Spruce (8.2 ± 2.5 %), Trembling Aspen (6.1 ± 2.1 %), and White Spruce (3.1 ± 1.8 %). These forests were similar to Trembling Aspen in that Low Shrub cover (6.9 ± 1.7 %) and Tall Shrub cover (4.4 ± 2.5 %) were relatively low. This forest type had relatively high total stem counts (2593 ± 194 stems/ha). Moss/Lichen cover (72.3 ± 3.2 %) was relatively high and was primarily composed of lichen, whereas Herb cover (10.1 ± 2.2 %) was well

below all other habitat types. The basal area per hectare of snags ($1.6 \pm 0.3 \text{ m}^2/\text{ha}$) was lower than other forested habitats but five times higher than Cutblocks.

Bird Community: The total density of birds (5.5 ± 0.4 birds per point) in Lodgepole Pine forests was slightly higher than Trembling Aspen forests but lower than other forested habitats. Yellow-rumped Warblers were found in all forested habitats, but were most common in Lodgepole Pine forests (Fig.3r). Dark-eyed Junco (Fig.3y), Gray Jay (Fig.3g), American Robin (Fig.3m), Bohemian Waxwing (Fig.3o), and Pine Grosbeak (Fig.3aa) also had their highest densities in Lodgepole Pine forests. One woodpecker species, Yellow-bellied Sapsucker, was found at relatively low density (Fig.3a) in Lodgepole Pine forests. Some other species found in Lodgepole Pine forests were Chipping Sparrow (Fig.3w), Ruby-crowned Kinglet (Fig.3k), Swainson's Thrush (Fig.3l), White-winged Crossbill (Fig.3ac), Boreal Chickadee (Fig.3h), and Varied Thrush (Fig.3n).

Mature White Spruce

Vegetation Characteristics: Mature White Spruce forests were a riparian forest type and are the primary forest type found along the Liard River. As the distance from the river increased, the Black Spruce component of the forests generally increased until the transition to pine. The other tree species found in White Spruce forests which accounted for nearly 20 % of the basal area were Black Spruce ($11.0 \pm 2.5 \%$), Trembling Aspen ($5.7 \pm 1.4 \%$), and Balsam Poplar ($1.1 \pm 0.8 \%$). This forest type had the largest mean diameter White Spruce ($22.7 \pm 0.9 \text{ cm}$), Balsam Poplar ($32.1 \pm 9.4 \text{ cm}$), and Trembling Aspen ($26.0 \pm 1.6 \text{ cm}$). These forests had the highest densities of White Spruce saplings ($880 \pm 141 \text{ stems/ha}$), and relatively high densities of White Spruce seedlings ($332 \pm 56 \text{ stems/ha}$). The densities of Black Spruce seedlings ($187 \pm 87 \text{ stems/ha}$) and saplings ($553 \pm 124 \text{ stems/ha}$) and Trembling Aspen saplings ($163 \pm 60 \text{ stems/ha}$) were also relatively high. These forests were characterized by the second highest Moss/Lichen cover ($87.0 \pm 1.8 \%$), and the highest Herb cover ($64.3 \pm 2.5 \%$), and Dwarf Shrub cover ($58.2 \pm 2.5 \%$). The total density of snags ($630 \pm 67 \text{ snags/ha}$) was the second highest and the mean basal area per hectare for snags ($9.9 \pm 1.0 \text{ m}^2/\text{ha}$) was higher than any other habitat type.

Bird Community: The total density of birds recorded in White Spruce forests (7.5 ± 0.4 birds per point) was slightly lower than in Balsam Poplar and Riparian forests but notably higher than Trembling Aspen, Lodgepole Pine and Mixed forests. Cavity nesters were more common in

White Spruce forests (1.6 ± 0.2 per point) than any other habitat type. Boreal Chickadee (Fig.3h), Golden-crowned Kinglet (Fig.3j), Three-toed Woodpecker (Fig.3b) and Pine Siskin (Fig.3ad) had their highest densities in White Spruce forests. As well, Golden-crowned Kinglet was only observed in association with the White Spruce component of two other forested habitats (Mixed and Riparian), and Three-toed Woodpecker was only observed in association with the White Spruce component of one other forested habitat (Riparian). Some other species found in White Spruce forests were Yellow-rumped Warbler (Fig.3r), White-winged Crossbill (Fig.3ac), Chipping Sparrow (Fig.3w), Dark-eyed Junco (Fig.3y), Swainson's Thrush (Fig.3l), Ruby-crowned Kinglet (Fig.3k), Yellow-bellied Sapsucker (Fig.3a), Tennessee Warbler (Fig.3q), Gray Jay (Fig.3g), Varied Thrush (Fig.3n), Red Crossbill (Fig.3ab) and Red-breasted Nuthatch (Fig.3i). Our single observation of a Winter Wren was in White Spruce forest (Table 1, Table 2).

Mature Mixed Forest

Vegetation Characteristics: Much of the mature forests in the Liard River Valley are not dominated by one tree species, but are characterized by a more even mix of tree species. The total basal area of the Mixed forests that we surveyed included Black Spruce (35.7 ± 5.3 %), White Spruce (27.8 ± 4.1 %), Trembling Aspen (19.4 ± 4.2 %) and Lodgepole Pine (16.1 ± 3.4 %). These forests had very high sapling counts (2053 ± 567 stems/ha) which were dominated by Black Spruce (1121 ± 256 stems/ha) and White Spruce (684 ± 208 stems/ha). Seedling counts were also dominated by White Spruce (124 ± 53 stems/ha) and Black Spruce (103 ± 36 stems/ha). This forest type had relatively high snag counts (527 ± 62) and the second highest snag basal area per hectare (5.99 ± 0.96). Mixed forest had the highest Moss/Lichen cover (89 ± 1 %).

Bird Community: The total density of birds in Mature Mixed forests (6.4 ± 0.6 birds per point) was higher than Trembling Aspen and Lodgepole Pine forests but lower than White Spruce, Balsam Poplar and Riparian forests. Mixed forests had the second highest density of cavity nesters (0.9 ± 0.3 per point); only White Spruce forests were higher. Ruby-crowned Kinglet (Fig.3k), Swainson's Thrush (Fig.3l), Red Crossbill (Fig.3ab), and Red-breasted Nuthatch (Fig.3i) had their highest densities in Mixed forest. One species of woodpecker, Yellow-bellied Sapsucker (Fig.3a), was recorded in Mixed forests. Some other species found in Mixed forests were White-winged Crossbill (Fig.3ac), Yellow-rumped Warbler (Fig.3r), Boreal Chickadee (Fig.3h), Dark-eyed Junco (Fig.3y), Chipping Sparrow (Fig.3w), Gray Jay (Fig.3g), and Warbling Vireo (Fig.3p).

Riparian Forest

Vegetation Characteristics: Riparian forests were generally characterized by a mixture of early successional and mature forest components. Low Shrub cover (42 ± 4 %) and Tall Shrub cover (33 ± 4 %) were relatively high. The tree species composition (basal area) was generally a mix of mature White Spruce (48 ± 7 %) and Balsam Poplar (47 ± 7 %). As well, White Spruce and Balsam Poplar accounted for 53% and 38% of the saplings and 70% and 29% of the seedlings. Our estimates of Bare ground (11 ± 3 %) correspond with the flooding that often occurs at the edges of these forests. The higher component of early successional stages found in these forests was reflected in the relatively low mean basal area of snags (2.78 ± 0.68 m²/ha).

Bird Community: We found the second highest total density of birds (7.9 ± 0.7 birds per point) in Riparian forests. Species which had their highest density in Riparian forests were White-winged Crossbill (Fig.3ac), Hammond's Flycatcher (Fig.3f), Alder Flycatcher (Fig.3d), Tennessee Warbler (Fig.3q), and Wilson's Warbler (Fig.3v). Two species, Three-toed Woodpecker (Fig.3b) and Golden-crowned Kinglet (Fig.3j), which were most common in mature White Spruce forests, were also found in association with White Spruce in the Riparian forests. Similarly, Least Flycatchers which were most commonly found in Balsam Poplar forests, were found in association with Balsam Poplar in Riparian forests (Fig.3e). Other species commonly found in Riparian forests were Warbling Vireo (Fig.3p), Chipping Sparrow (Fig.3w), Yellow-rumped Warbler (Fig.3r), Swainson's Thrush (Fig.3l), American Redstart (Fig.3t), Dark-eyed Junco (Fig.3y), White-throated Sparrow (Fig.3z), Northern Waterthrush (Fig.3u), Lincoln's Sparrow (Fig.3x), Gray Jay (Fig.3g), and Magnolia Warbler (Fig.3s). As well, our single observation of a McGillivray's Warbler was in riparian shrubs (Table 1, Table 2).

Table 3 summarizes the mean maximum number of birds per point for each species by three riparian types. While we recognize that our sample sizes for each type was relatively small, we did find considerable variation in species composition across riparian types. Least Flycatcher and Yellow Warbler were primarily found at Large Stream points. Boreal Chickadee, Golden-crowned Kinglet, Ruby-crowned Kinglet, Three-toed Woodpecker, and White-winged Crossbill were relatively common on Small Stream and Back-channel points, but were not detected on Large Stream points. Magnolia Warbler, and Alder Flycatcher were most common on Back-channel points.

Cutblocks

Vegetation Characteristics: All Cutblocks had been harvested by clearcut logging and had recently been mechanically prepared for planting. The previous forest cover had been mature White Spruce forest and in general cutblocks were characterized by post-harvest slash and some dry shrub. While some larger deciduous trees, primarily Balsam Poplar, had been left standing, the total basal area of deciduous trees in cutblocks was only 7 % of that recorded in White Spruce forests. Similarly, some snags had been left standing but the basal area per hectare of snags found in Cutblocks ($0.31 \pm 0.16 \text{ m}^2/\text{ha}$) was well below the levels found in all forest types (3 % of that measured in mature White Spruce). Dwarf Shrub cover ($14.6 \pm 2.0 \%$), Low Shrub cover ($8.8 \pm 1.9 \%$) and Tall Shrub cover ($2.0 \pm 0.8 \%$) were all relatively low. While Herb cover ($43.9 \pm 3.6 \%$) was higher than Trembling Aspen and Lodgepole Pine forests, it was lower than that found in other forest types. Bare ground ($11.7 \pm 1.7 \%$) was highest here and virtually non-existent in all other habitat types except the flooded edges of Riparian forests. Moss/Lichen cover ($20.3 \pm 3.8 \%$) was relatively low and much of the moss found in Cutblocks were remnants from the previous forest and were either dead or dying. Post-harvest slash accounted for the relatively high counts ($6.6 \pm 0.5 /\text{ha}$) and large diameter ($16.5 \pm 1.0 \text{ cm}$) of Coarse Woody Debris. Many of the Cutblock sites had been planted with White Spruce and had relatively high densities of White Spruce seedlings ($515 \pm 80 \text{ stems/ha}$) and relatively low densities of White Spruce saplings ($180 \pm 70 \text{ stems/ha}$). The densities of Trembling Aspen seedlings ($746 \pm 244 \text{ stems/ha}$) and saplings ($362 \pm 141 \text{ stems/ha}$) were highest in Cutblocks.

Bird Community: Cutblocks had the lowest density of birds (3.3 ± 0.7 birds per point) of all habitat types and there was a complete absence of birds at four of the 22 Cutblock points. White-throated Sparrow (Fig.3z) and Lincoln's Sparrow (Fig.3x) had their highest densities in Cutblocks. The highest densities of Alder Flycatcher were found in both Cutblocks and Riparian forest (Fig.3d). Four cavity nesters, Mountain Bluebird, Northern Flicker, Yellow-bellied Sapsucker, and a single Hairy Woodpecker, were observed at low densities in association with scattered deciduous trees and spruce snags that had not been cut. This is consistent with other studies which have found that snag retention increases bird use of clearcuts (Dickson et.al. 1983). Some other species found in Cutblocks were Dark-eyed Junco (Fig.3y), Chipping Sparrow (Fig.3w), and American Robin (Fig.3m).

Habitat Specialist Species

We use the terms “generalist” and “specialist” to describe the occurrence of species across our broad habitat types. Generalists have a more even distribution across habitat types. This does not mean that generalist species do not have specific habitat requirements. Rather, “generalist” species may be able to find the habitat characteristics they require in a variety of broad habitat types as defined in this study. Examples of species which were more general in their occurrence across habitat types were Swainson’s Thrush (Fig.3l), Chipping Sparrow (Fig.3w), and Dark-eyed Junco (Fig.3y) which were present in relatively even densities and proportion of detections across the seven habitats we surveyed (Table 1, Table 2).

Table 5 summarizes the results for 21 specialist species which had at least 0.70 of their detections within 1 or 2 habitat types. We found that the bird communities in all 7 habitat classes included some specialist species. Of the 30 species with over 5 detections, three species had at least 0.70 of their detections in one habitat type: Least Flycatcher in Balsam Poplar, Pine Grosbeak in Lodgepole Pine, and Three-toed Woodpecker in White Spruce. An additional 18 species had at least 0.70 of their detections within 2 habitat types.

DISCUSSION

Bird species most likely to be negatively affected by habitat loss in the Liard River Valley are habitat specialists, particularly those associated with mature White Spruce forest. Every habitat type investigated in this study supported a distinct assemblage of bird species, each including habitat specialists. Thus the avian diversity found in the Liard River Valley is based on its mosaic of natural habitats, and alteration or removal of any specific habitat such as White Spruce forest will likely have a negative impact on the natural avian diversity found in the Liard River Valley. While some generalist forest bird species can satisfy their specific habitat requirements in a variety of broad habitat types, specialist species are limited by the availability of particular habitat types (Mannan and Meslow 1984). It is these specialist species which are most threatened by alterations to the natural landscape and may entirely disappear from an area when their required habitats are lost.

The habitat types defined in this study were quite broad, and did not allow us to detect all habitat associations. Some species occurred in a variety of habitats but may in fact have strong preferences on a micro-habitat scale. For example, although we recorded Yellow-bellied Sapsuckers in all habitats they appeared to be associated with patches of Trembling Aspen or Balsam Poplar within each broad habitat type. Accordingly, our single observation of sapsuckers in a Cutblock was of a pair of birds calling from a Balsam Poplar snag which had been left standing. Thus despite the occurrence of Yellow-bellied Sapsuckers in many habitat types, a micro-habitat based study would likely reveal that this species requires deciduous trees.

To date, the vast majority of forest harvested in the Liard River Valley has been alluvial White Spruce. Current forest management plans for the Liard River Valley call for replacing over 90% of the area's old-growth White Spruce with younger forests, using a 100 year rotation (Kaska Forest Resources Ltd., 1993). Our results show that mature White Spruce forests are very important to birds which nest in tree cavities; the highest density and highest proportion of detections of cavity nesters were found in these forests, and Three-toed Woodpecker in particular was a habitat specialist associated with White Spruce. Golden-crowned Kinglet was also a habitat specialist associated with White Spruce forests, and where both Golden-crowned Kinglet and Three-toed Woodpecker were detected in other habitat types, they were associated with White Spruce. This is consistent with other studies which have shown that populations of Golden-crowned Kinglet and cavity nesters are at risk with the loss of old-growth forest (Mannan and Meslow 1984). White Spruce forest also accounted for a relatively high proportion of detections for an additional five specialist species: Boreal Chickadee, Pine Siskin, Red-breasted Nuthatch, Red Crossbill, and Varied Thrush. If logging of the Liard River Valley's White Spruce forests continues at current rates, local populations of these seven species will likely decrease. Significant changes to the current forest management practices are required which recognize that old-growth White Spruce forests are essential breeding habitat for one of the Liard River Valley's distinct avian communities. These results underscore the need to maintain significant areas of unaltered natural habitat in order to provide for the species which depend on them. Much of the current logging activity in the Liard River Valley is in the riparian areas and many clearcuts extend to the river's edge. Our study concurs with many others which have shown that riparian forests are exceptionally rich and diverse (Thomas et al. 1979; Ohmart and Anderson 1982; Darveau et.al. 1995). Surveys of northeastern British Columbia have found that riparian White Spruce forests support a unique assemblage of warbler species (Siddle 1991; Enns and

Siddle 1993). The riparian and Balsam Poplar forests of the Liard River Valley had the highest densities of birds and were either the primary or secondary habitat for 16 of the 21 specialist species we identified. We found that three shrub dwelling species, Tennessee Warbler, Wilson's Warbler and Northern Waterthrush, use riparian shrubs but do not use clearcuts.

Current Yukon timber management guidelines require a 30 metre harvest-free treed buffer along large permanent watercourses (streams >5 metres wide) and a 15 metre harvest-free treed buffer on small permanent watercourses (streams 0.5 to 5 metres wide) (Forest Resources 1995). Our vegetation data for Riparian forests show that a 15 metre buffer creates on average a forest strip of only two trees at any given point along the buffer and will often result in a discontinuous buffer. While these buffers may afford some physical protection for the river bank, they likely do little to maintain productive riparian forest habitat and associated bird communities. Darveau and co-workers (1995) found that riparian buffers should be at least 60 metres wide to be of use to forest dwelling species such as the Golden-crowned Kinglet. Further, high rates of predation and parasitism within 50 metres of the forest edge (Paton 1994) indicate that intact forest buffers and corridors must be at least 100 metres wide to be of value to interior forest dwelling species. Yukon forest managers should implement requirements for significantly wider buffers (e.g. 60 - 100 metres) with the recognition that buffer strips are intended to minimize the impact of logging activities on riparian areas and do not constitute the larger old-growth forest reserves which are required by interior forest dwelling species.

Timber management guidelines for the Yukon require lower levels of protection for small rivers (15 metre harvest-free treed buffer), intermittent and ephemeral streams (no treed buffer required) and other vegetated wetland types are not granted specific protection by the guidelines (Forest Resources 1995). A policy of reduced levels of protection for small streams and a lack of protection for other wetland types is not consistent with the value of those habitats to riparian forests bird communities. We found that while some species dependent on riparian forests were associated with "large streams" such as the Liard and Meister Rivers, others were more predominant along smaller streams. Further, the levels of protection required by current timber management guidelines for riparian types (Forest Resources 1995) are the inverse of the total densities of birds we recorded in those riparian types. We found the highest densities of riparian birds associated with slow-flowing back-channels which are not specifically protected under current timber management guidelines. While our sample size was limited our results indicate

that forest bird species associated with riparian areas require the diversity of habitats associated with a variety of stream sizes as well as slow-flowing back-channels. The importance of riparian forests to the natural avian diversity of the Liard River Valley underscores the need to protect specific riparian areas. In the Yukon, timber management guidelines should be expanded to establish adequate harvest-free buffers of intact forest along all watercourses and wetland areas, including large and small streams, back-channels, sloughs, ephemeral and intermittent streams, small oxbow lakes and other wetland types.

While most of the current logging activity in the Liard River Valley is confined to the riparian forests, specifically mature White Spruce, logging operations are expanding into Lodgepole Pine forests. Elsewhere in Canada, Trembling Aspen and Balsam Poplar forests are the focus of intense harvesting. Our results show that there is variation in the density of birds across forested habitats, and that each forest type is characterized by a different avian community. Specialist species are associated with each of these forest types and thus each type contributes to the natural avian diversity of the Liard River Valley.

Up to 14 of the species detected on our surveys are at the northern or western edge of their breeding ranges in the southern and southeastern Yukon (Godfrey 1986). Among these are five species we identified as habitat specialists: Golden-crowned Kinglet, Hammond's and Least Flycatchers, American Redstart, and Magnolia Warbler. Any significant loss of the required breeding habitat for these species in the southern Yukon may result in significant reductions in breeding populations of these species. As well, 12 species detected in this study are experiencing population declines in at least part of their range in Canada (Dunn 1991). For example the habitat specialists Least Flycatcher, Northern Waterthrush and American Redstart, are already experiencing declines elsewhere (Dunn 1991), and losses of their required breeding habitat in the Yukon may be detrimental to their populations as a whole.

It should be noted that this study assessed habitat associations of songbirds and woodpeckers only, and does not address the habitat associations of other forest birds such as hawks, owls, grouse, and sandpipers. Further studies using different survey techniques would be required to assess the requirements of these groups.

In summary, each of the seven broad forest types investigated supports a distinct community of bird species, including habitat specialists; thus each forest type must be maintained in order to maintain the natural diversity of birds in the Liard River Valley. Mature White Spruce forest, which is the habitat most threatened by logging, is important for cavity nesters as well as Golden-crowned Kinglets. Riparian forests in the valley are very rich and diverse, and support most of the habitat specialists identified in the area. Cutblocks support lower densities and diversity of birds than any forest type. The current management regime is likely to have negative impacts on habitat specialists associated with White Spruce forest.

RECOMMENDATIONS

1) Establish a network of protected areas within the Liard River Valley, representing all forest types. The first priority should be to identify areas of White Spruce forest to be set aside from logging. Due to the fragmented nature of this heavily harvested type, the largest remaining areas of White Spruce forest should be included in the set-aside. To be effective these protected areas should be large in size and connected by protected corridors.

2) Revise timber management guidelines to recognize the value of the full range of riparian types, and require larger harvest-free treed buffers. We recommend that protection not be scaled based on the perceived importance of large streams. Rather high levels of protection should be established on large and small streams, back-channels, sloughs, intermittent and ephemeral streams, large and small lakes including oxbows and other wetland types. Significant harvest-free treed buffers (e.g. 60 - 100 metres) should be established along all riparian and wetland areas. To be effective buffers must be free from all forms of timber harvesting. We caution that since buffers which are less than 100 metres wide may not provide breeding habitat for interior forest species, they are not adequate to cover recommendation (1) above.

3) Since old-growth forest appears to support so many specialist species, while cutblocks do not appear to provide rich bird habitat, management practices should be altered to incorporate old-growth reserves, a much longer rotation as well as alternatives to clear-cut logging, such as selection logging. In addition, non-commercial trees and snags should be left standing.

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TABLE 1. Means and standard errors for all habitat parameters across habitat types.

	Trembling Aspen	Balsam Poplar	Cutblock	Mixed Forest	Lodgepole Pine	Riparian Forest	White Spruce
No. of Points	9	7	15	20	11	20	29
Percent Ground Cover							
Bare		0.5 ± 0.3	11.7 ± 1.7		0.3 ± 0.3	11.0 ± 2.5	0.1 ± 0.1
Litter	50.2 ± 3.8	84.5 ± 3.2	46.4 ± 4.9	23.5 ± 2.3	42.3 ± 3.7	57.7 ± 3.9	30.6 ± 1.9
Moss	65.0 ± 4.6	6.8 ± 3.5	20.3 ± 3.8	89.1 ± 1.2	72.3 ± 3.2	26.3 ± 4.2	87.0 ± 1.8
Herb	38.5 ± 3.4	51.7 ± 5.6	43.9 ± 3.6	47.0 ± 3.7	10.1 ± 2.2	54.1 ± 3.7	64.3 ± 2.5
Dwarf Shrub	47.2 ± 3.2	39.5 ± 4.0	14.6 ± 2.0	47.4 ± 3.4	46.3 ± 3.6	36.9 ± 3.3	58.2 ± 2.5
Low Shrub	7.0 ± 1.2	67.4 ± 5.0	8.8 ± 1.9	20.9 ± 3.7	6.8 ± 1.6	42.2 ± 3.9	36.5 ± 2.9
Tall Shrub	2.6 ± 0.6	36.3 ± 5.8	2.0 ± 0.8	9.0 ± 2.6	4.4 ± 2.5	33.5 ± 4.0	12.2 ± 2.2
Number of Saplings per hectare							
Balsam Poplar	3.7 ± 3.7	14.3 ± 10.4	75.6 ± 57.3	3.0 ± 3.0		595.0 ± 189.7	37.9 ± 37.9
Black Spruce	285.2 ± 111.3		4.4 ± 3.1	1121.2 ± 255.6	124.2 ± 44.4	58.3 ± 37.5	552.9 ± 123.6
Lodgepole Pine	663.0 ± 312.4			148.5 ± 69.6	703.0 ± 130.4	3.3 ± 2.3	
Trembling Aspen	477.8 ± 125.4		746.7 ± 244.2	97.0 ± 30.0	45.5 ± 16.9	60.0 ± 27.2	163.2 ± 60.4
White Birch			4.4 ± 3.1			16.7 ± 10.7	50.6 ± 34.5
White Spruce	537.0 ± 134.3	142.9 ± 56.3	180.0 ± 70.2	684.8 ± 208.5	233.3 ± 72.0	816.7 ± 239.2	880.5 ± 141.2
Number of Seedlings per hectare							
Balsam Poplar			15.6 ± 15.6		6.1 ± 4.2	156.7 ± 85.0	3.4 ± 2.6
Black Spruce	3.7 ± 3.7			103.0 ± 36.0	6.1 ± 4.2	1.7 ± 1.7	187.4 ± 86.6
Lodgepole Pine	3.7 ± 3.7				221.2 ± 54.7		
Trembling Aspen	14.8 ± 8.8		362.2 ± 141.1	9.1 ± 5.1	45.5 ± 18.5	3.3 ± 3.3	5.7 ± 3.4
White Birch							
White Spruce	63.0 ± 26.2	38.1 ± 33.4	515.6 ± 80.7	124.2 ± 52.6	63.6 ± 20.8	380.0 ± 129.3	332.2 ± 56.1
Number of Trees and Snags per hectare							
Snags	696 ± 107	376 ± 778	13 ± 6	527 ± 62	421 ± 70	298 ± 52	630 ± 67
Trees	2144 ± 171	1148 ± 238	91 ± 31	2633 ± 142	2173 ± 167	1327 ± 157	1675 ± 118
Total Stems	2841 ± 249	1524 ± 272	104 ± 32	2106 ± 172	2594 ± 194	1625 ± 188	2305 ± 159
Mean Number and DBH of Snags with a minimum DBH of 7cm.							
Count	370.4 ± 51.1	161.9 ± 32.7	8.9 ± 4.3	354.5 ± 43.3	181.8 ± 29.0	158.3 ± 33.7	417.2 ± 39.8
Mean DBH	11.0 ± 0.8	15.8 ± 2.3	21.5 ± 1.7	13.5 ± 0.8	10.6 ± 0.7	13.5 ± 0.8	17.7 ± 1.0
Mean DBH of Trees with a minimum DBH of 7cm.							
Balsam Poplar		29.5 ± 2.0	12.8 ± 0.0			17.9 ± 1.7	32.1 ± 9.4
Black Spruce	12.1 ± 0.9		17.0 ± 0.0	13.3 ± 0.7	11.2 ± 1.1	14.0 ± 1.0	13.8 ± 0.6
Lodgepole Pine	13.9 ± 1.3			19.0 ± 1.0	13.8 ± 0.7	16.5 ± 1.0	
Spruce sp.				9.5 ± 0.0		17.6 ± 4.4	16.4 ± 1.7
Trembling Aspen	15.7 ± 1.0			24.7 ± 2.1	14.7 ± 1.6	22.1 ± 1.9	26.0 ± 1.6
White Spruce	12.8 ± 1.3	12.7 ± 1.1	11.6 ± 1.0	20.2 ± 1.9	12.3 ± 2.4	16.0 ± 1.2	22.7 ± 0.9
Mean Basal Area per hectare of Snags and Trees with a minimum DBH of 7cm.							
Snags	3.85 ± 0.70	3.79 ± 1.26	0.31 ± 0.16	5.99 ± 0.96	1.59 ± 0.29	2.78 ± 0.68	9.88 ± 0.95
Trees	29.89 ± 3.44	47.91 ± 8.18	0.23 ± 0.18	34.41 ± 3.51	21.92 ± 1.09	22.77 ± 4.27	46.10 ± 2.90
Total	33.75 ± 3.69	51.71 ± 7.72	0.54 ± 0.09	40.40 ± 3.70	23.51 ± 0.99	25.56 ± 3.80	55.98 ± 2.54
Alder						0.01 ± 0.01	
Balsam Poplar		43.76 ± 8.15	0.06 ± 0.06			6.66 ± 1.61	0.40 ± 0.29
Larch				0.08 ± 0.08			
Lodgepole Pine	3.52 ± 0.89			4.66 ± 0.91	18.38 ± 1.29	0.36 ± 0.25	
Trembling Aspen	21.63 ± 3.33			8.78 ± 2.38	1.27 ± 0.42	0.18 ± 0.13	2.62 ± 0.64
White Birch			0.01 ± 0.01	0.09 ± 0.09		0.06 ± 0.05	0.03 ± 0.02
White Spruce	3.18 ± 0.88	4.16 ± 1.81	0.11 ± 0.05	9.32 ± 2.02	0.66 ± 0.51	14.72 ± 3.52	37.98 ± 2.68
Black Spruce	1.56 ± 0.50		0.05 ± 0.05	11.46 ± 2.12	1.61 ± 0.54	0.66 ± 0.28	4.34 ± 0.88
Spruce Sp.				0.02 ± 0.02		0.12 ± 0.08	0.74 ± 0.35
All Spruce	4.74 ± 1.08	4.16 ± 1.81	0.16 ± 0.07	20.80 ± 2.62	2.26 ± 0.85	15.50 ± 3.63	43.06 ± 2.49
Percent Basal Area by species							
Balsam Poplar		90 ± 7	14 ± 14			47 ± 7	1 ± 1
Larch				0 ± 0			
Lodgepole Pine	20 ± 6			16 ± 3	83 ± 4	2 ± 1	
Trembling Aspen	64 ± 5			19 ± 4	6 ± 2	1 ± 1	6 ± 1
White Birch			14 ± 14	0 ± 0		0 ± 0	0 ± 0
Black Spruce	7 ± 3		14 ± 14	36 ± 5	8 ± 3	2 ± 1	11 ± 2
White Spruce	9 ± 2	10 ± 7	57 ± 20	28 ± 4	3 ± 2	48 ± 7	81 ± 3
Spruce Sp.				0 ± 0		0 ± 0	1 ± 1
All Spruce	15 ± 3	10 ± 7	71 ± 18	64 ± 5	11 ± 3	50 ± 7	93 ± 2
Course Woody Debris: counted on 10 metre transect							
Total count	5.6 ± 0.8	4.10 ± 0.57	6.60 ± 0.52	5.5 ± 0.57	4.45 ± 0.59	6.75 ± 0.55	5.22 ± 0.48
Count > 7cm	1.8 ± 0.3	2.38 ± 0.46	4.80 ± 0.44	3.3 ± 0.43	3.03 ± 0.46	4.67 ± 0.48	2.85 ± 0.31
Mean Diameter	12.6 ± 1.0	13.07 ± 1.01	16.46 ± 1.00	12.6 ± 0.71	12.30 ± 0.62	12.78 ± 0.49	15.85 ± 1.00

TABLE 2. Mean number of birds per point and standard errors for each species across habitat types. The total number of detections per species (N) is a sum of both counts at all census points. Values for TOTAL and HIGH COUNT do not include White-winged Crossbill detections.

Species	N	Trembling Aspen	Balsam Poplar	Cutblock	Mixed Forest	Lodgepole Pine	Riparian Forest	White Spruce
Number of Points		9	10	22	19	28	26	33
Yellow-bellied Sapsucker	35	0.56 ± 0.29	0.60 ± 0.27	0.09 ± 0.09	0.26 ± 0.13	0.11 ± 0.08	0.15 ± 0.07	0.27 ± 0.10
Hairy Woodpecker	2	0.11 ± 0.11		0.05 ± 0.05				
Three-toed Woodpecker	11						0.08 ± 0.05	0.27 ± 0.09
Northern Flicker	6			0.14 ± 0.10		0.04 ± 0.04	0.04 ± 0.04	0.03 ± 0.03
woodpecker sp.	2				0.05 ± 0.05			0.03 ± 0.03
Western Wood-Pewee	1			0.05 ± 0.05				
Alder Flycatcher	14		0.10 ± 0.10	0.23 ± 0.11			0.23 ± 0.13	
Least Flycatcher	49		2.20 ± 0.68				0.42 ± 0.17	
Hammond's Flycatcher	54		0.80 ± 0.20		0.11 ± 0.07	0.04 ± 0.04	0.96 ± 0.15	0.15 ± 0.08
Gray Jay	34		0.20 ± 0.13	0.05 ± 0.05	0.21 ± 0.16	0.50 ± 0.17	0.19 ± 0.16	0.21 ± 0.08
Boreal Chickadee	62	0.22 ± 0.15			0.74 ± 0.25	0.18 ± 0.09	0.19 ± 0.10	0.97 ± 0.22
Red-breasted Nuthatch	7				0.11 ± 0.07	0.04 ± 0.04	0.04 ± 0.04	0.09 ± 0.05
Winter Wren	1							0.03 ± 0.03
Golden-crowned Kinglet	52				0.11 ± 0.07		0.31 ± 0.13	0.82 ± 0.17
Ruby-crowned Kinglet	51	0.33 ± 0.24	0.10 ± 0.10		0.89 ± 0.15	0.32 ± 0.12	0.19 ± 0.10	0.33 ± 0.08
Mountain Bluebird	4			0.18 ± 0.11				
Swainson's Thrush	68	0.33 ± 0.24	0.60 ± 0.22		0.68 ± 0.17	0.25 ± 0.10	0.54 ± 0.14	0.45 ± 0.11
Hermit Thrush	1		0.10 ± 0.10					
American Robin	26	0.11 ± 0.11		0.18 ± 0.13	0.16 ± 0.09	0.39 ± 0.11	0.12 ± 0.08	0.09 ± 0.07
Varied Thrush	13		0.30 ± 0.15			0.11 ± 0.08	0.04 ± 0.04	0.18 ± 0.08
Bohemian Waxwing	9	0.11 ± 0.11				0.25 ± 0.12		0.03 ± 0.03
Warbling Vireo	56	0.56 ± 0.29	1.40 ± 0.16		0.16 ± 0.09		0.69 ± 0.15	0.12 ± 0.07
Tennessee Warbler	17		0.20 ± 0.13		0.05 ± 0.05		0.23 ± 0.10	0.21 ± 0.07
Yellow Warbler	4		0.10 ± 0.10				0.08 ± 0.05	
Magnolia Warbler	14		0.30 ± 0.21				0.19 ± 0.12	0.12 ± 0.07
Yellow-rumped Warbler	195	0.67 ± 0.29	0.60 ± 0.22		1.37 ± 0.17	1.64 ± 0.21	0.58 ± 0.14	1.39 ± 0.16
American Redstart	26		0.50 ± 0.22				0.42 ± 0.13	0.06 ± 0.04
Northern Waterthrush	14		0.50 ± 0.22				0.31 ± 0.11	
McGillivray's Warbler	1						0.04 ± 0.04	
Common Yellowthroat	1						0.04 ± 0.04	
Wilson's Warbler	6		0.10 ± 0.10				0.15 ± 0.09	0.03 ± 0.03
Chipping Sparrow	102	1.44 ± 0.29		0.50 ± 0.18	0.53 ± 0.21	0.50 ± 0.13	0.65 ± 0.15	0.61 ± 0.12
Lincoln's Sparrow	17			0.36 ± 0.18			0.27 ± 0.10	
White-throated Sparrow	39		0.30 ± 0.15	0.82 ± 0.26			0.35 ± 0.17	
White-crowned Sparrow	2			0.09 ± 0.06				
Dark-eyed Junco	99	0.56 ± 0.18		0.55 ± 0.16	0.68 ± 0.11	0.79 ± 0.13	0.35 ± 0.12	0.61 ± 0.11
Pine Grosbeak	10					0.21 ± 0.11	0.04 ± 0.04	0.03 ± 0.03
Purple Finch	2				0.05 ± 0.05			0.03 ± 0.03
Red Crossbill	11				0.16 ± 0.12	0.07 ± 0.07	0.04 ± 0.04	0.15 ± 0.06
White-winged Crossbill	179	0.22 ± 0.22			2.53 ± 1.30	0.29 ± 0.25	3.31 ± 2.48	1.06 ± 0.39
Pine Siskin	7	0.11 ± 0.11			0.05 ± 0.05	0.04 ± 0.04		0.12 ± 0.07
CAVITY NESTERS	130	0.78 ± 0.28	0.60 ± 0.27	0.46 ± 0.21	0.90 ± 0.25	0.36 ± 0.12	0.46 ± 0.14	1.55 ± 0.24
HIGH COUNT		4.22 ± 0.89	7.50 ± 0.82	2.68 ± 0.56	5.16 ± 0.49	4.68 ± 0.36	6.15 ± 0.61	5.76 ± 0.34
TOTAL	1125	5.11 ± 1.10	9.00 ± 1.00	3.27 ± 0.67	6.37 ± 0.58	5.46 ± 0.41	7.92 ± 0.69	7.45 ± 0.42
Total number of detections for eleven species recorded on point counts but not analyzed by habitat.								
Common Goldeneye	3							
goldeneye sp.	3							
Common Merganser	3							
American Kestrel	1							
Spruce Grouse	4							
Ruffed Grouse	4							
Greater Yellowlegs	1							
Lesser Yellowlegs	1							
Solitary Sandpiper	2							
Spotted Sandpiper	10							
Common Raven	1							
Bank Swallow	38							
TOTAL	71							

TABLE 3. Relative proportion of detections accounted for by each habitat type, for each species. These values are based on detections per point and are not affected by the number of census points in each habitat. Values for "TOTAL" do not include White-winged Crossbill detections.

Species	Trembling Aspen	Balsam Poplar	Cutblock	Mixed Forest	Lodgepole Pine	Riparian Forest	White Spruce
Yellow-bellied Sapsucker	0.27	0.29	0.04	0.13	0.05	0.08	0.13
Hairy Woodpecker	0.71		0.29				
Three-toed Woodpecker						0.22	0.78
Northern Flicker			0.56		0.15	0.16	0.13
woodpecker sp.				0.63			0.37
Western Wood-Pewee			1.00				
Alder Flycatcher		0.18	0.41			0.41	
Least Flycatcher		0.84				0.16	
Hammond's Flycatcher		0.39		0.05	0.02	0.47	0.07
Gray Jay		0.15	0.03	0.15	0.37	0.14	0.16
Boreal Chickadee	0.10			0.32	0.08	0.08	0.42
Red-breasted Nuthatch				0.39	0.13	0.14	0.34
Winter Wren							1.00
Golden-crowned Kinglet				0.09		0.25	0.66
Ruby-crowned Kinglet	0.15	0.05		0.41	0.15	0.09	0.15
Mountain Bluebird			1.00				
Swainson's Thrush	0.12	0.21		0.24	0.09	0.19	0.16
Hermit Thrush		1.00					
American Robin	0.11		0.17	0.15	0.37	0.11	0.09
Varied Thrush		0.48			0.17	0.06	0.29
Bohemian Waxwing	0.28				0.64		0.08
Warbling Vireo	0.19	0.48		0.05		0.24	0.04
Tennessee Warbler		0.29		0.08		0.33	0.30
Yellow Warbler		0.57				0.43	
Magnolia Warbler		0.49				0.31	0.20
Yellow-rumped Warbler	0.11	0.10		0.22	0.26	0.09	0.22
American Redstart		0.51				0.43	0.06
Northern Waterthrush		0.62				0.38	
McGillivray's Warbler						1.00	
Common Yellowthroat						1.00	
Wilson's Warbler		0.35				0.54	0.11
Chipping Sparrow	0.34		0.12	0.12	0.12	0.15	0.14
Lincoln's Sparrow			0.57			0.43	
White-throated Sparrow		0.20	0.56			0.24	
White-crowned Sparrow			1.00				
Dark-eyed Junco	0.16		0.15	0.19	0.22	0.10	0.17
Pine Grosbeak					0.76	0.14	0.11
Purple Finch				0.63			0.37
Red Crossbill				0.38	0.17	0.09	0.36
White-winged Crossbill	0.03			0.34	0.04	0.45	0.14
Pine Siskin	0.35			0.16	0.11		0.38
CAVITY NESTERS	0.15	0.12	0.09	0.18	0.07	0.09	0.30
TOTAL	0.11	0.20	0.07	0.14	0.12	0.17	0.16

TABLE 4: Mean number of birds per point and standard errors for all species detected in three riparian habitat types: Large Streams, Small Streams and Back-channels. Values for TOTAL and HIGH COUNT do not include White-winged Crossbill detections.

Species	Large (>5m)	Small (0.5-5m)	Back-channel
Number of points	12	8	6
Yellow-bellied Sapsucker	0.17 ± 0.11		0.33 ± 0.21
Three-toed Woodpecker		0.25 ± 0.16	
Northern Flicker		0.13 ± 0.13	
Alder Flycatcher	0.17 ± 0.11	0.13 ± 0.13	0.50 ± 0.50
Least Flycatcher	0.83 ± 0.32		0.17 ± 0.17
Hammond's Flycatcher	0.75 ± 0.22	1.50 ± 0.27	0.67 ± 0.21
Gray Jay	0.08 ± 0.08	0.50 ± 0.50	
Boreal Chickadee		0.50 ± 0.27	0.17 ± 0.17
Red-breasted Nuthatch		0.13 ± 0.13	
Golden-crowned Kinglet		0.63 ± 0.32	0.50 ± 0.34
Ruby-crowned Kinglet		0.38 ± 0.26	0.33 ± 0.21
Swainson's Thrush	0.25 ± 0.13	0.75 ± 0.31	0.83 ± 0.31
American Robin	0.17 ± 0.17	0.13 ± 0.13	
Varied Thrush	0.08 ± 0.08		
Warbling Vireo	0.83 ± 0.27	0.63 ± 0.26	0.50 ± 0.22
Tennessee Warbler	0.08 ± 0.08	0.25 ± 0.16	0.50 ± 0.34
Yellow Warbler	0.17 ± 0.11		
Magnolia Warbler	0.08 ± 0.08	0.13 ± 0.13	0.50 ± 0.50
Yellow-rumped Warbler	0.50 ± 0.19	0.38 ± 0.18	1.00 ± 0.37
American Redstart	0.33 ± 0.19	0.38 ± 0.18	0.67 ± 0.33
Northern Waterthrush	0.17 ± 0.11	0.63 ± 0.26	0.17 ± 0.17
McGillivray's Warbler		0.13 ± 0.13	
Common Yellowthroat			0.17 ± 0.17
Wilson's Warbler	0.08 ± 0.08	0.38 ± 0.26	
Chipping Sparrow	0.75 ± 0.22	0.25 ± 0.16	1.00 ± 0.37
Lincoln's Sparrow	0.33 ± 0.19	0.13 ± 0.13	0.33 ± 0.21
White-throated Sparrow	0.42 ± 0.34	0.25 ± 0.16	0.33 ± 0.21
Dark-eyed Junco	0.25 ± 0.13	0.25 ± 0.25	0.67 ± 0.33
Pine Grosbeak		0.13 ± 0.13	
Red Crossbill			0.17 ± 0.17
White-winged Crossbill			14.33 ± 10.11
HIGH COUNT	4.50 ± 0.76	7.38 ± 1.15	7.83 ± 1.05
TOTAL	6.50 ± 1.10	8.90 ± 1.16	9.50 ± 0.92

TABLE 5. General indication of habitat specialists: Species with at least .70 of detections within 1 or 2 habitat types. Species with at least .70 of detections in one habitat are noted with an asterisk (*). In each case where two habitats are listed, the first had the higher value.

Species	Habitats	Proportion
Three-toed Woodpecker *	White Spruce, Riparian	1.00
Northern Flicker	Cutblock, Riparian	.72
Alder Flycatcher	Riparian, Cutblock	.82
Least Flycatcher *	Balsam Poplar, Riparian	1.00
Hammond's Flycatcher	Riparian, Balsam Poplar	.86
Boreal Chickadee	White Spruce, Mixed Forest	.74
Red-breasted Nuthatch	Mixed Forest, White Spruce	.73
Golden-crowned Kinglet	White Spruce, Riparian	.91
Varied Thrush	Balsam Poplar, White Spruce	.77
Bohemian Waxwing	Lodgepole Pine, Trembling Aspen	.92
Warbling Vireo	Balsam Poplar, Riparian	.72
Magnolia Warbler	Balsam Poplar, Riparian	.80
American Redstart	Balsam Poplar, Riparian	.94
Northern Waterthrush	Balsam Poplar, Riparian	1.00
Wilson's Warbler	Riparian, Balsam Poplar	.89
Lincoln's Sparrow	Cutblock, Riparian	1.00
White-throated Sparrow	Cutblock, Riparian	.79
Pine Grosbeak *	Lodgepole Pine, Riparian	.90
Red Crossbill	Mixed Forest, White Spruce	.74
White-winged Crossbill	Riparian, Mixed Forest	.79
Pine Siskin	White Spruce, Trembling Aspen	.73

FIGURE 1: Map of the Liard River Valley study area with general survey locations are shown in grey. Scale = 1:350,000 (1 cm to 3.5 km).

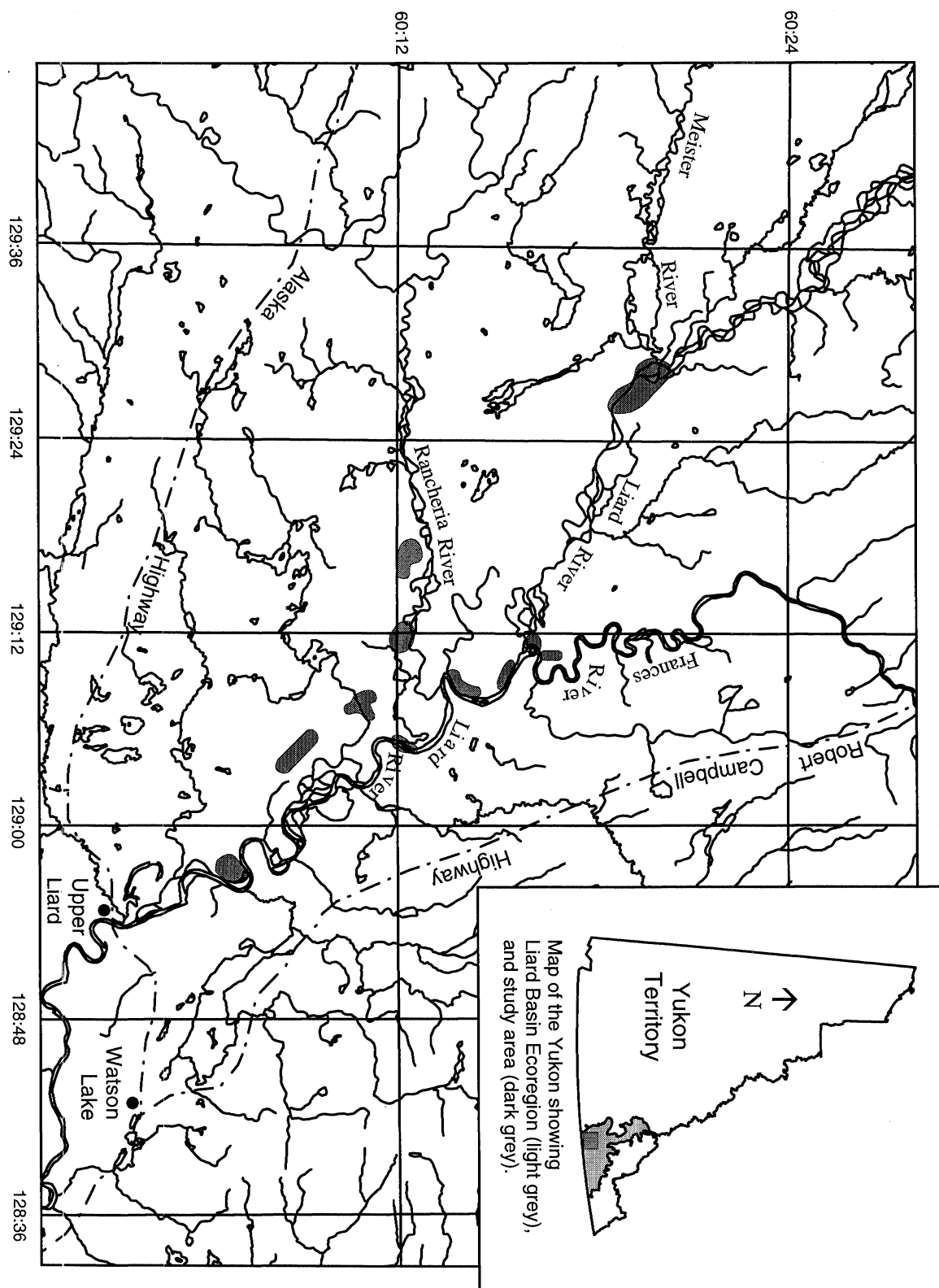


FIGURE 2: An example configuration of the vegetation sampling design: Three 10x10 metre vegetation quadrats (shaded grey) set inside a fixed radius (75 metre) bird census point.

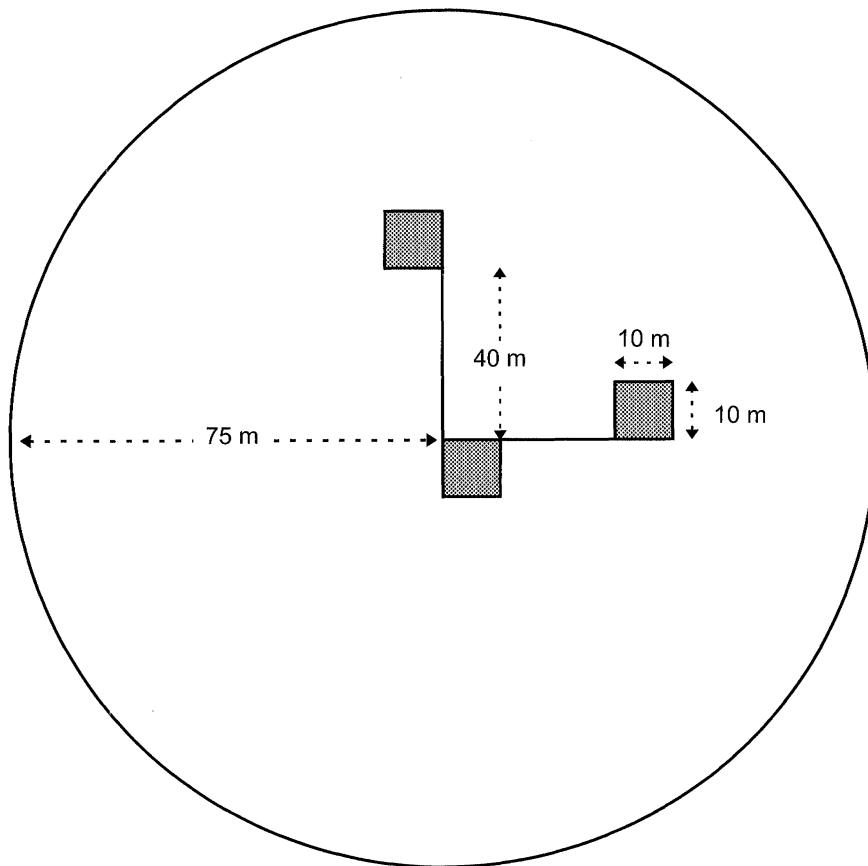


FIGURE 3a-c: Mean number of birds per point across habitat types.

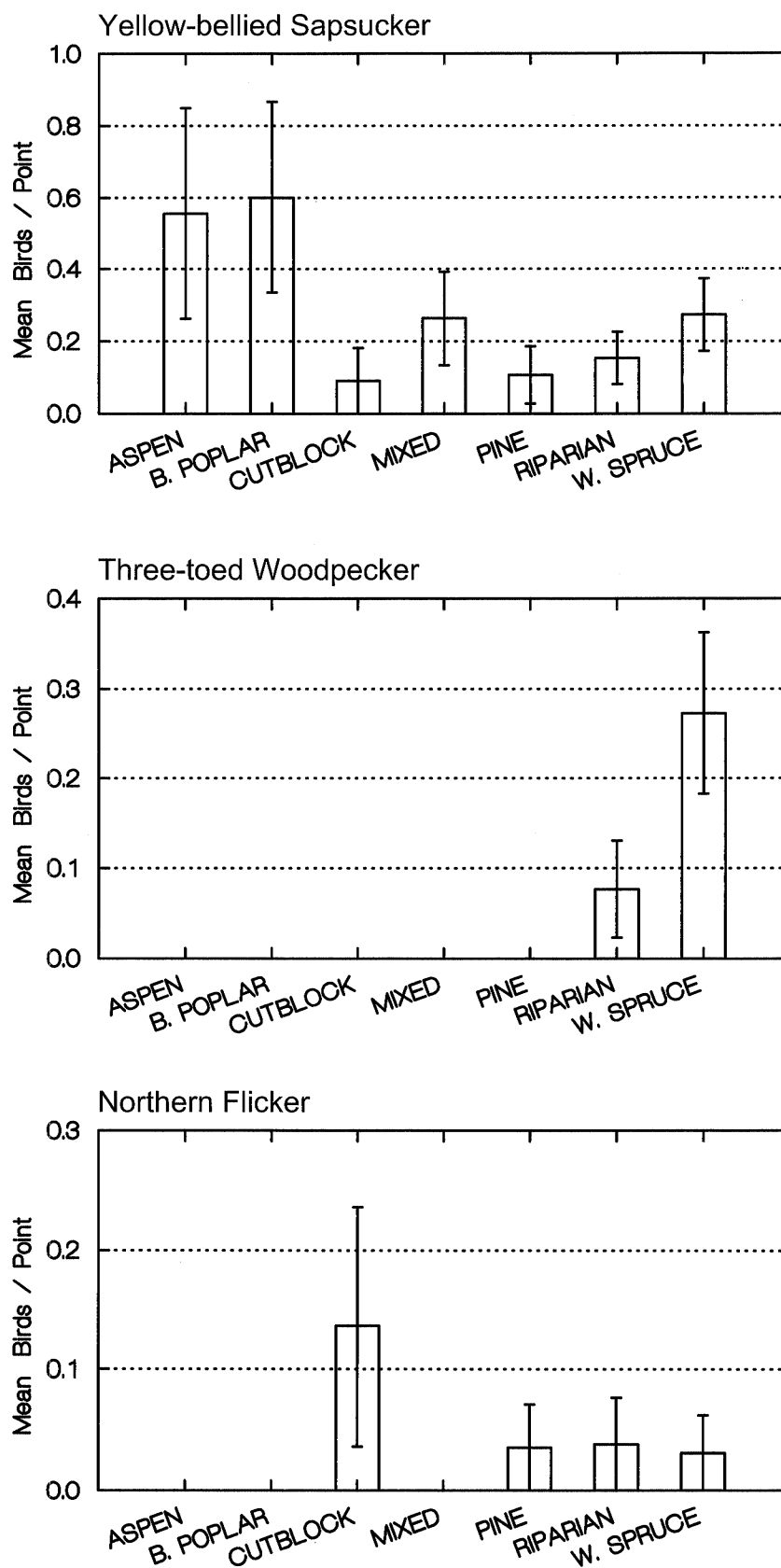


FIGURE 3d-f: Mean number of birds per point across habitat types.

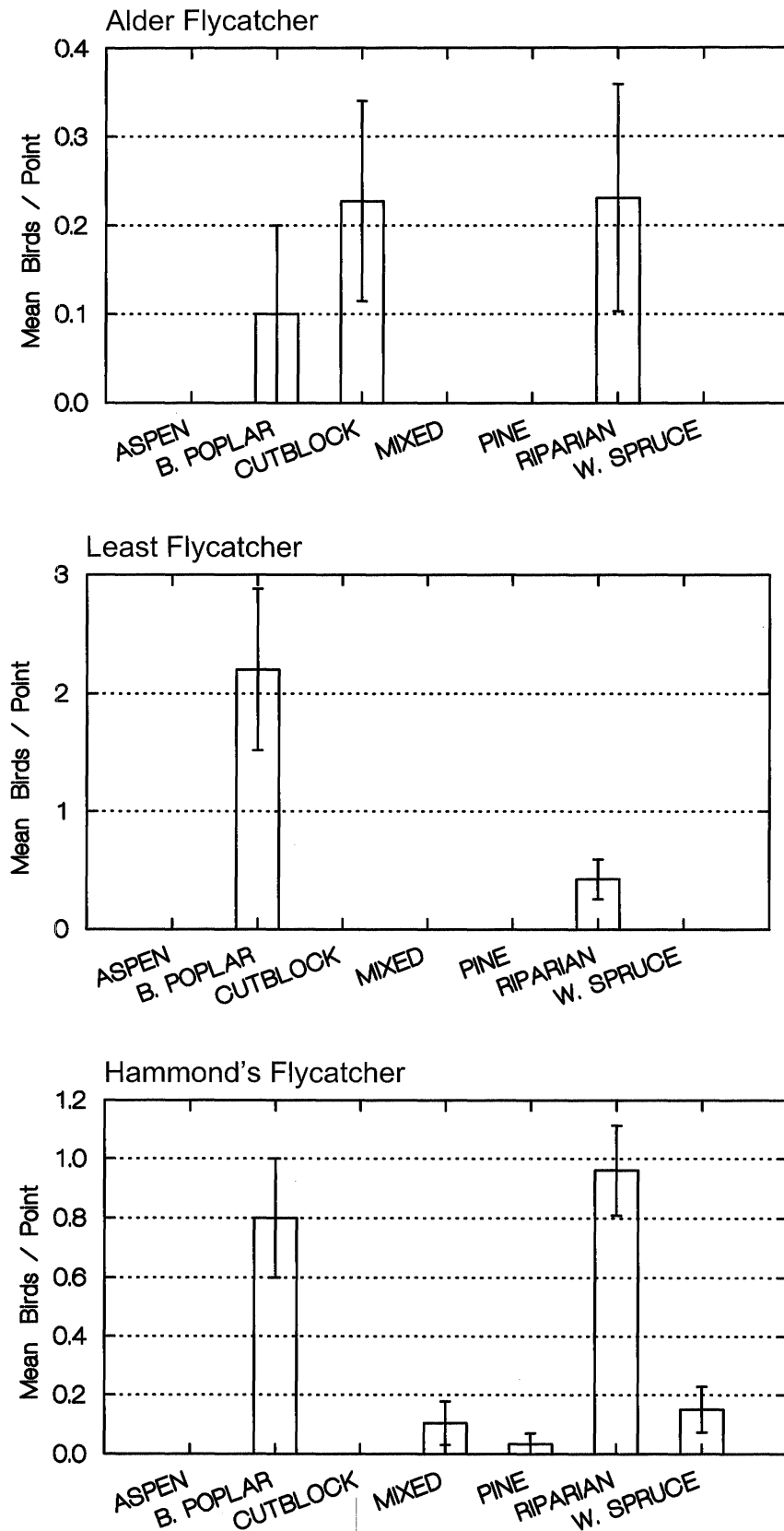


FIGURE 3g-i: Mean number of birds per point across habitat types.

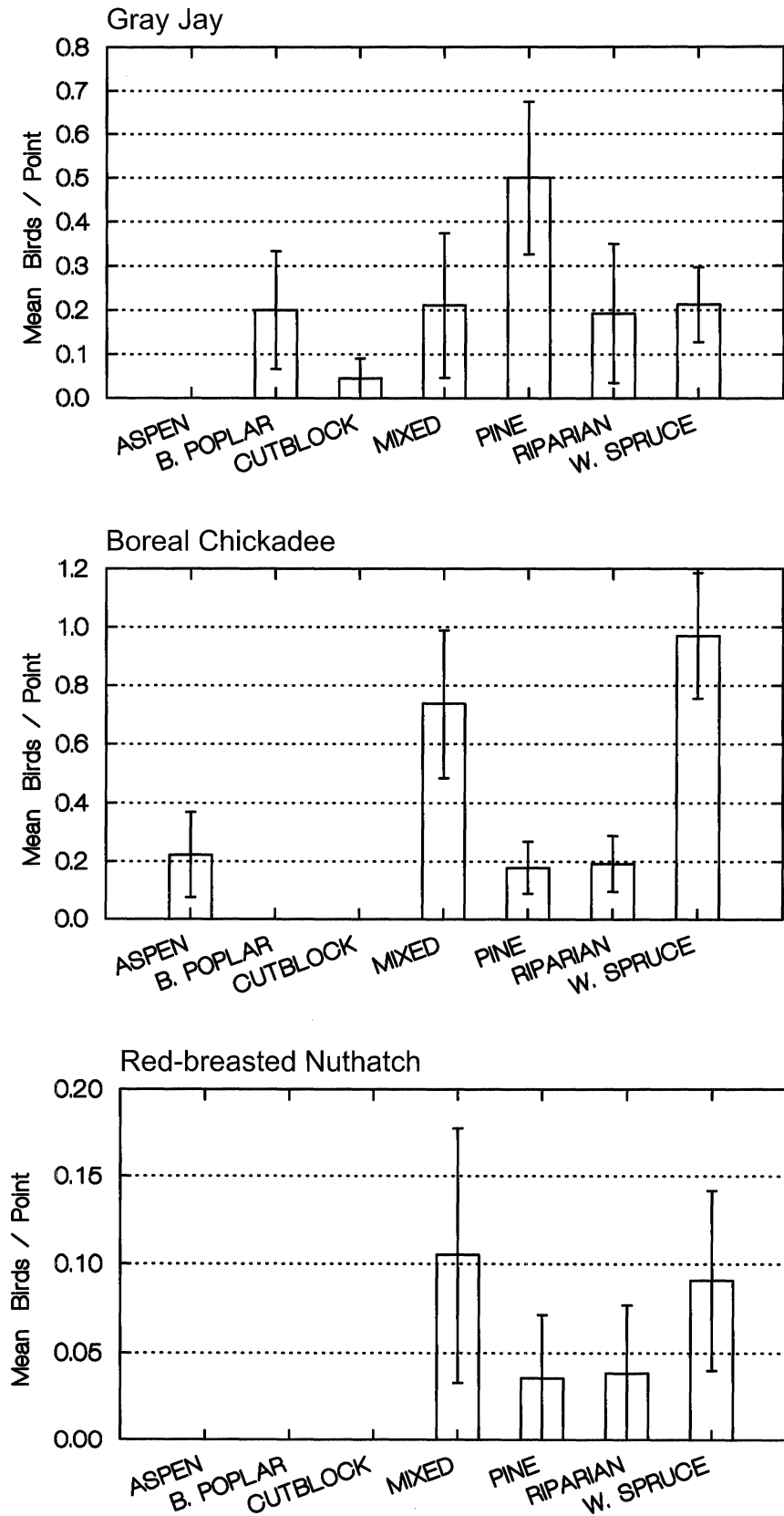


FIGURE 3j-l: Mean number of birds per point across habitat types.

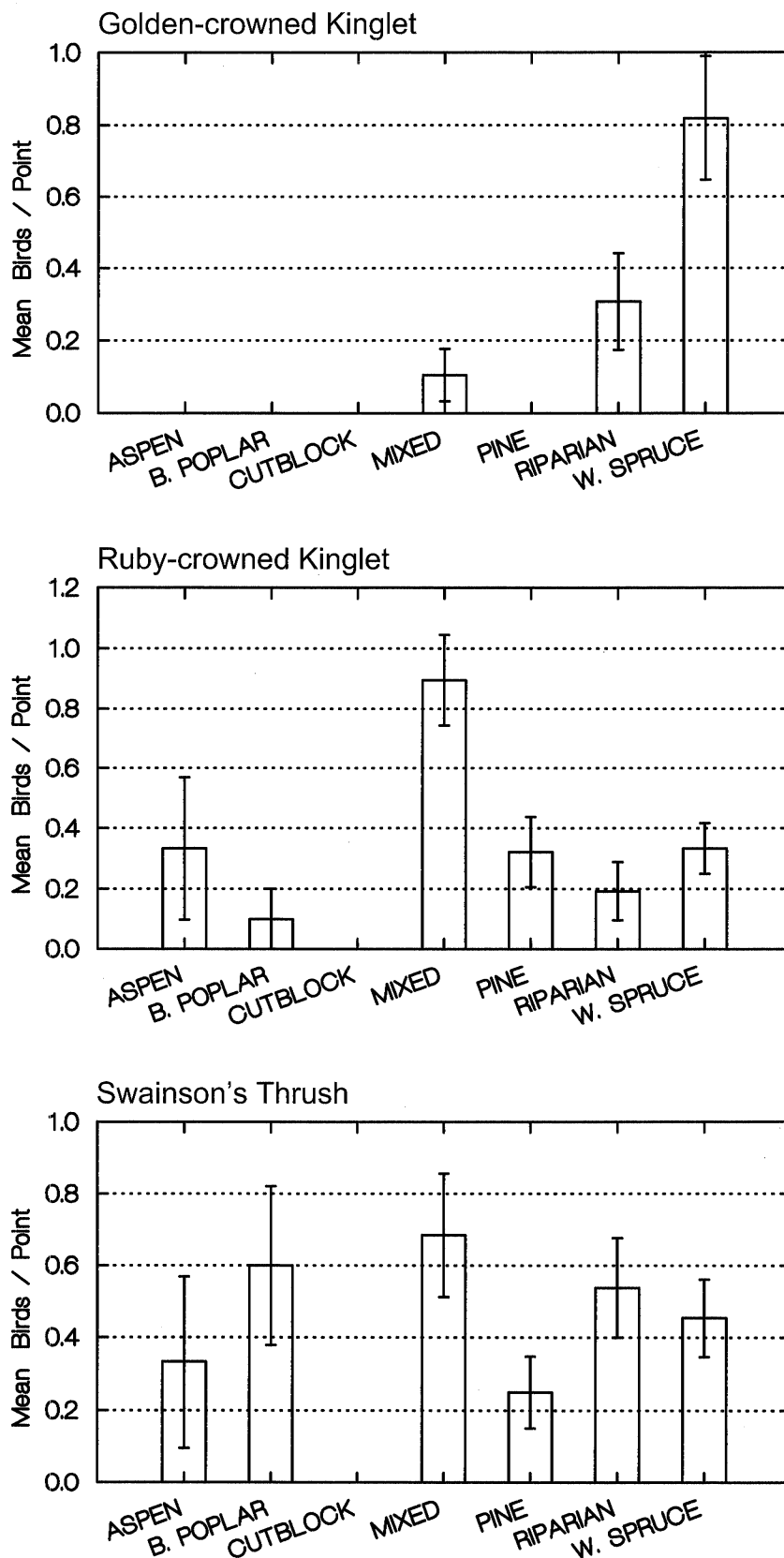


FIGURE 3m-o: Mean number of birds per point across habitat types.

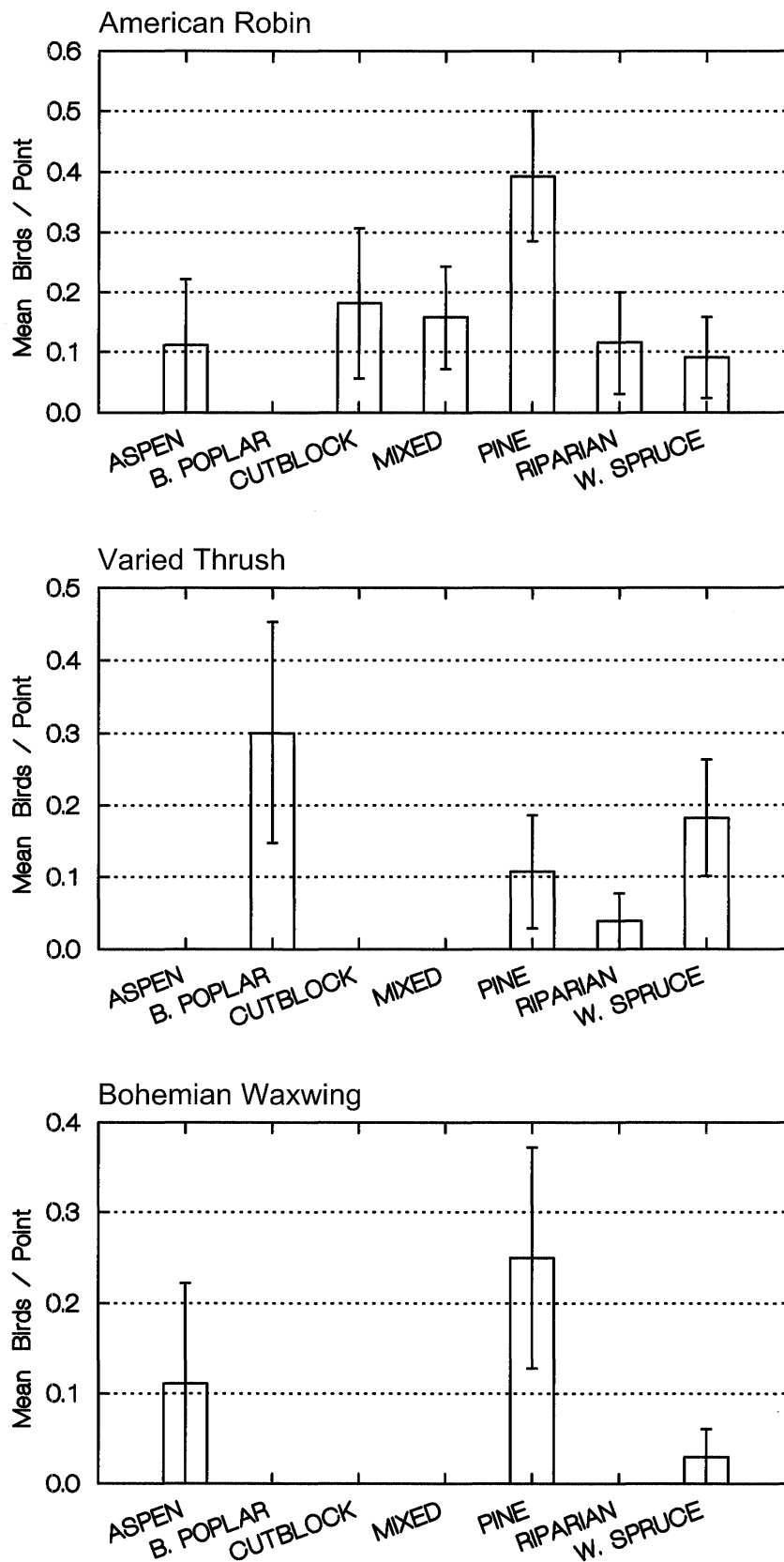


FIGURE 3p-r: Mean number of birds per point across habitat types.

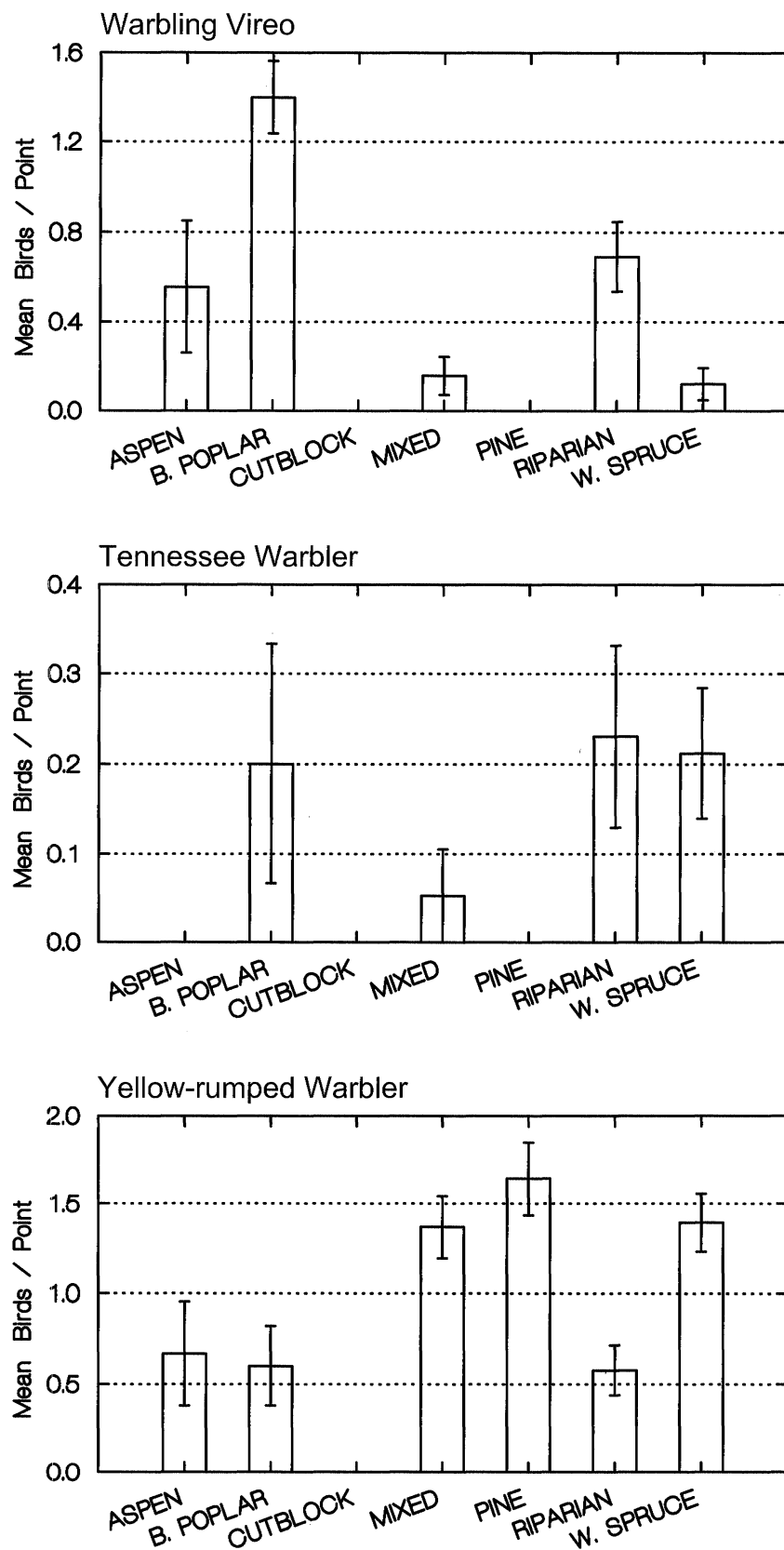


FIGURE 3s-u: Mean number of birds per point across habitat types.

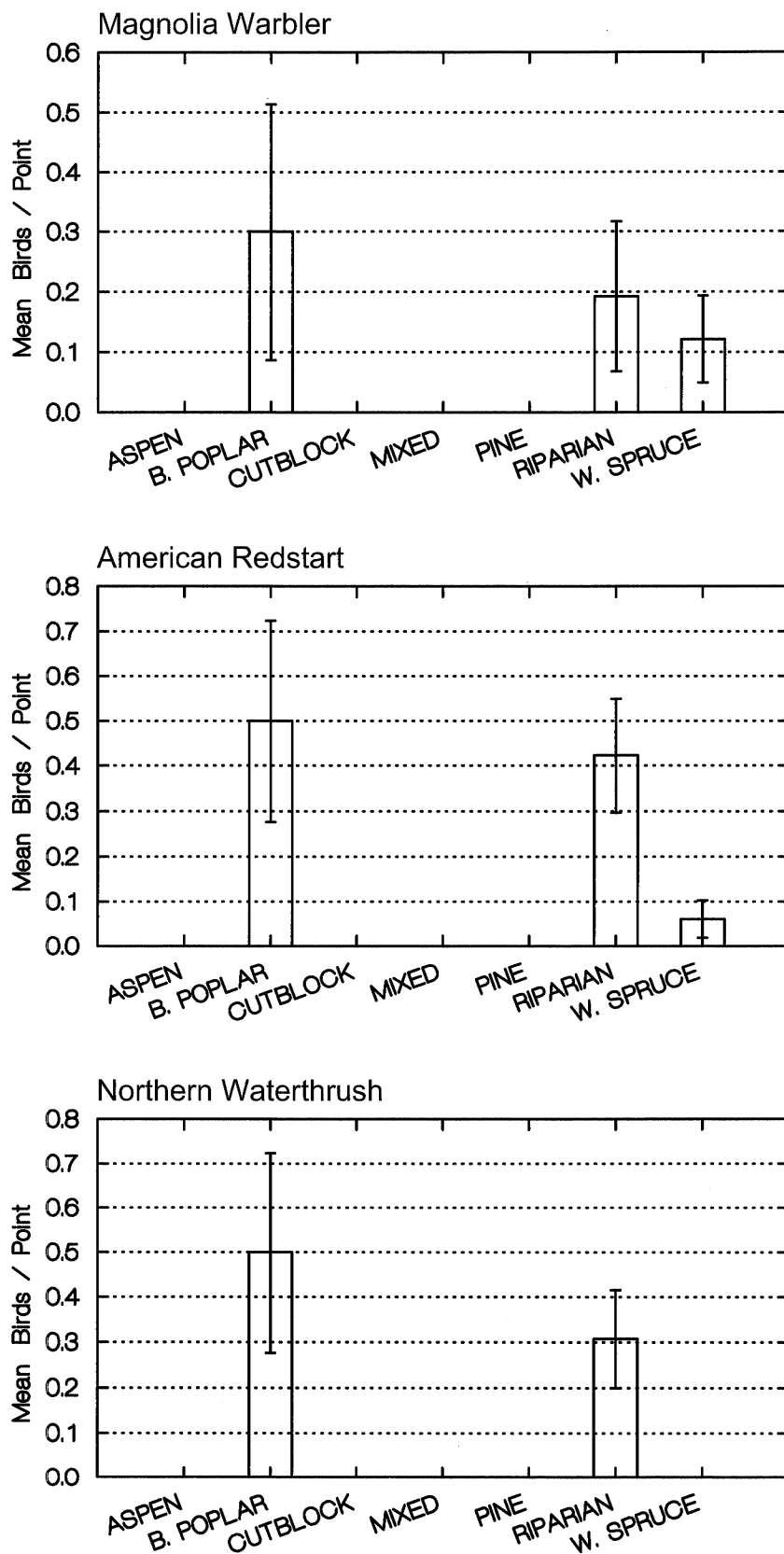


FIGURE 3v-x: Mean number of birds per point across habitat types.

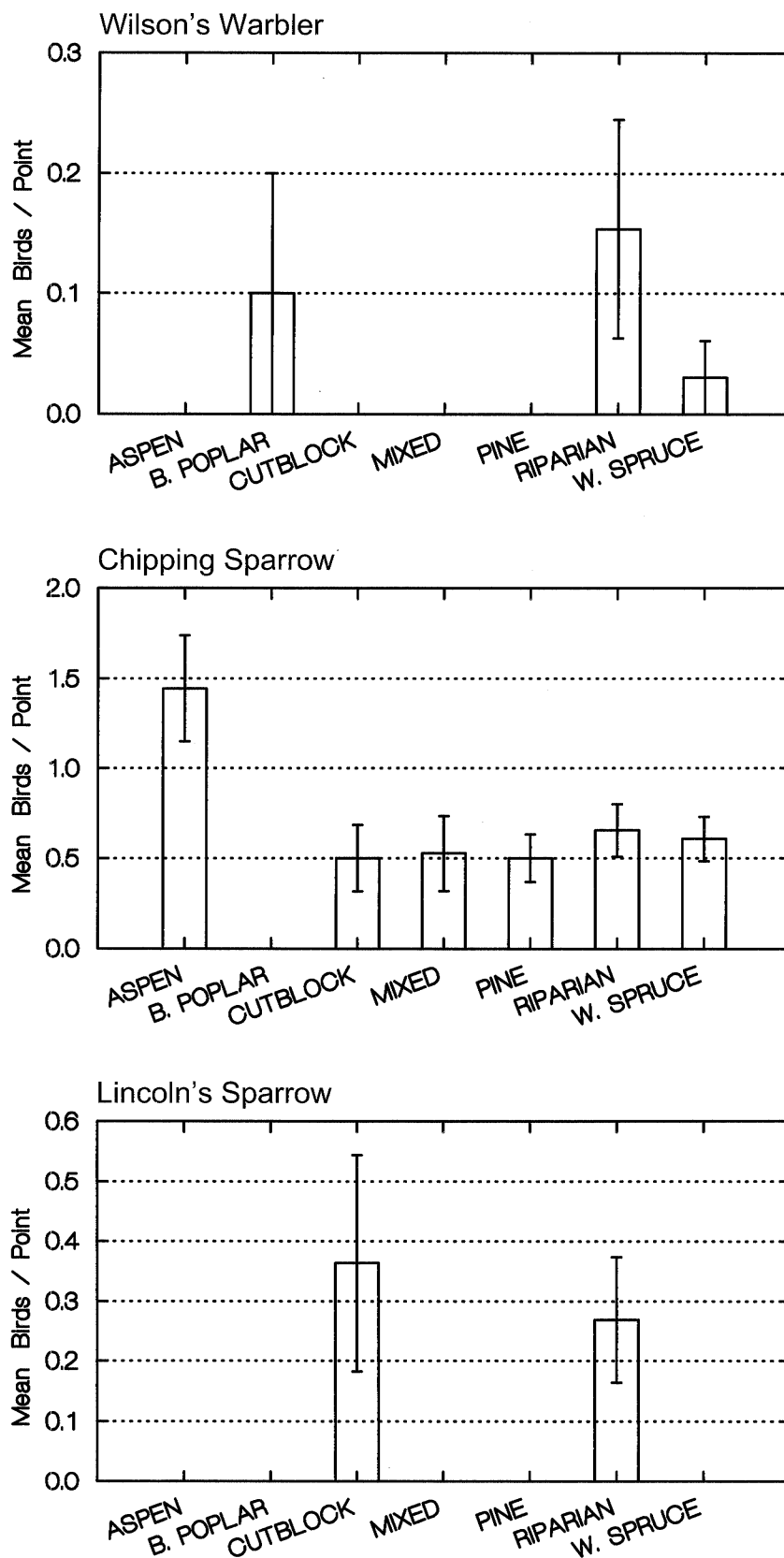


FIGURE 3y-aa: Mean number of birds per point across habitat types.

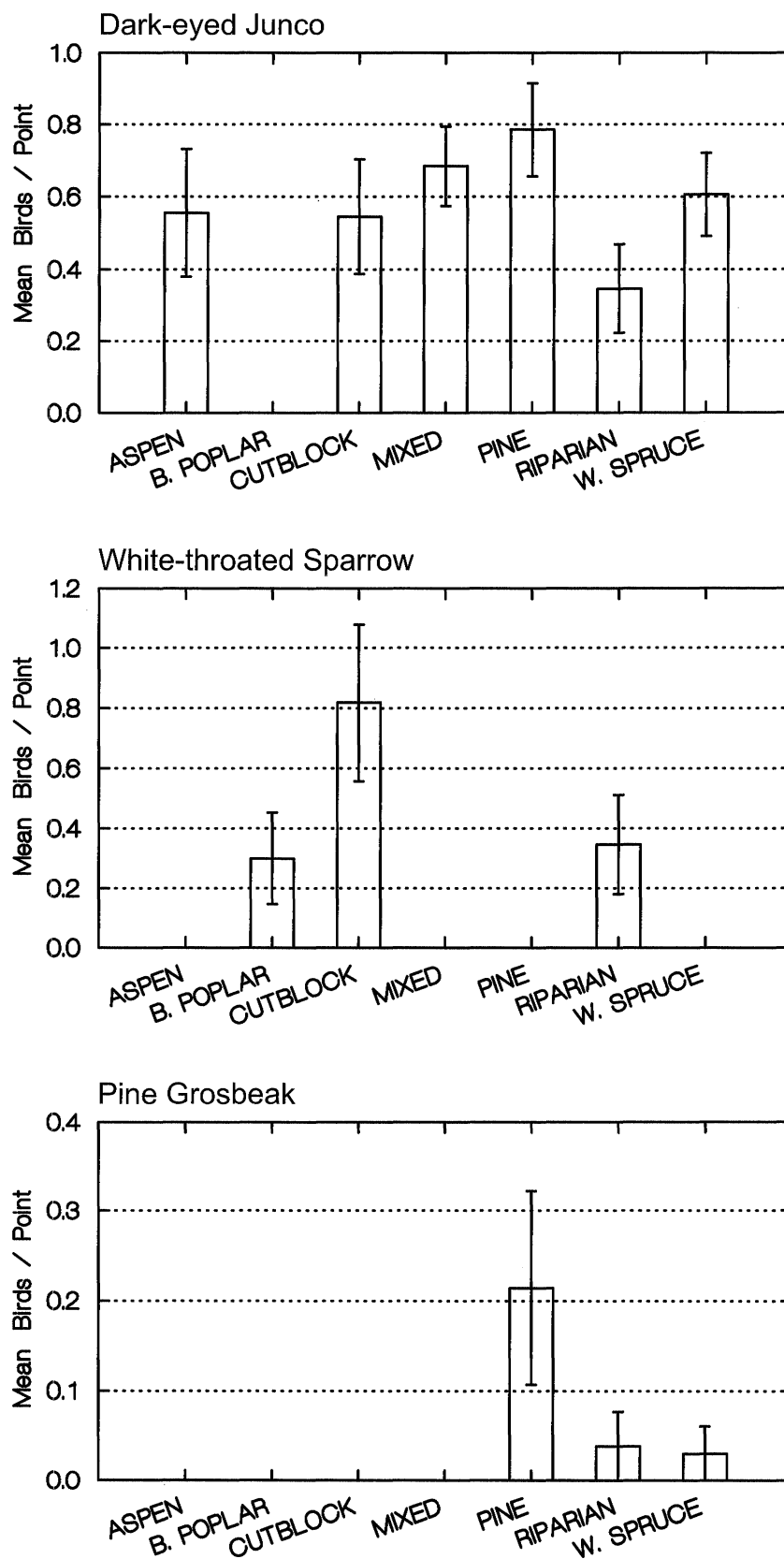
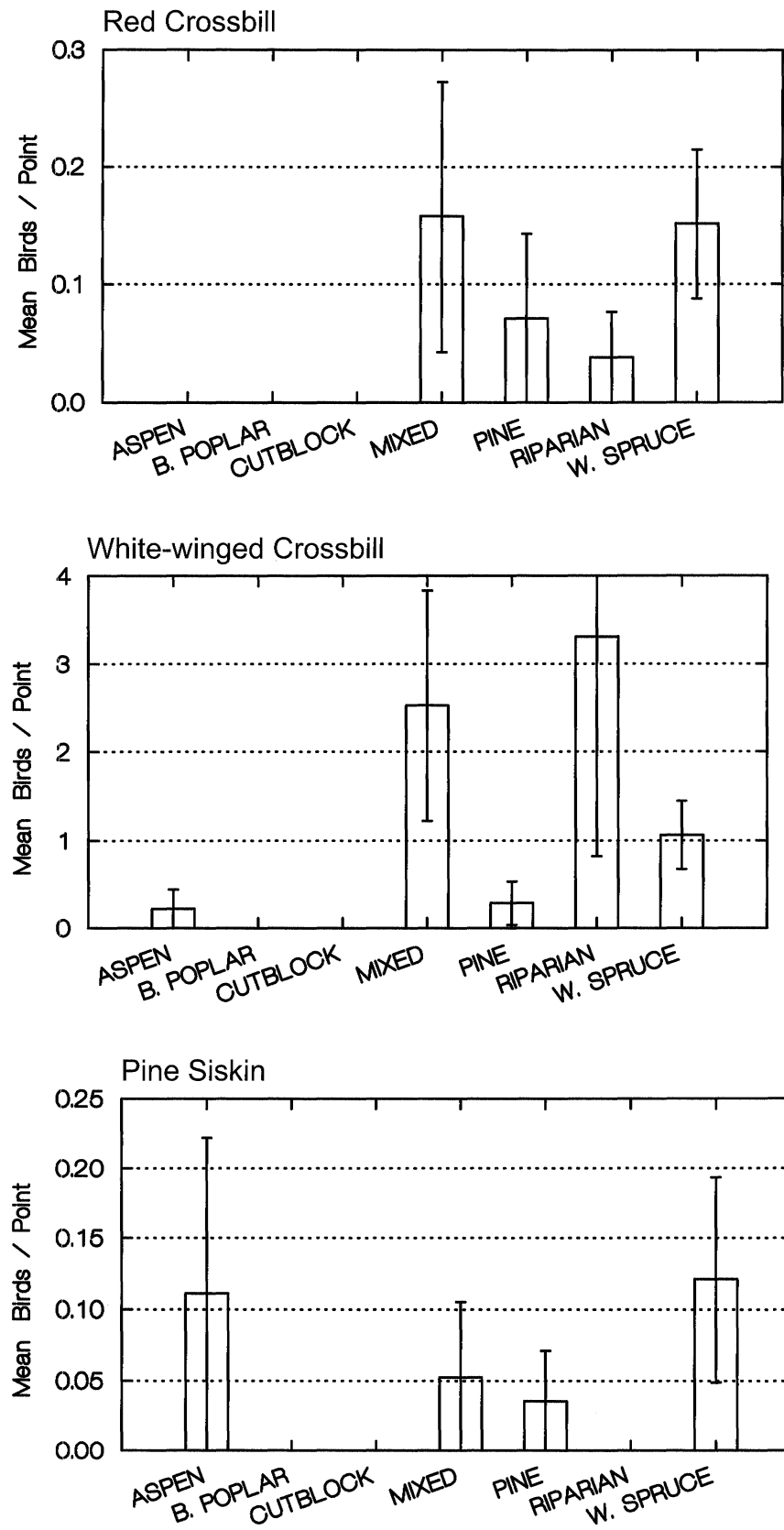


FIGURE 3ab-ad: Mean number of birds per point across habitat types.



APPENDIX A: Common and scientific names of 102 bird species observed during our study from 29 May to 27 July 1994 in the Liard River Valley, Yukon.

Common Name	Scientific Name	Common Name	Scientific Name
Red-throated Loon	<i>Gavia stellata</i>	Eastern Kingbird	<i>Tyrannus tyrannus</i>
Pacific Loon	<i>Gavia pacifica</i>	Say's Phoebe	<i>Sayornis saya</i>
Common Loon	<i>Gavia immer</i>	Tree Swallow	<i>Tachycineta bicolor</i>
Canada Goose	<i>Branta canadensis</i>	Violet-green Swallow	<i>Tachycineta thalassina</i>
Green-winged Teal	<i>Anas crecca</i>	N. Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>
Mallard	<i>Anas platyrhynchos</i>	Bank Swallow	<i>Riparia riparia</i>
Northern Shoveler	<i>Anas clypeata</i>	Cliff Swallow	<i>Hirundo pyrrhonota</i>
American Wigeon	<i>Anas americana</i>	Gray Jay	<i>Perisoreus canadensis</i>
Ring-necked Duck	<i>Aythya collaris</i>	Common Raven	<i>Corvus corax</i>
Greater Scaup	<i>Aythya marila</i>	Black-capped Chickadee	<i>Parus atricapillus</i>
Harlequin Duck	<i>Histrionicus histrionicus</i>	Boreal Chickadee	<i>Parus hudsonicus</i>
Common Goldeneye	<i>Bucephala clangula</i>	Red-breasted Nuthatch	<i>Sitta canadensis</i>
Barrow's Goldeneye	<i>Bucephala islandica</i>	Winter Wren	<i>Troglodytes troglodytes</i>
Bufflehead	<i>Bucephala albeola</i>	Golden-crowned Kinglet	<i>Regulus satrapa</i>
Common Merganser	<i>Mergus merganser</i>	Ruby-crowned Kinglet	<i>Regulus calendula</i>
Red-breasted Merganser	<i>Mergus serrator</i>	Mountain Bluebird	<i>Sialia currucoides</i>
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Townsend's Solitaire	<i>Myadestes townsendi</i>
Northern Harrier	<i>Circus cyaneus</i>	Swainson's Thrush	<i>Catharus ustulatus</i>
Sharp-shinned Hawk	<i>Accipiter striatus</i>	Hermit Thrush	<i>Catharus guttatus</i>
Northern Goshawk	<i>Accipiter gentilis</i>	American Robin	<i>Turdus migratorius</i>
Red-tailed Hawk	<i>Buteo jamaicensis</i>	Varied Thrush	<i>Ixoreus naevius</i>
American Kestrel	<i>Falco sparverius</i>	Bohemian Waxwing	<i>Bombicilla garrulus</i>
Spruce Grouse	<i>Dendragapus canadensis</i>	Solitary Vireo	<i>Vireo solitarius</i>
Ruffed Grouse	<i>Bonasa umbellus</i>	Warbling Vireo	<i>Vireo gilvus</i>
Semipalmated Plover	<i>Charadrius semipalmatus</i>	Tennessee Warbler	<i>Vermivora peregrina</i>
Killdeer	<i>Charadrius vociferus</i>	Orange-crowned Warbler	<i>Vermivora celata</i>
Greater Yellowlegs	<i>Tringa melanoleuca</i>	Yellow Warbler	<i>Dendroica petechia</i>
Lesser Yellowlegs	<i>Tringa flavipes</i>	Magnolia Warbler	<i>Dendroica magnolia</i>
Spotted Sandpiper	<i>Actitis macularia</i>	Yellow-rumped Warbler	<i>Dendroica coronata</i>
Semipalmated Sandpiper	<i>Calidris pusilla</i>	Townsend's Warbler	<i>Dendroica townsendi</i>
Least Sandpiper	<i>Calidris minutilla</i>	American Redstart	<i>Setophaga ruticilla</i>
Long-billed Dowitcher	<i>Limnodromus scolopaceus</i>	Northern Waterthrush	<i>Seiurus noveboracensis</i>
Common Snipe	<i>Gallinago gallinago</i>	MacGillivray's Warbler	<i>Oporornis tolmiei</i>
Bonaparte's Gull	<i>Larus philadelphia</i>	Common Yellowthroat	<i>Geothlypis trichas</i>
Mew Gull	<i>Larus canus</i>	Wilson's Warbler	<i>Wilsonia pusilla</i>
Herring Gull	<i>Larus argentatus</i>	Western Tanager	<i>Piranga ludoviciana</i>
Great Horned Owl	<i>Bubo virginianus</i>	Lark Sparrow	<i>Chondestes grammacus</i>
Great Gray Owl	<i>Strix nebulosa</i>	Chipping Sparrow	<i>Spizella passerina</i>
Boreal Owl	<i>Aegolius funereus</i>	Lincoln's Sparrow	<i>Melospiza lincolni</i>
Common Nighthawk	<i>Chordeiles minor</i>	Swamp Sparrow	<i>Melospiza georgiana</i>
Belted Kingfisher	<i>Ceryle alcyon</i>	White-throated Sparrow	<i>Zonotrichia albicollis</i>
Northern Flicker	<i>Colaptes auratus</i>	White-crowned Sparrow	<i>Zonotrichia leucophrys</i>
Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>	Dark-eyed Junco	<i>Junco hyemalis</i>
Hairy Woodpecker	<i>Picoides villosus</i>	Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Three-toed Woodpecker	<i>Picoides tridactylus</i>	Rusty Blackbird	<i>Euphagus carolinus</i>
Olive-sided Flycatcher	<i>Contopus borealis</i>	Brown-headed Cowbird	<i>Molothrus ater</i>
Western Wood-Pewee	<i>Contopus sordidulus</i>	Pine Grosbeak	<i>Pinicola enucleator</i>
Yellow-bellied Flycatcher	<i>Empidonax flaviventris</i>	Purple Finch	<i>Carpodacus purpureus</i>
Alder Flycatcher	<i>Empidonax alnorum</i>	Red Crossbill	<i>Loxia curvirostra</i>
Least Flycatcher	<i>Empidonax minimus</i>	White-winged Crossbill	<i>Loxia leucoptera</i>
Hammond's Flycatcher	<i>Empidonax hammondi</i>	Pine Siskin	<i>Carduelis pinus</i>

APPENDIX B: Field accounts of four rare bird species observed in the Liard River Valley study area from 29 May to 27 July 1994.

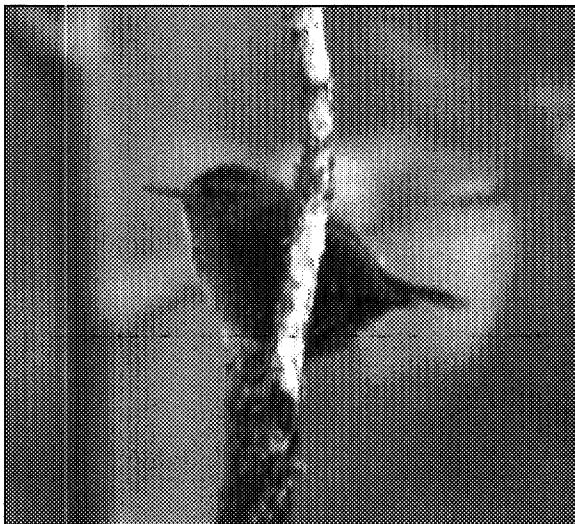
Four species observed during our study, Solitary Vireo, Winter Wren, Lark Sparrow and Eastern Kingbird were either rare or not previously recorded in the Liard River Valley. The following field notes and photographs serve to document these unusual species.

Solitary Vireo, *Vireo solitarius*

On 13 June, a Solitary Vireo was heard briefly singing by C. Eckert in mature mixed forest along the Liard River approximately two kilometers downstream from the Meister River. Its song, similar to a Red-eyed Vireo but slower, was rich and loud with a series of “cheerio” and “chu-wee” notes with distinct pauses between notes.

Winter Wren, *Troglodytes troglodytes*

On 13 June, C. Eckert and P. Sinclair observed a Winter Wren at a wet draw in old-growth White Spruce forest along the Liard River one kilometre south of the Meister River. The area was characterized by a high density of deadfall and large coarse woody debris. The wren was first noted by its hard double chip note and extraordinary song - a long series of soaring trills and warbles. It was about the size of a Golden-crowned Kinglet and had a dark brown back, paler brown undersides with fine barring on the belly and heavier barring along the flanks, a short dark brown tail and short dark brown wings with some darker barring across the flight feathers. Its face was medium brown with a paler brown supercilium. Its short bill was mostly dark with a paler base to the lower mandible. On 13 June the bird was observed carrying nest material (moss) although there were no further signs of nesting. The wren was also observed at that location on June 14, 15, 17, and July 27.



Winter Wren (*Troglodytes troglodytes*), 13 June 1994.
Liard River, Yukon. Photo by Cameron Eckert

Lark Sparrow, *Chondestes grammacus*

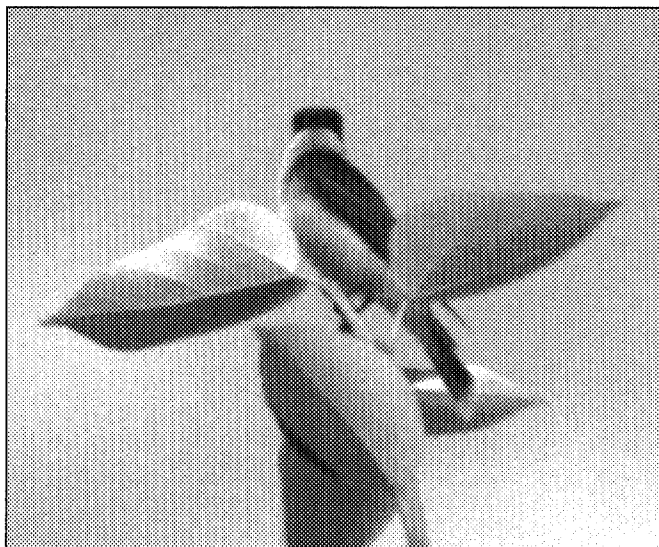
On 15 July, C. Eckert and P. Sinclair flushed a single Lark Sparrow from willows along the Liard River near the Rancheria River. The chunky sparrow appeared slightly larger than a White-throated Sparrow. It had a bold chestnut-brown crown, a white central crown stripe, a bright chestnut ear patch on a white face, a white throat, breast and belly with a single black spot in the centre of its breast, a pale greyish-brown back broken by short blackish stripes, a dark brown tail with white outer tail feathers. The bird was observed for a few minutes before it flew off, called a sharp “tisp” a few times and disappear to the south down the river. It was not seen again. This was the first record of Lark Sparrow for the Yukon.



Lark Sparrow (*Chondestes grammacus*), 15 July 1994.
Liard River, Yukon. Photo by Cameron Eckert.

Eastern Kingbird, *Tyrannus tyrannus*

On 27 July, C. Eckert and P. Sinclair observed an Eastern Kingbird at the Meister River Delta (confluence of the Meister and Liard). The thrush-sized bird was distinctive with a white throat, breast and belly contrasting against a black cap, back and wings and a black tail with a white band across the base. The bird appeared after a brief but intense thunder storm. We observed the bird for just a few minutes as it hawked insects from its perch on top of a young Balsam Poplar. It then flew off to the south, disappeared from sight and was not seen again. Eastern Kingbird was a species that we had watched for throughout the study and it was on the very last day in the field that we observed this bird.



Eastern Kingbird (*Tyrannus tyrannus*), 27 July 1994, Liard River, Yukon. Photo by Cameron Eckert.

APPENDIX C: Mammals, amphibians, and fish species observed in the study area from 29 May to 27 July 1994.		
Mammals	Scientific Name	Comment
Black Bear	<i>Ursus americanus</i>	Tracks and scat commonly seen. Both "black" and "brown" bears observed.
Wolf	<i>Canis lupus</i>	Tracks and scat only.
Moose	<i>Alces alces</i>	Cows and calves commonly observed.
Meadow Jumping Mouse	<i>Zapus princeps</i>	One seen in shrubby clearing.
Red Squirrel	<i>Tamiasciurus hudsonicus</i>	Commonly observed.
Woodchuck	<i>Marmota monax</i>	Observed on four occasions.
Porcupine	<i>Erithixon dorsatum</i>	Feeding sign.
Snowshoe Hare	<i>Lepus americanus</i>	Seen in Lodgepole Pine forest.
Caribou	<i>Rangifer sp.</i>	Scat only.
Pine Marten	<i>Martes americana</i>	One seen in Lodgepole Pine forest.
Beaver	<i>Castor canadensis</i>	Commonly observed along the main river and back-channels.
Amphibians		
Northern Wood Frog	<i>Rana sylvatica</i>	Commonly observed in wet areas.
Fish		
Northern Pike	<i>Esox lucius</i>	seen in Liard River
Arctic Grayling	<i>Thymallus arcticus</i>	seen in Liard River
Dolly Varden	<i>Salvelinus malma</i>	seen in Liard River

APPENDIX D: Dominant plant species (herb, moss, lichen & shrub) recorded in vegetation plots by habitat type.

Dominant herb species recorded in each habitat type:

Common Name	Scientific Name	Trembling Aspen	Balsam Poplar	Cutblock	Mixed Forest	Lodgepole Pine	Riparian Forest	White Spruce
Arrow-leaved Coltsfoot	<i>Petasites sagittatus</i>		X					
Cutleaf Anemone	<i>Anemone multifida</i>		X				X	
Arnica	<i>Arnica sp.</i>		X				X	
Aster	<i>Aster sp.</i>		X				X	X
Red Baneberry	<i>Actaea rubra</i>		X		X		X	
Bastard Toadflax	<i>Geocaulon lividum</i>	X	X	X	X	X	X	X
Strawberry Blight	<i>Chenopodium capitatum</i>			X				
Bunchberry	<i>Cornus canadensis</i>	X	X	X	X	X	X	X
Butterweed	<i>Senecio sp.</i>		X	X			X	X
Calypso Orchid	<i>Calypso bulbosa</i>				X	X		X
Cordylis	<i>Cordylis sp.</i>			X				
Cow-Parsnip	<i>Heracleum lanatum</i>		X					
Dwarf Rattlesnake-Plantain	<i>Goodyera repens</i>						X	X
Dwarf Scouring Rush	<i>Equisetum scirpoides</i>				X			X
Common Dandelion	<i>Taraxacum officinale</i>			X				
Death Camus	<i>Zygadeunus elegans</i>					X		
Equisetum	<i>Equisetum sp.</i>		X	X	X		X	X
False Lilly-of-the-Valley	<i>Maianthemum canadense</i>					X		
Fireweed	<i>Epilobium latifolium</i>	X	X	X	X	X	X	X
Anemone sp.	<i>Anemone sp.</i>					X		
Sweet Coltsfoot	<i>Petasites frigidus</i>		X				X	X
Grass	<i>Poaceae spp.</i>	X	X	X	X	X	X	X
Platanthera Orchid	<i>Platanthera sp.</i>						X	X
Arctic Wintergreen	<i>Pyrola Grandiflora</i>							X
Tall Larkspur	<i>Delphinium glaucum</i>			X	X			
One-leaved Rein Orchid	<i>Platanthera obtusata</i>							X
Lupin	<i>Lupinus arcticus</i>	X		X	X	X	X	X
Sedge	<i>Carex sp.</i>		X					
Meadowrue	<i>Thalictrum sp.</i>		X				X	
Tall Bluebell	<i>Mertensia paniculata</i>	X	X	X	X		X	X
Common Mitrewort	<i>Mitella nuda</i>							X
Northern Monkshood	<i>Aconitum delphinifolium</i>			X			X	X
Bedstraw	<i>Galium sp.</i>	X	X	X	X	X	X	X
One-sided Pyrola	<i>Pyrola secunda</i>		X				X	X
Palmate Coltsfoot	<i>Petasites palmatus</i>	X	X	X	X	X	X	X
Pea sp.								X
Pyrola	<i>Pyrola sp.</i>	X	X		X		X	X
Rough Cinquefoil	<i>Potentilla norvegica</i>			X				
Sparrow's Egg Orchid	<i>Cypripedium passerinum</i>						X	X
Single Delight	<i>Moneses uniflora</i>						X	X
Stinging Nettle	<i>Urtica dioica</i>						X	
Wild Strawberry	<i>Fragaria virginiana</i>		X	X	X		X	X
Tall Jacob's Ladder	<i>Polemonium acutiflorum</i>			X				
Vetch	<i>Astragalus sp.</i>		X				X	X
Violet	<i>Viola sp.</i>				X			
Arctic Wormwood	<i>Artemesia arctica</i>		X				X	X
Yellow Avens	<i>Dryas drummondii</i>						X	
Labrador Lousewort	<i>Pedicularis labradorica</i>	X			X	X		X
Common Yarrow	<i>Achillea millefolium</i>		X	X	X		X	X

APPENDIX D continued: Dominant plant species (herb, moss, lichen & shrub) recorded in vegetation plots by habitat type.

Dominant moss and lichen species recorded in each habitat type:

Common Name	Scientific Name	Trembling Aspen	Balsam Poplar	Cutblock	Mixed Forest	Lodgepole Pine	Riparian Forest	White Spruce
Caribou Lichen	<i>Cladina rangiferina</i>	X			X	X	X	X
Ground-Cedar	<i>Lycopodium complanatum</i>	X			X	X	X	X
Knight's Plume	<i>Ptilium crista-castrensis</i>	X		X	X	X	X	X
Red-stemmed Feathermoss	<i>Pleurozium schreberi</i>	X		X	X	X	X	X
Step Moss	<i>Hylocomium splendens</i>	X	X	X	X	X	X	X
Stiff Clubmoss	<i>Lycopodium annotinum</i>	X		X			X	X
Dog Lichen	<i>Peltigera canina</i>				X			X
Freckle Lichen	<i>Peltigera aphthosa</i>				X			X
Streamside Moss	<i>Scouleria aquatica</i>						X	
Common Leafy Moss	<i>Plagiomnium medium</i>							X
Fairy Parasol	<i>Splachnum luteum</i>							X
Pipe-cleaner Moss	<i>Rhytidiopsis robusta</i>							X
Pixie Cup Lichen	<i>Cladonia pyxidata</i>							X

Dominant shrub species recorded in each habitat type (d=dwarf, l=low, t=tall):

Common Name	Scientific Name	Trembling Aspen	Balsam Poplar	Cutblock	Mixed Forest	Lodgepole Pine	Riparian Forest	White Spruce
Alder	<i>Alnus sp.</i>	D,L,T	D,L,T	D,L,T	D,L,T	L,T	D,L,T	D,L,T
Crowberry	<i>Empetrum nigrum</i>	D			D	D	D	D
High Bush Cranberry	<i>Viburnum edule</i>	D,L	D,L	D,L	D,L	D,L	D,L	D,L
Creeping Juniper	<i>Juniperus horizontalis</i>	D			D,L	L	D	D
Kinnikinnick	<i>Arctostaphylos uva-ursi</i>	D	D	D	D	L	D	D
Low Bush Cranberry	<i>Vaccinium vitis-idaea</i>	D		D	D	D,L	L	D
Labrador Tea	<i>Ledum groenlandicus</i>	D,L		D	D,L	D,L	D,L	D,L
Red Bearberry	<i>Arctostaphylos rubra</i>	D						D
Prickly Rose	<i>Rosa acicularis</i>	D,L	D,L,T	D,L	D,L	D,L	D,L	D,L
Soapberry	<i>Shepherdia canadensis</i>	D,L		D,L	D,L	D,L	D,L	D,L
Twin-flower	<i>Linnaea borealis</i>	D	D	D	D	L	D	D
Willow sp.	<i>Salix sp.</i>	D,L,T	D,L,T	D,L,T	D,L,T	D,L,T	D,L,T	D,L,T
Red Osier Dogwood	<i>Cornus stolonifera</i>		D,L				D,L	D,L
Wild Raspberry	<i>Rubus idaeus</i>		D,L	D,L	D		D,L	
Trailing Raspberry	<i>Rubus acaulis</i>		D	D			D	D
Shrub Birch	<i>Betula glandulosa</i>			L	D,L,T	T		D,L
Ribes sp.	<i>Ribes sp.</i>		L	D,L			D,L	D
Strawberry sp.	<i>Rubus sp.</i>			D,L			D	D
Saskatoon Berry	<i>Amelanchier alnifolia</i>				L,T			
Shrubby Cinquefoil	<i>Potentilla fruticosa</i>				L		L	
Dwarf Blueberry	<i>Vaccinium caespitosum</i>							L