Birds

TERRESTRIAL AVIAN HABITATS AND THEIR UTILIZATION UPPER TANANA RIVER VALLEY, ALASKA 1977

by

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Studies were undertaken in the Tetlin-Northway area of the upper Tanana River Valley, Alaska, during the summer of 1977 to determine avian species density and habitat utilization of vegetation types typical of those to be crossed by the Northwest Alaskan Gas Pipeline in Interior Alaska. Little quantitative data has been available on the utilization by birds of taiga habitats in Alaska or northwestern Canada, and what information is available has been the result of studies completed only within the last few years: Populations and energetics in two upland taiga communities of mixed vegetation types near Fairbanks were studied in 1971 by West and DeWolfe (1974); population density and diversity and avian habitat selection in five lowland taiga mosaic vegetation types were studied near Fairbanks in 1975 by Spindler (1976); and species composition, abundance, and some structural components of bird populations in eight representative vegetation communities in the Kluane National Park, southwest Yukon Territory, were studied in 1973 by Theberge (1976). Also, in a more comprehensive work, Erskine (1977) has summarized available data and discussed the density, diversity, and distribution of avian populations throughout the northern coniferous forest region of Canada.

The Tetlin-Northway area lies mid-way between Kluane National Park and Fairbanks, and our study was designed to compare the major avian habitats of interior Alaska relative to population density, diversity, biomass, productivity, and habitat selection patterns. With this information, it becomes possible to predict the number of birds that will be destroyed or displaced per habitat unit destroyed by pipeline construction and to predict the changes of bird composition that might occur with habitat alteration.

STUDY AREA

The primary study area consisted of census plots set up between Tetlin Junction (63°19'N, 142°36'W) and the airport at Northway (62°58'N, 141°56'W) in the upper Tanana River Valley in eastern interior Alaska (Fig. 1). Applicable information, however, from lowland taiga plots near Fairbanks (64°52'N, 148°43'W), obtained in 1975 by Spindler (1976), have been incorporated into the study.

The taiga of interior Alaska is composed of a large variety of vegetation types, with vegetation patterns in the uplands generally differing somewhat from the lowlands (see Viereck 1975). Briefly, the uplands contain all stages of forest succession, from sapling stands to

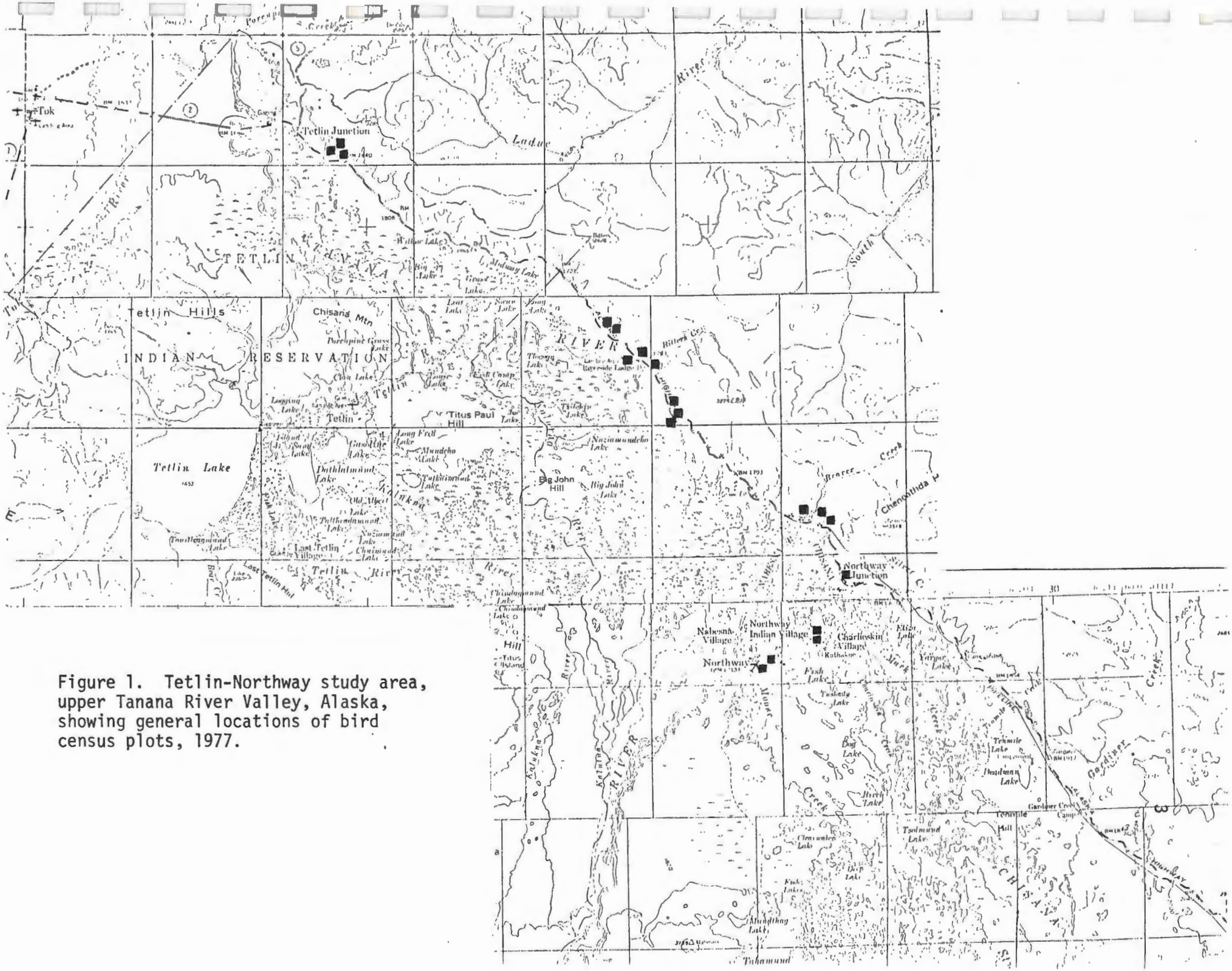

Figure 1. Tetlin-Northway study area, upper Tanana River Valley, Alaska, showing general locations of bird census plots, 1977.

mature forests of Quaking Aspen (Populus tremuloides)*, Balsam Poplar (P. balsamifera), Paper Birch (Betula papyrifera), White Spruce (Picea glauca), and Black Spruce (Picea mariana). Extensive pure stands of Quaking Aspen and Black Spruce are common; the other trees also occur in pure stands, but forests of mixed composition are more frequent. Upland valley bottoms often contain extensive bogs (mostly ericaceous shrubs and Eriophorum tussocks) and shrub thickets (mostly Salix sp. and Alnus sp.), in addition to forests, woodlands, and dwarf forests. The lowlands usually consist of a complex mosaic of wetlands (rivers, lakes, ponds, and marshes), meadows, and bogs in addition to shrub thickets, woodlands, and forests in various stages of succession. The mosaic pattern of vegetational diversity in the taiga arises from such interrelated factors as wildfire, permafrost, alluviation, soil type, slope, aspect, and water relations (Viereck 1970, 1973, 1975). Frequent interdigitation of upland and lowland habitats where the Tanana-Yukon Highlands meet the Tanana River Valley resulted in a high diversity of vegetation types in the study area.

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*Plant nomenclature follows Hultén (1968), with the exception of the genus Salix, which follows Viereck and Little (1972).

METHODS

Using the classification of major avian habitats previously developed for Alaska by Kessel (unpubl. data), which differentiates vegetative habitats on the basis of life-form and height of the vegetation, census plots were selected in each of the six major terrestrial woody avian habitats present in the upper Tanana Valley. Kessel's avian habitat classification system resembles aspects of Fosberg's (1967) vegetation classification, at least at the physiogonomic level, but distinguishes several shrub habitats of differing heights, based on observed bird utilization: Dwarf Shrub Mat (<.05 m); Low Shrub Thicket (0.5-1.0 m); Medium Shrub Thicket (1.1-2.4 m); Tall Shrub Thicket (2.5-4.6 m); and forests (>4.6 m), including Coniferous Forest, Deciduous Forest, and Mixed Coniferous-Deciduous Forest. In the Tanana Valley, the three lower shrub classes rarely occur in homogeneous stands large enough to census quantitatively; hence, in this study, we combined all woody vegetation habitats up to 2.4 m and referred to this compound habitat as Low and Medium Shrub Thickets. Additionally, we recognized another, perhaps compound, habitat of Scattered Woodland and Dwarf Forest, characterized by open stands of growth-stunted trees.

Within each of the six major avian habitats, we censused several replicate plots in common vegetative types typical and representative of that avian habitat. In spite of the fact that homogeneous stands large enough to encompass a standardized 10-hectare (25 acre) census plot were

difficult to locate, we did set up at least one such plot in each major habitat. In addition, a number of smaller "miniplots" (1.61-2.20 ha) were established in smaller mixed and pure vegetation stands to increase sample size and to increase the variety of vegetation types that could be sampled, even though we recognized that small census plots are generally undesirable because of edge effect and high variability (Oelke 1966, Erskine 1977).

Habitat Description

Each 10-ha census plot was subdivided by seven equally-spaced transect lines, resulting in 49 equal-sized subplots. These subplots were used as sample units in vegetation analyses. Each subplot was sampled at two replicate points, using the point-centered quarter method (Cottam and Curtis 1956), with modifications to include sampling of ground cover, understory, and tall shrub vegetation (Ohmann and Ream 1971). The 51 variables used in the habitat analyses are listed in Table 1. In measuring habitat variables, we defined "tree" in two ways: For tree/shrub species importance values and for variables based on tree/shrub measurements (diameter, basal area, height, distribution and diversity of tree/shrub heights, distribution and diversity of foliage volume, and density of tree/shrub stems), a tree was any stem $\geq$ 2.54 cm dbh; for distance between trees (TRDISTANCE), a tree was any stem >4.6 m tall. Height definitions of individual stems in these analyses should not be confused with our definitions of avian

Table 1. Summary of values of habitat variables from each bird census plot, Tetlin-Northway study area, Alaska, August 1977

Variable	Symbol	SHRUB THICKETS			
		Lowland Medium-Tall Willow	Lowland Tall Willow-Poplar	Upland Tall Willow	Upland Low & Medium Willow
Ground Cover (in percent)					
Grass*	GRASS	19.1	13.2	35.1	53.2
Herbs*	HERBS	13.6	14.4	12.5	7.6
Moss and Lichen*	MOSS&L	15.8	12.1	22.5	7.6
Dwarf Shrub (<0.5 high)*	DSHRUB	25.9	35.0	22.5	31.6
Litter*	LITTER	19.3	25.3	6.2	0.0
Water, standing*	WATER	6.3	0.0	1.2	0.0
Fire Evidence (0=minimum, 2.0=maximum)	FIRE	0.03	0.0	0.0	0.0
Edge (0=minimum, 2.0=maximum)	EDGE	0.35	1.0	0.71	1.0
Woody Growth Form (percent of stems)					
Single Stem, large or small diameter	SS	47.2	48.2	26.8	60.7
Multiple Stem, small diameter	MSS	52.8	51.8	73.2	39.3
Multiple Stem, large diameter	MSL	0.0	0.0	0.0	0.0
Slope, average (%)*	SLOPE	0	0	0	0
Aspect, average azimuth (0-360°)*	ASPECT	flat	flat	flat	flat
Tree/Shrub Diameter (cm dbh)*	DIAMETER	4	5	4	4
Distance between Trees/Shrubs (≥2.54 cm dbh definition) (m)*	DISTANCE	15.1	3.9	3.1	14.1
Distance between Trees (>4.6 m height) (m)	TRDISTANCE	42.8	5.0	6.0	49.3
Tree/Shrub Height (m)	HEIGHT	3.7	4.7	4.4	3.3
Distribution of Tree/Shrub Height (% in each class)					
>30 m	H>30	0.0	0.0	0.0	0.0
20.1-30 m	H20-30	0.0	0.0	0.0	0.0
10.1-20 m	H10-20	0.3	0.0	1.8	0.0
4.7-10 m	HT	17.5	60.7	33.9	14.3
2.5-4.6 m	HTS	68.1	39.3	57.1	46.4
0-2.4 m	HLMS	13.4	0.0	7.1	39.3
Height Diversity (H')	HDIV	0.853	0.670	0.947	1.001
Canopy Thickness (m)	THICK	2.7	3.7	3.3	2.9
Total Canopy Coverage (% of sky observed)**	CANOPY	22.5	25.7	42.9	4.3
Distribution of Foliage Volume (% in each class)					
>4.6 m†	FV4	4.0	0.0	4.7	0.0
2.5-4.6 m†	FV3	19.4	17.6	39.1	3.7
1.1-2.4 m†	FV2	21.6	25.5	28.1	14.8
0-1.0 m†	FV1	54.9	56.9	28.1	81.5
Foliage Diversity (H')†	FDIV	1.107	0.975	1.224	0.571
Brush Density, 0-1.0 m high (stems/ha)	BRUSH	24012.	30335.	33158.	9523.
Tree/Shrub Density, ≥2.54 cm dbh (stems/ha)*	TRDENS	44	672	1012	50
Distribution of Tree/Shrub Density (% in each class)					
>4.6 m (tree layer)	DT	14.4	43.6	32.1	10.7
2.5-4.6 m (tall shrub layer)	DTS	72.2	56.4	60.8	50.0
1.1-2.4 m (medium shrub layer)	DLMS	13.4	0.0	7.1	39.3
Density Diversity (H')	DDIV	0.787	0.685	0.855	0.953
Basal Area of Trees/Shrubs (cm^2/ha)*	BASAL	740	14794	29528	811
Tree and Tall Shrub Species Relative Importance (%)					
White Spruce*	WSPRUCE	16.7	2.6	30.4	66.1
Black Spruce*	BSPRUCE	0.0	0.0	0.0	0.0
Paper Birch*	BIRCH	1.8	16.5	0.0	0.0
Quaking Aspen*	ASPEN	0.0	0.0	0.0	0.0
Willow*	WILLOW	18.9	47.1	69.6	33.9
Balsam Poplar*	POPLAR	26.0	33.8	0.0	0.0
*Alnus incana**	INCANA	36.6	0.0	0.0	0.0
*Alnus crispa**	CRISPA	0.0	0.0	0.0	0.0
Tree/Tall Shrub Diversity (H')†	TSDIV	1.404	1.113	0.614	0.640
Stand Age (years)		(low/med shrub)	(tall shrub)		
Mean Age	MAGE	148	82	27	42	44
Maximum Age	XAGE	200	180	36	65	60
Index of Heterogeneity (stems/DIST)††	SHET	97.9	27.7	53.3	4.7
Index of Heterogeneity (trees/TRDIST)††	THET	76.7	36.5	56.1	6.2

*See Ohmann and Ream (1971)
†See MacArthur (1964)
**See James and Shugart (1970)
††See Roth (1976)

Table 1. (cont'd)

Variable	Symbol	DECIDUOUS FOREST				
		Upland Aspen-Poplar	Upland Aspen #1	Upland Aspen #2	Upland Birch #1	Upland Birch #2
Ground Cover (in percent)						
Grass*	GRASS	17.5	6.1	5.3	10.7	7.6
Herbs*	HERBS	5.0	12.0	14.7	12.0	17.7
Moss and Lichens*	MOSS&L	3.8	2.0	6.6	8.1	12.7
Dwarf Shrub (<0.5 high)*	DSHRUB	37.5	47.2	29.3	22.6	17.7
Litter*	LITTER	26.2	32.7	44.1	46.6	44.3
Water, standing*	WATER	0.0	0.0	0.0	0.0	0.0
Fire Evidence (0=minimum, 2.0=maximum)	FIRE	2.0	1.14	2.0	1.76	0.5
Edge (0=minimum, 2.0=maximum)	EDGE	1.0	0.33	0.71	0.14	0.0
Woody Growth Form (percent of stems)						
Single Stem, large or small diameter	SS	75.0	91.3	96.4	37.0	60.7
Multiple Stem, small diameter	MSS	8.9	5.9	0.0	40.5	28.6
Multiple Stem, large diameter	MSL	16.1	2.8	3.6	22.5	10.7
Slope, average (%)*	SLOPE	25	23	24	23	24
Aspect, average azimuth (0-360°)*	ASPECT	215	199	264	242	283
Tree/Shrub Diameter (cm dbh)*	DIAMETER	13	12	9	12	11
Distance between Trees/Shrubs (≥2.54 cm dbh definition) (m)*	DISTANCE	2.9	2.8	1.7	2.9	2.4
Distance between Trees (>4.6 m height) (m)	TRDISTANCE	2.9	2.9	1.7	3.2	2.6
Tree/Shrub Height (m)	HEIGHT	12.0	11.7	10.4	10.4	10.1
Distribution of Tree/Shrub Height (% in each class)						
>30 m	H>30	0.0	0.0	0.0	0.0	0.0
20.1-30 m	H20-30	3.6	0.0	0.0	3.3	0.0
10.1-20 m	H10-20	58.9	60.7	53.6	38.3	48.2
4.7-10 m	HT	26.8	34.4	39.3	42.9	42.9
2.5-4.6 m	HTS	10.7	4.3	7.1	14.3	7.1
0-2.4 m	HLMS	0.0	0.6	0.0	1.3	1.8
Height Diversity (H')	HDIV	1.023	0.836	0.889	1.178	0.975
Canopy Thickness (m)	THICK	6.4	5.4	4.6	7.7	6.3
Total Canopy Coverage (% of sky observed)**	CANOPY	74.3	71.2	75.7	78.6	81.4
Distribution of Foliage Volume (% in each class)						
>4.6 m†	FV4	65.2	65.2	66.2	56.2	60.6
2.5-4.6 m†	FV3	9.1	9.7	9.1	21.2	17.0
1.1-2.4 m†	FV2	7.6	8.6	7.8	8.6	8.5
0-1.0 m†	FV1	18.2	16.5	16.9	14.0	13.8
Foliage Diversity (H')†	FDIV	1.003	1.013	0.991	1.139	1.088
Brush Density, 0-1.0 m high (stems/ha)	BRUSH	5997	5694	7407	7509	5997
Tree/Shrub Density, ≥2.54 cm dbh (stems/ha)*	TRDENS	1225	1243	3403	1158	1696
Distribution of Tree/Shrub Density (% in each class)						
>4.6 m (tree layer)	DT	83.9	94.1	87.5	81.1	89.3
2.5-4.6 m (tall shrub layer)	DTS	16.1	5.4	12.5	17.6	8.9
1.1-2.4 m (medium shrub layer)	DLMS	0.0	0.5	0.0	1.3	1.8
Density Diversity (H')	DDIV	0.441	0.241	0.377	0.532	0.389
Basal Area of Trees/Shrubs (cm^2/ha)*	BASAL	206382	168679	279860	183793	187515
Tree and Tall Shrub Species Relative Importance (%)						
White Spruce*	WSPRUCE	0.0	14.3	7.0	2.5	3.9
Black Spruce*	BSPRUCE	0.0	0.0	0.0	0.0	0.0
Paper Birch*	BIRCH	0.0	1.1	0.0	53.8	55.9
Quaking Aspen*	ASPEN	58.5	72.7	76.6	1.1	0.0
Willow*	WILLOW	16.3	9.1	6.3	16.9	24.9
Balsam Poplar*	POPLAR	25.2	1.9	10.1	0.7	0.0
*Alnus incana**	INCANA	0.0	0.0	0.0	0.0	0.0
*Alnus crispa**	CRISPA	0.0	0.9	0.0	24.9	15.3
Tree/Tall Shrub Diversity (H')†	TSDIV	0.957	0.895	0.796	1.157	1.085
Stand Age (years)						
Mean Age	MAGE	100	96	59	84	58
Maximum Age	XAGE	105	107	72	125	76
Index of Heterogeneity (stems/DIST)††	SHET	13.2	22.0	44.1	32.1	32.4
Index of Heterogeneity (trees/TRDIST)††	THET	13.2	20.8	44.1	28.4	20.8

Table 1. (cont'd)

Variable	Symbol	MIXED DECIDUOUS-CONIFEROUS FOREST: Upland Aspen-White Spruce	Upland Birch-White Spruce	Upland White Spruce-Aspen-Birch	Upland White Spruce-"Toothpick" Birch
Ground Cover (in percent)					
Grass*	GRASS	14.6	10.2	2.7	1.2
Herbs*	HERBS	10.1	13.2	10.7	8.9
Moss and Lichens*	MOSS&L	14.6	19.2	17.9	11.4
Dwarf Shrub (<0.5 high)*	DSHRUB	19.1	15.0	38.3	27.8
Litter*	LITTER	41.6	42.4	30.4	50.7
Water, standing*	WATER	0.0	0.0	0.0	0.0
Fire Evidence (0=minimum, 2.0=maximum)	FIRE	2.0	0.0	2.0	2.0
Edge (0=minimum, 2.0=maximum)	EDGE	0.25	0.04	0.2	0.1
Woody Growth Form (percent of stems)					
Single Stem, large or small diameter	SS	84.4	62.3	47.5	78.5
Multiple Stem, small diameter	MSS	7.8	28.5	50.0	3.6
Multiple Stem, large diameter	MSL	7.8	9.2	2.5	17.9
Slope, average (%)*	SLOPE	32	17	23	19
Aspect, average azimuth (0-360°)*	ASPECT	105	282	292	184
Tree/Shrub Diameter (cm dbh)*	DIAMETER	11	11	9	9
Distance between Trees/Shrubs (≥2.54 cm dbh definition) (m)*	DISTANCE	2.6	2.6	2.7	2.1
Distance between Trees (>4.6 m height) (m)	TRDISTANCE	3.0	3.0	3.3	2.1
Tree/Shrub Height (m)	HEIGHT	10.0	10.2	7.2	8.6
Distribution of Tree/Shrub Height (% in each class)					
>30 m	H>30	0.0	0.0	0.0	0.0
20.1-30 m	H20-30	4.7	6.6	0.0	0.0
10.1-20 m	H10-20	32.8	38.0	25.0	25.0
4.7-10 m	HT	43.8	33.9	41.3	64.3
2.5-4.6 m	HTS	18.8	20.4	32.5	8.9
0-2.4 m	HLMS	0.0	1.0	1.3	1.8
Height Diversity (H')	HDIV	1.185	1.284	1.134	0.918
Canopy Thickness (m)	THICK	6.6	7.7	5.5	5.9
Total Canopy Coverage (% of sky observed)**	CANOPY	68.8	78.8	57.0	78.6
Distribution of Foliage Volume (% in each class)					
>4.6 m†	FV4	53.9	54.2	30.4	52.6
2.5-4.6 m†	FV3	19.7	20.4	31.3	20.5
1.1-2.4 m†	FV2	10.5	11.6	24.1	11.5
0-1.0 m†	FV1	15.8	13.8	14.3	15.4
Foliage Diversity (H')†	FDIV	1.181	1.179	1.347	1.200
Brush Density, 0-1.0 m high (stems/ha)	BRUSH	11420	7005	14321	9523
Tree/Shrub Density, ≥2.54 cm dbh (stems/ha)*	TRDENS	1451	1443	1372	2178
Distribution of Tree/Shrub Density (% in each class)					
>4.6 m (tree layer)	DT	78.1	74.5	61.2	87.5
2.5-4.6 m (tall shrub layer)	DTS	21.9	24.5	37.5	12.5
1.1-2.4 m (medium shrub layer)	DLMS	0.0	1.0	1.3	0.0
Density Diversity (H')	DDIV	0.526	0.405	0.725	0.377
Basal Area of Trees/Shrubs (cm^2/ha)*	BASAL	218077	227359	139768	184042
Tree and Tall Shrub Species Relative Importance (%)					
White Spruce*	WSPRUCE	29.8	30.1	36.1	43.5
Black Spruce*	BSPRUCE	0.0	0.0	0.0	0.0
Paper Birch*	BIRCH	2.7	44.6	8.6	37.5
Quaking Aspen*	ASPEN	41.1	0.0	9.5	3.8
Willow*	WILLOW	9.7	3.4	24.9	15.2
Balsam Poplar*	POPLAR	16.7	0.0	3.5	0.0
*Alnus incana**	INCANA	0.0	0.0	0.0	0.0
*Alnus crispa**	CRISPA	0.0	21.9	17.5	0.0
Tree/Tall Shrub Diversity (H')†	TSDIV	1.349	1.169	1.571	1.141
Stand Age (years)			(Burn 1) Both (Burn 2)		
Mean Age	MAGE	63	106 91 57	54	50
Maximum Age	XAGE	80	130	57	75
Index of Heterogeneity (stems/DIST)††	SHET	28.3	30.7	17.9	42.0
Index of Heterogeneity (trees/TRDIST)††	THET	39.8	32.3	14.6	42.0

Table 1. (cont'd)

Variable	Symbol	CONIFEROUS FOREST			SCATTERED WOODLAND AND DWARF FOREST	
		Upland White Spruce #1	Upland White Spruce #2	Upland Black Spruce	Upland Black Spruce Bog	Lowland White Spruce-Birch Woodland
Ground Cover (in percent)						
Grass*	GRASS	11.9	5.2	10.1	21.0	7.9
Herbs*	HERBS	11.3	10.4	12.7	13.9	6.5
Moss and Lichens*	MOSS&L	38.1	49.3	38.0	25.7	18.4
Dwarf Shrub (<0.5 high)*	DSHRUB	22.6	7.8	29.1	30.2	58.0
Litter*	LITTER	15.9	27.3	10.1	8.1	9.2
Water, standing*	WATER	0.2	0.0	0.0	1.1	0.0
Fire Evidence (0=minimum, 2.0=maximum)	FIRE	0.14	0.86	0.0	0.0	1.29
Edge (0=minimum, 2.0=maximum)	EDGE	0.0	0.29	0.3	0.1	1.0
Woody Growth Form (percent of stems)						
Single Stem, large or small diameter	SS	88.5	86.5	98.2	98.2	100.0
Multiple Stem, small diameter	MSS	9.5	7.0	1.8	1.8	0.0
Multiple Stem, large diameter	MSL	2.0	7.0	0.0	0.0	0.0
Slope, average (%)*	SLOPE	29	38	8	2	0
Aspect, average azimuth (0-360°)*	ASPECT	165	283	185	224	flat
Tree/Shrub Diameter (cm dbh)*	DIAMETER	16	16	8	5	5
Distance between Trees/Shrubs (≥2.54 cm dbh definition) (m)*	DISTANCE	3.3	2.7	1.9	1.7	4.9
Distance between Trees (>4.6 m height) (m)	TRDISTANCE	3.7	2.9	2.4	7.4	9.0
Tree/Shrub Height (m)	HEIGHT	14.6	15.0	6.7	3.6	3.7
Distribution of Tree/Shrub Height (% in each class)						
>30 m	H>30	3.8	0.0	0.0	0.0	0.0
20.1-30 m	H20-30	29.1	37.5	0.0	0.0	0.0
10.1-20 m	H10-20	24.2	26.8	12.5	0.0	0.0
4.7-10 m	HT	28.1	19.6	60.7	19.6	42.9
2.5-4.6 m	HTS	14.5	12.5	23.2	67.9	35.7
0-2.4 m	HLMS	0.3	3.6	3.6	12.5	21.4
Height Diversity (H')	HDIV	1.481	1.420	1.022	0.842	1.061
Canopy Thickness (m)	THICK	12.3	11.7	4.9	2.6	2.9
Total Canopy Coverage (% of sky observed)**	CANOPY	61.2	74.3	40.0	15.7	1.4
Distribution of Foliage Volume (% in each class)						
>4.6 m†	FV4	51.0	57.5	28.6	2.9	0.0
2.5-4.6 m†	FV3	16.9	16.3	22.2	11.8	5.9
1.1-2.4 m†	FV2	13.3	16.3	22.2	35.3	11.8
0-1.0 m†	FV1	18.8	10.0	27.0	50.0	82.4
Foliage Diversity (H')†	FDIV	1.226	1.140	1.380	1.069	0.579
Brush Density, 0-1.0 m high (stems/ha)	BRUSH	6299	11992	15874	25044	5291
Tree/Shrub Density, ≥2.54 cm dbh (stems/ha)*	TRDENS	904	1357	2899	3403	424
Distribution of Tree/Shrub Density (% in each class)						
>4.6 m (tree layer)	DT	82.6	80.3	69.6	12.5	32.1
2.5-4.6 m (tall shrub layer)	DTS	17.1	16.1	26.8	75.0	42.9
1.1-2.4 m (medium shrub layer)	DLMS	0.3	3.6	3.6	12.5	25.0
Density Diversity (H')	DDIV	0.477	0.590	0.725	0.736	1.074
Basal Area of Trees/Shrubs (cm^2/ha)*	BASAL	287809	427725	186724	71198	18825
Tree and Tall Shrub Species Relative Importance (%)						
White Spruce*	WSPRUCE	74.0	66.6	9.5	0.0	73.4
Black Spruce*	BSPRUCE	0.5	0.0	86.2	100.0	7.9
Paper Birch*	BIRCH	5.9	15.5	0.0	0.0	18.8
Quaking Aspen*	ASPEN	7.0	0.0	0.0	0.0	0.0
Willow*	WILLOW	0.0	0.0	0.0	0.0	0.0
Balsam Poplar*	POPLAR	0.0	0.0	0.0	0.0	0.0
*Alnus incana**	INCANA	0.0	0.0	0.0	0.0	0.0
*Alnus crispa**	CRISPA	12.6	17.9	4.3	0.0	0.0
Tree/Tall Shrub Diversity (H')†	TSDIV	0.863	0.868	0.487	0.000	0.742
Stand Age (years)						
Mean Age	MAGE	166	160	154	56	124
Maximum Age	XAGE	200	185	250	65	190
Index of Heterogeneity (stems/DIST)††	SHET	28.6	27.9	20.4	44.1	27.7
Index of Heterogeneity (trees/TRDIST)††	THET	25.8	24.1	22.0	99.5	42.6

habitat vegetation layers, although they generally correspond. A summary of the ages of trees and shrubs on census plots on the Tetlin Northway study area is given in Appendix Table A-1.

Bird Censusing

We used a modification of the territory mapping census method (Williams 1936, Kendeigh 1944, International Bird Census Committee 1970). Each of the seven equally-spaced transect lines was flagged, and a numbered colored tag was used to mark the seven equal intervals along the line; these numbered tags, then, marked the centers of the 49 subplots and aided in accurately plotting the locations of birds observed. The miniplots consisted of only one transect line, which varied from seven to ten subplots in length.

During a census, the observer followed the transect lines, stopping for 2-7 minutes, depending upon avian activity, at each subplot. All birds seen or heard were recorded on a map, with special designations for singing males or territorial females. The species, sex, activity, height of observation, and vegetation utilized were recorded for each bird observed. Each census of a 10-ha plot took approximately 4 hours, usually between 0300-0800 (Alaska Standard Time), which is generally within the time of greatest singing activity. Exact timing was adjusted to meet the variation of song periods on plots of differing topography and habitat. Ideally censuses should not be conducted on rainy or windy mornings; however, the weather was less than ideal during the

breeding season of 1977, so about 25% of the censuses were conducted in rainy weather. Eight censuses were completed on each 10-ha plot between 29 May and 9 July 1977. Only one plot was censused per morning. Censuses were conducted in paris of two consecutive days at each plot, to maximize consistency.

Census methods on the miniplots were identical to the 10-ha plots, except that censusing started 13 June and was completed 13 July 1977. Six to nine censuses were completed on each miniplot. Two to three adjacent miniplots were censused each morning.

Breeding density was determined by estimating the number of territories of each species, based on repeated observations of territorial males, females, or breeding pairs. We also recorded non-territorial and non-breeding birds and calculated an index of abundance based on the mean number of birds observed per census. This index was used to compare abundance of permanent resident non-territorial species or those which bred asynchronously from the majority of summer resident species.

Densities on the miniplots have been extrapolated to a 10-ha basis and adjusted for the edge effect and other confounding effects of small plot size through the use of regression analyses. The 10 ha plots were generally paired with adjacent, similar habitat miniplots, so we were able to develop a linear regression equation for each habitat type to identify the relationship between density/10 ha and density/miniplot line. The extrapolated miniplot estimates were

adjusted by the factor derived in the regression model for the nearest similar habitat.

Community Analyses

The avian communities in the six major avian habitats were compared relative to species composition, species diversity, breeding density, productivity (breeding biomass and existence energy), and species abundance distribution (density-dominance structure). For diversity comparison, we used a calculated species diversity index, H' (Shannon and Weaver 1949). Species diversity has two components: number of species (species richness) and the eveness (species equitability) with which the individuals of the community are apportioned among those species (Pielou 1975). H' reaches its maximum value in communities with many species of nearly equal abundance. A community with many species distributed unevenly may have the same diversity index as a community with fewer species which are distributed evenly. Hence, for our comparison, in addition to H', we have used (a) the number of species, (b) an index of evenness, J' (Pielou 1975), and (c) graphs of species abundance distributions.

Breeding biomass was calculated for each plot as the sum of breeding biomass for each species breeding on the plot. Breeding biomass for each species was calculated as the product of the density of breeding birds and average weight of the species. Species weights used were an average weight for all adult specimens in the University of Alaska Museum

that had been collected in Alaska during the breeding season. If the sample size in the museum was too small, or variability too high, we consulted published literature (Carbyn 1971, West and DeWolfe 1974) for values determined from northern populations. The weights used for calculations in this study are presented in Appendix Table A-2. On plots with large-bodied breeding birds (e.g., cranes, waterfowl, grouse, or raptors), we apportioned the biomass according to estimated territory or "home range" sizes obtained from the literature, to prevent artificially high biomass extrapolations arising from small plot data. In several instances, an entire family of heavy-bodied birds occurred on a plot (Spruce Grouse in CF3 and Great Horned Owl on DF5) and even with apportionment skewed the total biomass disporportionately; these families were eliminated entirely from the biomass calculations. Breeding biomass was expressed as grams breeding birds per 10 ha.

Existence energy, sometimes referred to as metabolic density or consuming biomass, is an approximation of daily energy requirements. For each species in each major habitat, existence energy (M) was calculated as $M = D \cdot W^{0.76}$, where "D" is density in breeding birds per 10 hectares and where "W" is the average weight, determined as explained above. This method of estimating the daily energy expenditure in kilocalories (kcal) for the maintenance of bird biomass (Karr 1968) admittedly is rough, but it is adequate for comparisons of general community patterns. Calculations made by raising bird weight to a

fractional exponent (e.g., $W^{0.76}$) produces a better index of energy flow than breeding biomass alone by accounting for the lower metabolic rates of large-bodied birds (Salt 1957, Karr 1968, Kendeigh 1970).

Avian Habitat Selection

A set of 36 habitat variables was used to analyse habitat selection with analysis of variance, and a set of 32 variables was used in multiple regression techniques. Bird species which occurred on ten or more subplots were analyzed quantitatively. For analysis of variance, two data subsets were formed for each species: one containing all the habitat variables in all subplots where the species was present (species-present habitats) and the other containing all the habitat variables in subplots where it was absent (species-absent habitats). The mean of each habitat variable was then tested with one-way analysis of variance to determine significant differences between species-present and species-absent groups at the $p \leq 0.05$ significance level (Steel and Torrie 1960). Significant variables were assumed selected for if the mean of the species-present group was greater than the mean of the species-absent group, and selected against if the reverse occurred. Such variables were termed "selected variables," as in Anderson and Shugart (1974). A total of 36 habitat variables was analyzed for 26 species by this method, requiring 936 separate analyses of variance which were performed using "Biomedical Computer Program BMD07D" (Dixon 1972).

Multiple regression was used to order the habitat variables (independent variables) according to their effectiveness in predicting bird frequency of occurrence on each subplot (dependent variables) for each of the 26 species. Results from the analysis of variance procedures were used to select the most diagnostic variables suitable for regression analysis. Discrete or binomially-distributed variables (e.g., past fire, edge effect, water presence) were not regressed. The computer routines used were from the "Statistical Analysis System" program (Service 1972).

For each species-present data subset, the mean value of each habitat variable and importance values of the eight major tree and tree-sized shrub species were calculated and used for quantitative description of the preferred habitats. Importance values used were the sum of relative frequency, relative density, and relative dominance of the species in the stand, similar to Cottam and Curtis (1956).

Phenology

Various chronological, phenological, and weather data were tabulated during the field season; these data are given in Appendix Tables A-3, A-4, and A-5.

HABITAT DESCRIPTIONS

Several replicate bird census plots were established in vegetation types representative of each of the six major terrestrial woody avian habitats present in the upper Tanana River Valley. The exact locations of the plots in the Tetlin-Northway area are shown in Figure 2. A summary of the values of the 51 habitat variables used in the vegetative analyses of these plots is given in Table 1, and the frequency of occurrence of understory and ground cover plant species is given in Table 2. A general description of each plot in each of the major avian habitats follows below.

Low and Medium Shrub Thickets (LMS), Figure 3

Open or closed shrub stands of low (0.5-1.0 m) and medium (1.1-2.4 m) height Willow, Alder, or Dwarf Birch (*Betula* sp.). Such stands usually have extensive dwarf shrub, grass, sedge, or wet-sedge ground cover, with widely scattered, stunted trees. These habitats often resemble shrubby seral stages of temperate regions. While such seral stages do occur in the Tanana River Valley, most shrub habitats (especially in valleys and river flats) are relatively permanent habitats in which the vegetation is stunted by such rigorous growing conditions as permafrost, excessive moisture, elevation, and wildfire (Drury 1956, Viereck 1975, Calmes 1976).

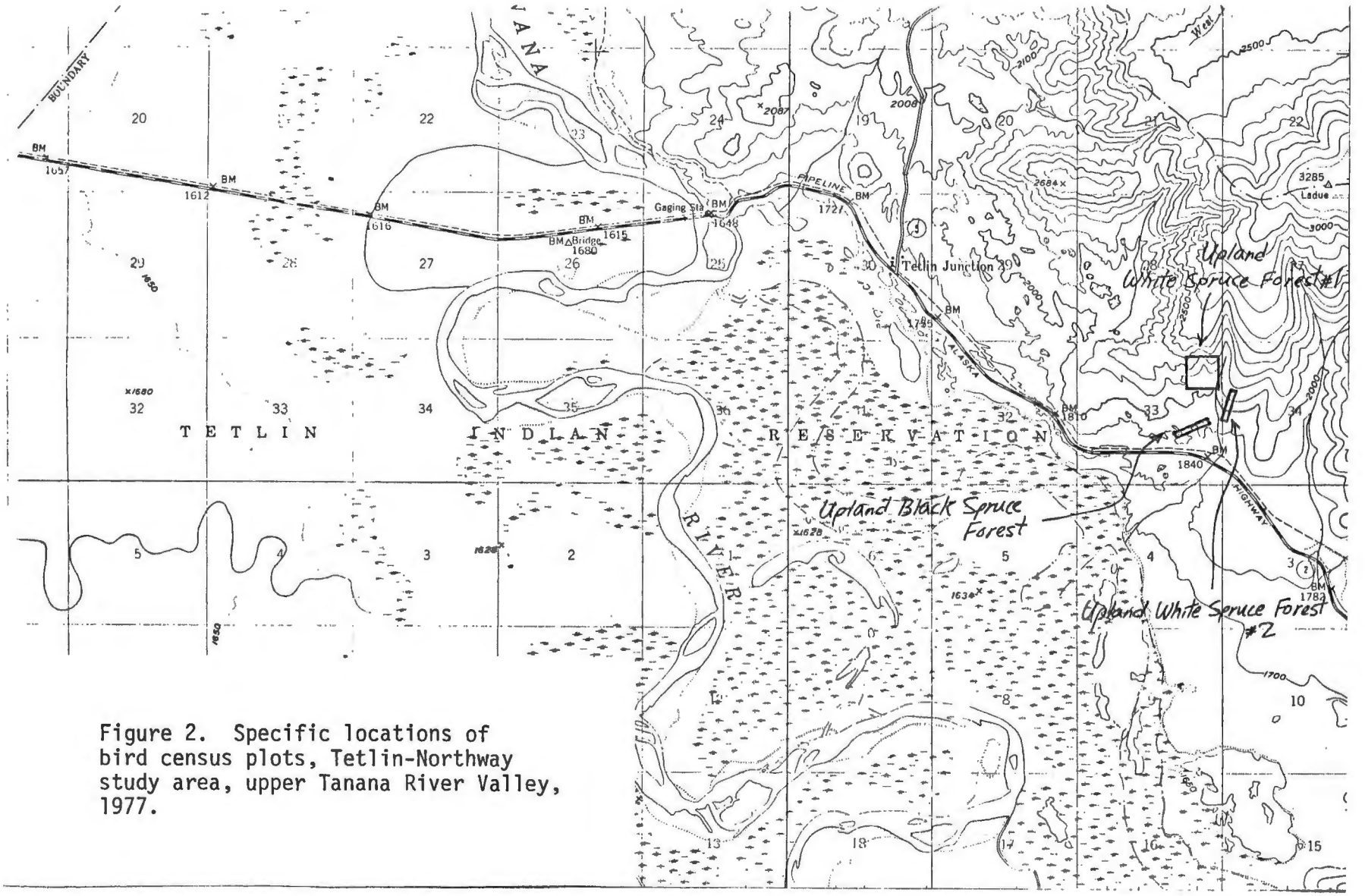

Figure 2. Specific locations of bird census plots, Tetlin-Northway study area, upper Tanana River Valley, 1977.

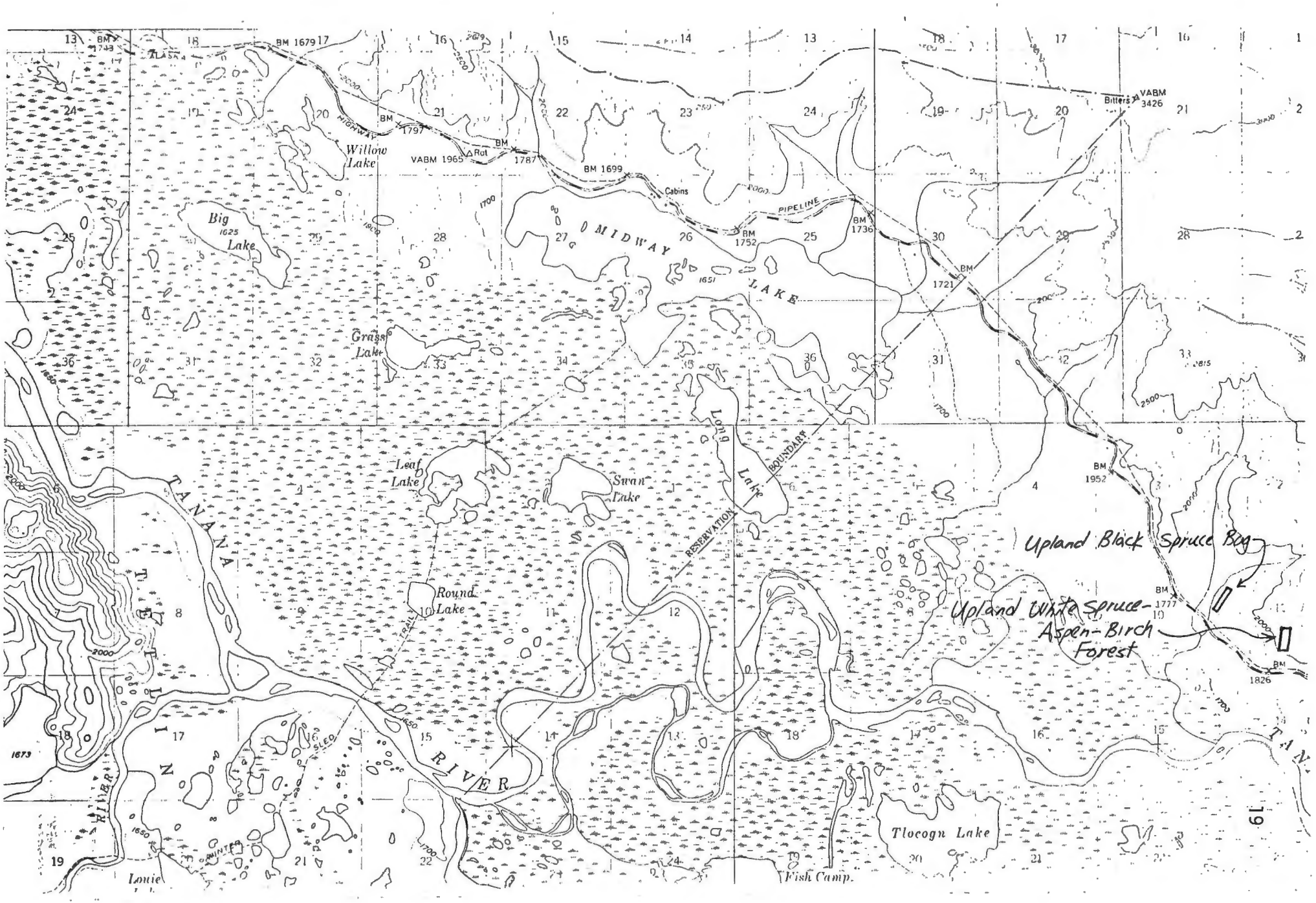

Figure 2. cont'd

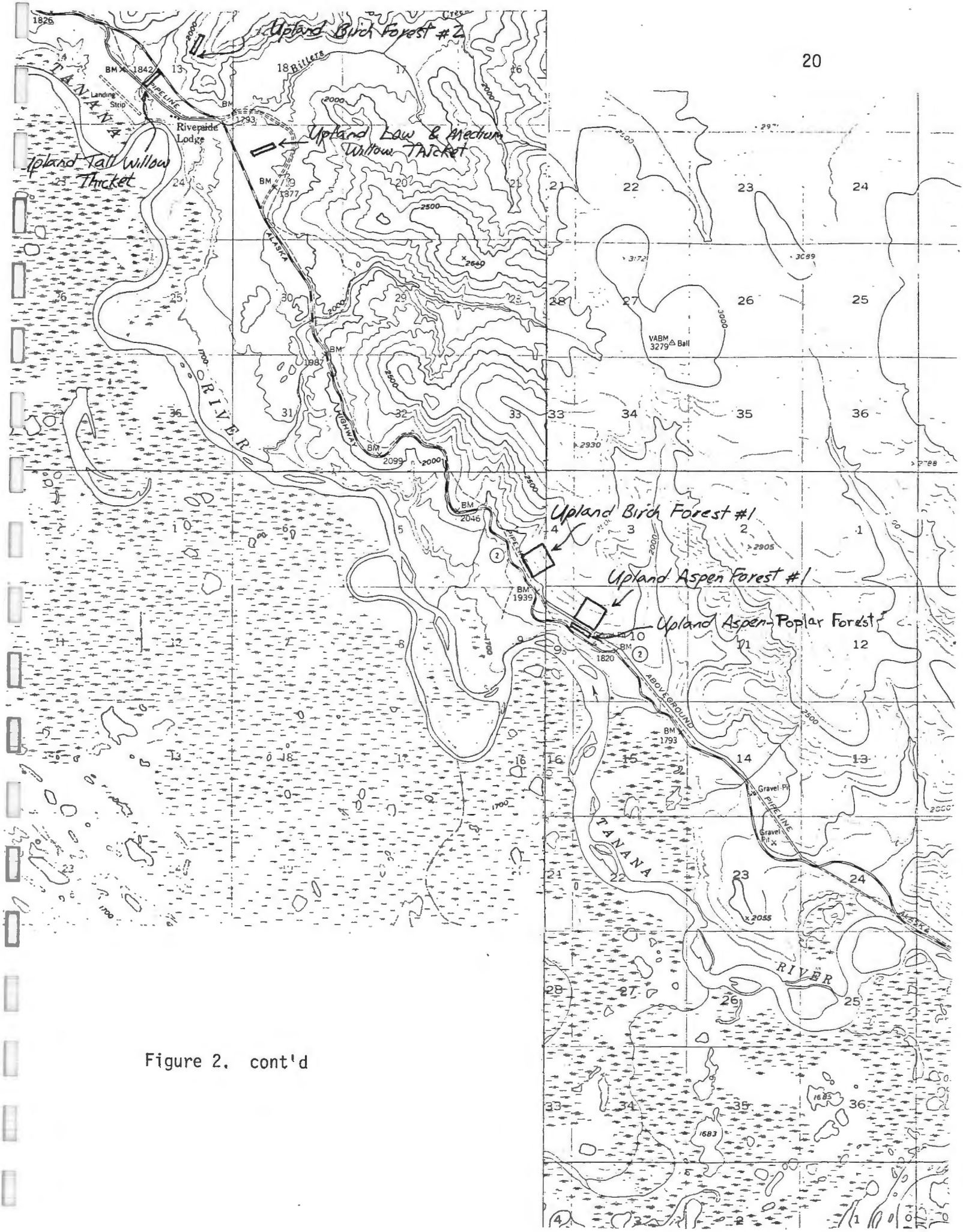

Figure 2. cont'd

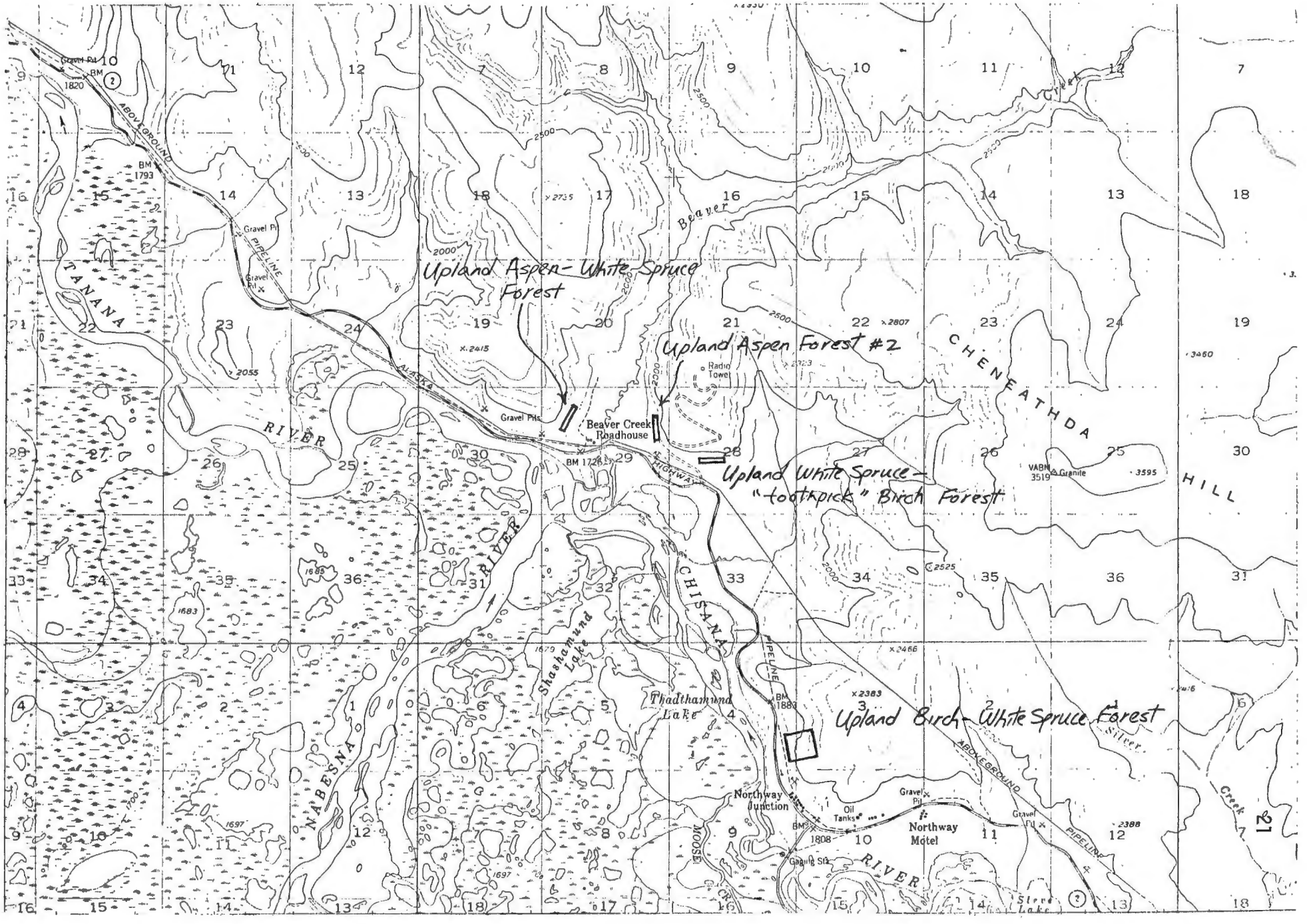

Figure 2. cont'd

Figure 2. cont'd

Table 2. Frequency of occurrence of plant species in understory and ground levels of each bird census plot, Tetlin-Northway study area, Alaska August 1977. Sample size is given in parentheses under each plot name.

	LOW AND MEDIUM SHRUB THICKETS (LMS)		TALL SHRUB THICKET (TS)			DECIDUOUS FOREST (DF)					MIXED DECIDUOUS-CONIFEROUS FOREST (MF)				CONIFEROUS FOREST (CF)			SCATTERED WOODLAND AND DWARF FOREST (WD)	
	Lowland Low & Medium Willow	Upland Low & Medium Willow	Lowland Tall Alder-Willow	Lowland Tall Willow-Poplar	Upland Tall Willow	Upland Aspen-Poplar	Upland Aspen #1	Upland Aspen #2	Upland Birch #1	Upland Birch #2	Upland Aspen-White Spruce	Upland Birch-White Spruce	Upland White Spruce-Aspen-Birch	Upland White Spruce-"Toothpick" Birch	Upland White Spruce #1	Upland White Spruce #2	Upland Black Spruce	Lowland White Spruce-Birch Woodland	Upland Black Spruce Bog
Sample Size	(38)	(14)	(32)	(14)	(14)	(14)	(98)	(14)	(98)	(14)	(16)	(98)	(20)	(14)	(98)	(14)	(14)	(14)	(14)
TREES																			
Betula papyrifera		50		21	7	14	20		83	71	13	80	30	79	17	43	7	14	
Picea glauca	21	14	34	85	71	29	26	7	9	29	75	62	55	86	96	100	7	86	
Picea mariana		7			7												100		100
Populus balsamifera	8		9	71		36	8	29	11		25		20						
Populus tremuloides			3			100	93	100	7		94		25	7	26				
TALL AND MEDIUM SHRUBS																			
Alnus crispa							1		54	36		51	45		27	57	43		
Alnus incana	5		94															7	
Betula glandulosa		14																	
Salix alaxensis			25	71														7	
Salix arbusculoides	3	38	34	64	43							1		7			7		14
Salix bebbiana		21	3	14	7	29	11	7	15	36	18	7	35	28					
Salix brachycarpa	5			36															35
Salix candida	34				21														
Salix glauca	21	71	6	71			3	7	1		13	1	10	14			29	28	7
Salix lanata richardsonii	11																		
Salix monticola	3			64	14							1							
Salix novae-angliae	97	28	34	64															
Salix planifolia pulchra	21	86	50	7	92												21	7	50
Salix scouleriana							1	29		21			10	21					
DWARF, LOW AND MEDIUM SHRUBS																			
Andromeda polifolia	3																		
Arctostaphylos rubra		36		42	50	36	8	7					10				50	64	93
Arctostaphylos uva-ursi	5		3	64			70	14			18			14	19			7	
Betula nana	100	79													1				
Chamaedaphne calyculata	3	21	18		57												7		64
Empetrum nigrum		7		7	21		14		3	7			20	7				100	50
Juniperus communis						7.1													
Ledum palustre	5	93	3	29	64	7.1	18		14	7	6	12	70		6		64	85	100
Linnaea borealis						92	89	93	84	71	75	22	35	100	57	42			14
Oxycoccus microcarpus																			93
Potentilla fruticosa	8	50	3		43						6								7
Rhododendron lapponicum		14																	

Table 2. (cont'd)

	LOW AND MEDIUM SHRUB THICKETS (LMS)		TALL SHRUB THICKET (TS)			DECIDUOUS FOREST (DF)					MIXED DECIDUOUS-CONIFEROUS FOREST (MF)				CONIFEROUS FOREST (CF)			SCATTERED WOODLAND AND DWARF FOREST (WD)	
	Lowland Low & Medium Willow	Upland Low & Medium Willow	Lowland Tall Alder-Willow	Lowland Tall Willow-Poplar	Upland Tall Willow	Upland Aspen-Poplar	Upland Aspen #1	Upland Aspen #2	Upland Birch #1	Upland Birch #2	Upland Aspen-White Spruce	Upland Birch-White Spruce	Upland White Spruce-Aspen-Birch	Upland White Spruce-"Toothpick" Birch	Upland White Spruce #1	Upland White Spruce #2	Upland Black Spruce	Lowland Spruce-Birch Woodland	Upland Black Spruce Bog
Ribes sp.			6		7				24	7		28			6				
Rosa acicularis	3		41	14		57	35	29	76	57	38	77	30	93	47	14	43	57	
Rubus idaeus									3							7			
Salix myrtillifolia	26				21													14	
Shepherdia canadensis				38		71	76	86		7	56		5	29	12				
Vaccinium uliginosum	18	29	22	7	14		8					1	10		1		86	86	100
Vaccinium vitis-idaea		21			79	35	68		18	7	13	15	85	14	91	29	100	100	100
Vibernum edule								43	19	21	6	1	5	43					
HERBS																			
Aconitum delphinifolium						43													
Amerorchis rotundifolia				17															
Anaphalis sp.	6																		
Anemone richardsonii												3			9				
Aster sp.	6														8				
Astragalus sp.				43															
Boschniakia rossica																			
Calla palustris	6		3																
Caltha palustris	6		9																
Castilleja caudata				7			1												
Corallorrhiza trifida															1				
Cornus canadensis															2				
Epilobium angustifolium		43	9	79	29	71	74	100	60	93	75	43	60	57	16	7			
Equisetum arvense					21		1			7		4	10		6		50		
Equisetum fluviatile	37		22		7														
Equisetum palustre	56																		
Equisetum pratense						7			50	7	6	71	60	7	42	64	36		
Equisetum scirpoides	34		47	50		21	72	57	55	57	44	33	65	50	45	36	86	21	79
Equisetum silvaticum			41			71									1		14		
Gentiana sp.	3																		
Geocaulon lividum			16		7	50	54	7	1		50	28	60	14	84	79	93	43	
Geum sp.																			
Goodyera repens															2				
Iris setosa			3																
Lupinus arcticus						100	33	64			31				26				
Lycopodium annotinum					7		2		4			4	10		2				
Mertensiana paniculata					29	93	55	79	83	100	63	48	40	86	20	43	36		7

Table 2. (cont'd)

	LOW AND MEDIUM SHRUB THICKETS (LMS)		TALL SHRUB THICKET (TS)			DECIDUOUS FOREST (DF)					MIXED DECIDUOUS-CONIFEROUS FOREST (MF)				CONIFEROUS FOREST (CF)			SCATTERED WOODLAND AND DWARF FOREST (WD)	
	Lowland Low & Medium Willow	Upland Low & Medium Willow	Lowland Tall Alder-Willow	Lowland Tall Willow-Poplar	Upland Tall Willow	Upland Aspen-Poplar	Upland Aspen #1	Upland Aspen #2	Upland Birch #1	Upland Birch #2	Upland Aspen-White Spruce	Upland Birch-White Spruce	Upland White Spruce-Aspen-Birch	Upland White Spruce-"Toothpick" Birch	Upland White Spruce #1	Upland White Spruce #2	Upland Black Spruce	Lowland Spruce-Birch Woodland	Upland Black Spruce Bog
Moneses uniflora									2						4	14	14		
Oxytropis campestris																		7	
Parnassia palustris	37			50														14	
Pedicularis labradorica	8		3				1		1						1			14	
Petasites hyperboreus				14	7				1						6		57		86
Polemonium acutiflorum						7	5	14	5		6	1							
Polygonum sp.		7																	
Potentilla palustris	5		34												1			7	
Pyrola asarifolia									5			2						21	
Pyrola chlorantha									10	7					1				
Pyrola grandiflora		36			8				1	7		2	10		5		7		50
Pyrola secunda				43		71	62	29	39		19	4	10	14	39	29	7		7
Pyrola sp.	21		47	14															
Rubus arcticus	84		81		29												14	7	14
Rubus chamaemorus		29			50										2		57		100
Rumex sp.	3														1			14	50
Saussurea angustifolia	11	7																	
Stellaria sp.									10	14	6	11			14		7	7	
Tofieldia pusilla	3																		
Valeriana capitata		7																	
Zygadenus elegans						7	3	21			31			7	10				
GRASSES AND SEDGES																			
Calamagrostis canadensis	13	100	63	79	79	100	60	43	84	64	81	80	65	14	84	57	86	86	43
Carex sp.	92	50	63	14	21	79	13	21	6	21			10	36	30		29	36	86
Eriophorum vaginatum	5	100			36													57	100

Figure 3. Low and Medium Shrub Thickets. Plot LMS2, Upland Low and Medium Willow, August 1977.

Figure 4. Tall Shrub Thicket. Plot TS3, Upland Tall Willow, August 1977.

1. Lowland Low and Medium Willow Thicket

Salix novae-angliae, S. candida, S. glauca, S. planifolia, and Betula nana formed a 1-2 m-high thicket (Table 2). Openings between shrubs and shrub clumps were either wet-sedge meadow (Carex sp., Eriophorum sp., and Equisetum palustre) or dry grass-herbaceous growth. Canopy coverage was <1%, and the tallest trees were scattered, stunted white spruce, <3 m tall and 100-200 years old (Table 1). The plot was within typical river-flat mosaic vegetation, and hence was surrounded by different habitats, Tall Willow to the NW and wetlands to the SE. Much of the plot was poorly drained and had standing water. Size: 4.25 ha. Elevation: 522 m. Location: Near the junction of the Tanana, Chisana, and Nabesna rivers, at 3.5 mi. Northway access road. The plot adjoined the Lowland Tall Alder-Willow Thicket plot (TS1), forming a 7.6 ha area that was censused as one unit.

2. Upland Low and Medium Willow Thicket

Salix planifolia, S. glauca, S. arbusculoides, and Betula nana formed an open 1-2 m tall thicket, with scattered White Spruce 3 m tall, 40-60 years old. Eriophorum vaginatum and Calamagrostis canadensis formed extensive sedge-grass tussock bog underneath the shrubs and where shrubs were sparse. Canopy coverage was 4%. The plot was flat, located in Bitters Creek Valley, and was surrounded by Aspen and Poplar forest. Size: 1.61 ha. Elevation: 549 m. Location: Milepost 1280, Alaska Highway, near Riverside Lodge.

3. Tussock-Low and Medium Shrub Bog

The plot was centered in an essentially treeless bog consisting of extensive Eriophorum vaginatum sedge tussocks growing up to 0.8 m above the ground, with ericaceous low shrubs growing between and on top of the tussocks. The most prominent low shrub species were Salix planifolia, S. arbusculoides, Betula glandulosa, B. nana, Ledum palustre, and Chamaedaphne calyculata. A few stunted Paper Birch, Thinleaf Alder (Alnus incana) and Black Spruce trees were interspersed across the bog. Canopy coverage was <1%, and the majority of shrub vegetation grew between 1.6 and 3.5 m high. The tallest trees were Paper Birch, which attained a height of 6 m and were 28-100 years old. The plot was flat and surrounded by similar habitat on all sides. Size: 10.0 ha. Elevation: 137 m. Location: Fairbanks Wildlife Management Area, Fairbanks.

Tall Shrub Thicket (TS), Figure 4

Open or closed shrub stands 2.5-4.6 m in heiht. Tall shrub stands are usually composed of Alder and Willow, although some stands include stunted trees or tree saplings ≤4.6 m tall. The understory and ground cover usually consist of herbs, grasses, sedges, and dwarf shrubs. Like the Low and Medium Shrub Thickets, the Tall Shrub Thickets may be successional stages of a forest sere, but are most frequently semi-permanent habitats which are maintained by permafrost, moisture, or elevation factors. Most tall shrub habitats occur in valley bottoms;

however, excessively moist hillsides and timberline areas also have extensive tall shrub stands.

1. Lowland Tall Alder-Willow Thicket

The plot was dominated by Alnus incana, Salix planifolia, S. arbusculoides, and S. novae-angliae, which averaged 3.7 m tall. Widely-scattered Poplars and White Spruce were much taller (to 10 m). Canopy coverage was 23%. Understory consisted mainly of Rosa acicularis, Chamaedaphne calyculata, Equisetum sylvaticum, E. scirpoides, Rubus arcticus, Calamagrostis canadensis, and Carex sp. Trees and large diameter shrubs averaged 82 years old and some were 180 years old, so the shrubby character of the plot had not been caused by wildfire. The plot may be considered typical riparian shrub habitat, as Moose Creek (a tributary of the Chisana River) frequently caused flooding on the plot. The plot was flat, poorly drained, and had standing water throughout the summer. The plot was surrounded by similar habitat on three sides, and adjoined the Lowland Low and Medium Willow Thicket plot (LMS1, above) on the SE. Size: 3.35 ha. Elevation: 522 m. Location: Near the junction of the Tanana, Chisana, and Nabesna rivers, 3.5 mi. Northway access road.

2. Lowland Tall Willow-Poplar Thicket

Salix alexensis, S. glauca, S. arbusculoides, S. monticola, S. novae-angliae, and Balsam Poplar dominated the plot. Calamagrostis

canadensis, Epilobium angustifolium, Equisetum scirpoides, Parnassia palustris, and Arctostaphylos uva-ursi were abundant ground cover plants. Canopy coverage was 26%, and canopy height averaged 4.6 m. The plot was flat and well-drained. Cleared in the mid-1940's, it was a successional stage of a sere that would normally terminate in White Spruce forest upon maturity. The plot was surrounded by similar habitat on two sides, airport pavement on the S, and Lowland White Spruce-Birch Woodland (WD1, see below) on the N side. Wetlands were present within 0.25 km. Size: 1.61 ha. Elevation: 522 m. Location: Northway Airport.

3. Upland Tall Willow Thicket

The plot was dominated by Salix planifolia and S. arbusculoides, with occasional scattered White Spruce trees. Canopy height was 4.4 m, and canopy coverage was 43%. Abundant ground cover plants were Calamagrostis canadensis, Eriophorum vaginatum, Vaccinium vitis-idaea, Ledum palustre, Chamaedaphne calyculata, Arctostaphylos rubra, and Potentilla fruticosa. The plot was in a creek valley, flat, and poorly drained. Average age of trees and large-diameter shrubs was 42 years, with a maximum age of 65 years. A wildfire had apparently burned the plot and surrounding area approximately 70 years ago. Size: 1.61 ha. Elevation: 550 m. Location: Milepost 1281, Alaska Highway, near Riverside Lodge.

4. Lowland Tall Alder-Willow Thicket

Alnus incana, Salix arbusculoides, S. planifolia, and S. bebbiana dominated the plot, growing on the edges of water-filled ice-wedge polygon troughs. Drier portions of the plot supported tall (to 10 m) but scattered Paper Birch, White Spruce, and Black Spruce. Average height of the canopy was 3.7 m, and canopy coverage was 26%. Ground cover was composed of Chamaedaphne calyculata, Ledum palustre, Vaccinium uliginosum, Calamagrostis canadensis, and Betula glandulosa. Large shrubs and trees were 45-90 years old, and evidence of recent fire was not observed. Excessive moisture and permafrost probably maintained this habitat as a shrub community. The plot was flat and surrounded by similar habitat except on the E side, where an open low shrub habitat occurred. Size: 10.0 ha. Elevation: 137 m. Location: Fairbanks Wildlife Management Area, Fairbanks.

Deciduous Forest (DF), Figure 5

Closed stands with trees >4.6 m high, composed of Quaking Aspen, Balsam Poplar, or Paper Birch. Most deciduous forests are transitional stages following fire and thus are not permanent habitats (Viereck 1975). The deciduous tree species have distinct site preferences. Aspen generally occurs on south-facing slopes or xeric sites, frequently with an understory of Willow shrubs, or with co-dominant tree-sized Willows. Poplar occurs in pure stands on river floodplain seres, and in mixed stands in the uplands with Aspen. Paper Birch grows on NE, E,

Figure 5a. Deciduous Forest, Aspen-dominant stand. Plot DF4, Upland Aspen #1, August 1977.

Figure 5b. Deciduous Forest, Birch-dominant stand. Plot DF4, Upland Birch #1, August 1977.

SE, SW, W, and NW slopes which are generally more mesic than slopes facing directly south. Alnus crispa is frequently an understory or co-dominant species in Birch stands, particularly on moist sites. Birch and Aspen forests also occur in pure or mixed stands on river terraces. Most deciduous forests are gradually overtaken by shade-tolerant White Spruce 80-120 years following the disturbance which initiated secondary succession--unless white spruce seed sources are unavailable (Lutz 1956, Viereck 1975).

1. Upland Aspen-Poplar Forest

The plot was dominated by Aspen, Poplar, and Willow (Salix bebbiana). Major understory species were Rosa acicularis, Shepherdia canadensis, Linnaea borealis, Epilobium angustifolium, Equisetum silvaticum, Lupinus arcticus, Calamagrostis canadensis, and Pyrola secunda. Canopy coverage was 74%, and average tree height was 12 m. The plot was surrounded by similar habitat, except on the N side where a highway passed within 100 m. The plot was on a SSW-facing (aspect 215°) 15% slope. Trees were 100-105 years old, and extensive evidence of past five was present. Size: 1.61 ha. Elevation: 550 m. Location: Milepost 1274, Alaska Highway.

2. Upland Aspen Forest #1

The plot was a nearly pure Aspen stand with minor amounts of Poplar, White Spruce, and Bebb Willow. Ground cover consisted of

Linnaea borealis, Shepherdia canadensis, Arctostaphylos uva-ursi, Vaccinium vitis-idaea, Epilobium angustifolium, Pyrola secunda, Mertensia paniculata, Equisetum scirpoides, and Calamagrostis canadensis. The plot was on a 23% slope, facing almost due S (199°). It was surrounded by similar habitat on all sides except the S, which bordered the Haines Petroleum Pipeline. Canopy coverage was 71%, and mean tree height was 12 m. Average tree age was 96 years, and evidence of past fire was high. Size: 10.0 ha. Elevation: 610-730 m. Location: Milepost 1274, Alaska Highway.

3. Upland Aspen Forest #2

The plot was a nearly pure Aspen stand, with small amounts of Poplar and Willow (Salix bebbiana and S. scouleriana). Abundant understory and ground cover plants were Linnaea borealis, Shepherdia canadensis, Vibernum edule, Epilobium angustifolium, Mertensia paniculata, Lupinus arcticus, and Calamagrostis canadensis. The plot was on a 24% slope facing nearly due W (264°). It was surrounded by similar habitat on all sides; however, a road passed within 100 m of the E side. Canopy coverage was 76%, and average tree height was 10 m. The plot was considerably younger than Aspen Forest #1 (DF1, above), with an average tree age of 59 years. Size: 1.61 ha. Elevation: 580 m. Location: One-half mile up Microwave Tower access road at Milepost 1267, Alaska Highway.

4. Upland Birch Forest #1

The plot was dominated by Paper Birch, with Alnus crispa and Salix bebbiana as understory and occasionally co-dominant species. On approximately 20% of the plot, A. crispa formed dense thickets underneath a sparse overstory of Paper Birch. Abundant understory and ground cover species were Rosa acicularis, Vibernum edule, Ribes sp., Calamagrastis canadensis, Linnaea borealis, Equisetum scirpoides, E. silvaticum, Epilobium angustifolium, and Mertensia paniculata. The plot occurred on a SW-facing (242°) 23% slope. Canopy coverage was 79%, and average tree height was 10 m. The trees were 84-125 years old, and evidence of fire was high, indicating that a fire around a century ago initiated secondary succession on this site. The plot was surrounded by similar habitat on all sides except the S, which bordered the Haines Petroleum Pipeline. Size: 10.0 ha. Elevation: 610-700 m. Location: Milepost 1275, Alaska Highway.

5. Upland Birch Forest #2

The plot was dominated by Paper Birch, with occasional Salix bebbiana, S. scouleriana, and Alnus crispa. Abundant understory plants were Rosa acicularis, Mertensia paniculata, Epilobium angustifolium, Linnaea borealis, Equisetum scirpoides, Vibernum edule, and Calamagrostis canadensis. The plot was on a west-facing (283°) 24% slope. Canopy coverage was 81%, and average tree height was 10 m. The stand was 58-76 years old, with some evidence of past

fire. The plot was surrounded by deciduous forest on three sides and mixed forest on the south side. Size: 1.61 ha. Elevation: 580 m. Location: One-half mile up old highway grade, Milepost 1281, Alaska Highway.

Mixed Deciduous-Coniferous Forest (MF), Figure 6

Closed stands of deciduous and coniferous trees >4.6 m tall, generally containing mixtures of one or two deciduous tree species and either White Spruce or Black Spruce--hence, the vegetation type name combinations of White Spruce-Birch, White Spruce-Poplar, White Spruce-Aspen, White Spruce-Aspen-Birch, Birch-White Spruce, Aspen-White Spruce, etc. Black Spruce-deciduous mixtures also occur, but are less common. Generally, all such mixtures represent stages of succession in which spruce is replacing the deciduous tree species (Viereck 1975). A stand with a dominance of spruce is usually successionally older than a stand dominated by a deciduous species (e.g., White Spruce-Birch is usually older than Birch-White Spruce).

1. Upland Aspen-White Spruce Forest

The plot was dominated by Quaking Aspen and White Spruce, with a co-dominance of Balsam Poplar. Abundant understory and ground cover plants were Shepherdia canadensis, Rosa acicularis, Linnaea borealis, Calamagrostis canadensis, Epilobium angustifolium, Mertensia paniculata, Geocaulon lividum, Equisetum scirpoides, and Zygadenus

Figure 6. Mixed Deciduous-Coniferous Forest.
Plot MF2, Upland Birch-White Spruce, August 1977.

elegans. The plot was on a steep (32%) E-facing (105°) slope. Canopy coverage was 69%, and average tree height was 10.0 m. Age of the stand was 63-80 years, and evidence of past fire was high. The plot was located on an ecotonal hillside: areas E of the plot and downhill were predominantly White Spruce, while areas W of the plot and uphill were predominantly Aspen. The S boundary adjoined the Haines Petroleum Pipeline. Size: 1.84 ha. Elevation: 550 m. Location: Milepost 1268, Alaska Highway, near Beaver Creek Roadhouse site.

2. Upland Birch-White Spruce Forest

The plot was dominated by Paper Birch and White Spruce, with the characteristic co-dominance of Alnus crispa typical of moist Birch sites. Abundant understory and ground cover plants were Rosa acicularis, Calamagrostis canadensis, Equisetum pratense, Mertensia paniculata, Epilobium angustifolium, Equisetum scirpoides, and Ribes sp. The plot was on a gentle (17%) W-facing (282°) slope. Canopy coverage was 79%; average tree height was 10 m. Two different forest fires had influenced vegetation on the plot: One fire 105-130 years ago burned over the plot and entire surrounding area; a later fire, 56-60 years ago, burned about a third of the western side of the plot. Hence, there were two distinct age-classes of trees. The plot was surrounded by similar mixed Birch-White Spruce forest on the S, W, and N, and by older White Spruce-Birch forest on the E. Size: 10.0 ha. Elevation: 580-640 m. Location: Milepost 1265, Alaska Highway.

3. Upland White Spruce-Aspen-Birch Forest

The plot was dominated by White Spruce, Aspen, and Paper Birch, with a thick understory of Salix bebbiana and Alnus crispa. Other important understory and ground cover species were Ledum palustre, Rosa acicularis, Vaccinium vitis-idaea, Linnaea borealis, Calamagrostis canadensis, Epilobium angustifolium, Equisetum pratense, E. scirpoides, Geocaulon lividum, and Mertensia paniculata. Canopy coverage was 57% and average tree height was 7 m. The average tree age was 54 years, and evidence of past fire was high. This plot had the greatest plant species diversity and the second greatest foliage distribution diversity of any Tetlin-Northway area plot (Table 1)--probably the result of past fire and the composition of surrounding habitats. Surrounding habitats were diverse: Black Spruce forest on the N and W, Aspen forest on the E, and similar mixed forest on the S. Size: 2.20 ha. Elevation: 580-620 m. Location: Milepost 1285, Alaska Highway.

4. Lowland White Spruce-Black Spruce-Birch Forest

The plot was dominated by White Spruce and Black Spruce, with scattered Paper Birch. A dense understory of Willow (S. arbusculoides, S. planifolia, and S. bebbiana) occurred on the drier portions of the plot. A small creek lined with Alnus incana flowed across the plot. Other abundant understory and ground cover species were Vaccinium uliginosum, V. vitis-idaea, Ledum palustre, Rosa acicularis, Equisetum pratense, Calamagrostis canadensis, and Moss. The canopy was nearly

open on the W but closed on the E side of the plot, with an average coverage of 34%. Average tree height was 7 m. Age of the stand was 50-70 years, with evidence of recent fire. Surrounding habitats were typical of Tanana River Valley flat mosaic vegetation: Tall Alder-Willow to the S, open White Spruce-Birch Woodland to the W, and similar mixed deciduous-coniferous forest on the N and E sides. Size: 10.0 ha. Elevation: 152 m. Location: Fairbanks Wildlife Management Area, Fairbanks.

5. Upland White Spruce-"Toothpick" Birch Forest

The plot was dominated by sparse, large White Spruces, with dense stands of pole-sized Paper Birch, resembling a "toothpick" forest from a distance. Important understory and ground cover species were Rosa acicularis, Vibernum edule, Salix glauca, Linnaea borealis, Mertensia paniculata, Epilobium angustifolium, and Equisetum scirpoides. Canopy coverage was 79%, and average tree height was 9m. The plot was on a moderate (17%) S-facing (184°) slope. Average age of the stand was 50 years, with high evidence of past forest fire. The scattered old White Spruces were probably survivors of a fire that burned the area 50-60 years ago (probably the same fire that burned the Aspen-White Spruce [MF1], Aspen #2 [DF3], and Birch-White Spruce [MF2] plots above). The plot was surrounded by similar habitat on all sides. Size: 1.61 ha. Elevation: 590 m. Location: One mile up microwave tower access road at Milepost 1267, Alaska Highway.

Coniferous Forest (CF), Figure 7

Closed stands of conifers >4.6 m high, mostly White Spruce and Black Spruce, but with occasional patches of Tamarack (Larix laricina) on flats W of Delta Junction. Understory shrubs are usually sparse, and moss frequently dominates the ground cover. White Spruce occurs in pure stands on well-drained sites, such as steep south-facing slopes and on sand and gravel in river flood plains. Black Spruce forms relatively tall (to 12 m), dense stands on moderately-drained sites in the lowlands and on N, NE, NW-facing slopes in the uplands. A transitional Black Spruce-White Spruce type occurs on intermediate sites. Black Spruce gradually replaces White Spruce in river valleys through a bog-forming (paludification) process lasting 200-250 years (Drury 1956, Viereck 1970). Tamarack occurs in the lowlands, most frequently on wet sites. White Spruce forests occasionally reach an age of 250 years, forming majestic stands of 40 m tall, 1 m dbh trees, which, along with the Black Spruce bog-forests on poorer sites, are considered to be climax stages of forest succession in central Alaska. Viereck (1975), however, notes that conifer stands older than 200 years are rare because of their high flammability and the high frequency of wildfire in interior Alaska.

1. Upland White Spruce Forest #1

The plot was an extensive, mature White Spruce stand growing on a steep (29%) south-facing (165°) slope. Occasional Black Spruce trees

Figure 7a. Coniferous Forest, White Spruce-dominant stand. Plot CF1, Upland White Spruce #1, September 1977.

Figure 7b. Coniferous Forest, Black Spruce-dominant stand. Plot CF3, Upland Black Spruce, September 1977.

occurred on the lower (S) side, and scattered Aspen trees blended in on the NE corner. Otherwise, the plot was surrounded by similar habitat. The ground cover was mostly moss, with Vaccinium vitis-idaea, Linnaea borealis, Rosa acicularis, Geocaulon lividum, Pyrola secunda, and Equisetum scirpoides interspersed. Canopy coverage was 61%. This plot had the largest trees observed in the Tetlin-Northway area; average tree height was 15 m, with occasional trees exceeding 37 m in height and 80 cm dbh. Trees averaged 166 years old, with the oldest being 200 years old. Minimal evidence of fire was observed. Elevation: 610-800 m. Location: 1.0 km N of Milepost 1299, Alaska Highway.

2. Upland White Spruce Forest #2

The plot was adjacent and similar to White Spruce Forest #1, above, except the White Spruce trees were denser and smaller, with occasional Paper Birch and Alnus crispa in the understory. Ground cover was largely moss, with some Linnaea borealis, Vaccinium vitis-idaea, Equisetum pratense, E. scirpoides, Geocaulon lividum, Mertensia paniculata, and Calamagrostis canadensis. Canopy coverage was 74%, and average tree height was 10 m. The plot was located on a W-facing (283°) steep (38%) slope. The stand was 160-185 years old. Evidence of fire was high. The plot was surrounded by similar habitat on all sides, except for a 50-200 m blowdown on the E side. Size: 1.61 ha. Elevation: 640 m. Location: 1.0 km N of Milepost 1299, Alaska Highway.

3. Upland Black Spruce Forest

The plot was dominated by Black Spruce, with widely scattered White Spruce. Abundant understory and ground cover species were Vaccinium uliginosum, V. vitis-idaea, Alnus crispa, Ledum palustre, Rosa acicularis, Geocaulon lividum, Equisetum scirpoides, Rubus chamaemorus, and Petasites hyperboreus. Canopy coverage was 40%, and average tree height was 7 m. The stand was over 250 years old and showed no evidence of fire. The plot was surrounded by similar habitat on all sides, except the SW corner which bordered the Haines Petroleum Pipeline. Size: 1.61 ha. Elevation: 580 m. Location: 0.5 km N of Milepost 1299, Alaska Highway.

4. Lowland Black Spruce Forest

The plot was dominated by Black Spruce, with occasional White Spruce and Tamarack. Understory and ground cover were mostly Betula glandulosa, B. nana, Vaccinium uliginosum, V. vitis-idaea, Ledum palustre, Arctostaphylos rubra, Rubus chamaemorus, and Sphagnum moss. Canopy coverage was 20%, and average height of trees was 8 m. The stand was 100-150 years old and showed minimal evidence of past fire. The site was flat, underlain by permafrost, and poorly drained. The plot was surrounded by similar habitat on two sides, with open Black Spruce bog on the W, and Tamarack forest and wetlands to the E. Size: 5.75 ha. Elevation: 137 m. Location: Fairbanks Wildlife Management Area, Fairbanks.

Scattered Woodland and Dwarf Forest (WD), Figure 8

Open stands of stunted trees separated so that most tree crowns do not touch each other. Such habitats are termed "Dwarf forest" if the height of trees is ≤4.6 m (15 feet) and "Woodland" if >4.6 m (15 ft). A sizeable proportion of interior Alaska woody habitats fall into this category, mainly because of extensive forest-tundra ecotone areas and stunted tree bogs. Common Woodland and Dwarf Forest habitats typical of the Tanana Valley are stunted Black Spruce bogs, stunted Paper Birch Woodlands, Timberline White Spruce Woodlands, etc.

This combination of vegetation types does not make as discrete or well-defined an avian habitat unit as the other habitat categories and may, in fact, not be a "good" habitat. Until we learn more about the avian community structures in these woodlands and dwarf forests, however, we have lumped them, for convenience, into this habitat classification.

1. Lowland White Spruce-Birch Woodland

The plot was dominated by widely-spaced White Spruces, with occasional widely-spaced Paper Birches. Average distance between trees was 9 m, while average tree height was 4 m. Canopy coverage was 1%. Abundant ground cover plants were Vaccinium uliginosum, V. vitis-idaea, Empetrum nigrum, Ledum palustre, Rosa acicularis, Arctostaphylos rubra, Eriophorum vaginatum, Geocaulon lividum, Calamagrostis canadensis, and Carex sp. Age of the stand was 124-190 years, with evidence of previous fire. Growth of the stand was

Figure 8a. Scattered Woodlands and Dwarf Forests. Plot WD1, Lowland White Spruce-Birch Woodland, August 1977.

Figure 8b. Scattered Woodlands and Dwarf Forests. Plot WD2, Upland Black Spruce Bog, August 1977.

obviously stunted by some local site factors, such as soil nutrients, lack of moisture, or permafrost, since the vegetation along the S side was vigorously-growing Willow and Poplar (Plot TS2). The site was flat and well-drained; however, wetland areas were less than 100 m away. Size: 1.61 ha. Elevation: 522 m. Location: Northway Airport.

2. Upland Black Spruce Bog

Tree growth on the plot was entirely Black Spruce, which were rarely over 10 m tall and averaged 4 m tall. The distance between trees averaged 7 m. Ground cover was mostly moss, Vaccinium uliginosum, V. vitis-idaea, Ledum palustre, Arctostaphylos rubra, Oxycoccus microcarpus, Salix planifolia, Chamaedaphne calyculata, Eriophorum vaginatum, Carex sp., Rubus chamaemorus, Petasites hyperboreus, and Equisetum scirpoides. Canopy coverage was 16%. The stand was over 250 years old, with no evidence of past fire. The plot was flat, located in the bottom of a creek valley, and was surrounded by similar habitat. Size: 1.61 ha. Elevation: 550 m. Location: Milepost 1285, Alaska Highway.

3. Lowland Black Spruce Bog

The plot consisted of an open, stunted Black Spruce stand with occasional Tamarack trees. Trees were rarely over 8 m tall, and averaged 4 m tall; distance between trees ranged from 4-8 m. Ground

cover was mostly moss, lichen, Vaccinium vitis-idaea, V. uliginosum, Ledum palustre, Andromeda polifolia, Rubus chamaemorus, Chamaedaphne calyculata, and Eriophorum vaginatum. Canopy coverage was <5%. The stand was 110-150 years old with minimum evidence of past forest fire. The plot was flat, underlain by permafrost, and surrounded by similar habitat on all sides except the E, which bordered a Black Spruce forest. Size: 4.25 ha. Elevation: 137 m. Location: Fairbanks Wildlife Mangement Area, Fairbanks.

COMMUNITY STRUCTURE AND HABITAT PRODUCTIVITY

Species composition and habitat productivity--as measured by density, biomass, and existence energy--differed markedly among major avian habitats (see Tables 3 and 4). These characteristics were generally similar, however, among replicate plots within the same habitat (see Appendix Table A-6). The greatest within habitat differences were between upland and lowland replicate plots. Lowland plots generally had higher densities and a greater number of species than upland plots in the same habitat and often had more comparatively larger-bodied birds present, such as waterfowl, cranes, and some shorebird species (see Appendix Table A-6).

Generally, habitats supporting high breeding bird densities in the upper Tanana River Valley also showed high breeding biomass, high expenditure of existence energy, and high species diversity values (Table 4 and 5). There was a logarithmic relationship between breeding density and species diversity (H') (Fig. 9), i.e., as breeding densities increased, the rate of increase in species diversity decreased, a pattern also observed by MacArthur (1964) and Karr (1968). Breeding density showed a positive linear relationship with breeding biomass ($y = -109.5 + 61.4x$, $r^2 = 0.566$, $p < 0.01$) (Fig. 10), and breeding biomass was highly correlated with breeding existence energy expenditure ($y = 143.3 + 0.34x$, $r^2 = 0.960$, $p < 0.001$). The slope of the relationship between density and biomass varies with the size and

Table 3. Summary of bird population data for the major woody avian habitats of the Tanana River Valley, Alaska, 1975 and 1977. Densities are given as the mean number of territories per 10 ha. (+ = small portion of a breeding territory on census plot, counted as 0.1 in density and diversity calculations; v = non-breeding visitor to plot; * = deletion from biomass calculations, because of disproportionate influence caused by a family of heavy-bodied birds.) Numerals in parentheses following density figures indicate the number of plots in which the species occurred, whether breeding or visiting.

	LOW AND MEDIUM SHRUB THICKETS	TALL SHRUB THICKET	DECIDUOUS FOREST		
			Aspen Dominant	Birch Dominant	All Deciduous Combined
Number of Plots	3	4	3	2	5
Total Sample Area (ha)	15.9	16.6	13.2	11.6	24.8
SPECIES/(ABBREVIATION)					
Mallard (MAL)	+ (1)	+ (2)			
Pintail (PIN)		0.3 (1)			
Green-winged Teal (GWT)	+ (1)	0.5 (2)			
Sharp-shinned Hawk (SSH)				+ (1)	+ (1)
American Kestrel (KES)					
Spruce Grouse (SG)					
Ruffed Grouse (RG)			+ (1)	+ (1)	+ (2)
Sandhill Crane (SHC)	+ (1)				
Common Snipe (SNP)	3.6 (3)	2.3 (2)			
Solitary Sandpiper (SSP)	v (1)	0.5 (3)			
Lesser Yellowlegs (LYL)	1.6 (1)	1.4 (3)			
Great Horned Owl (GHO)				0.3*(1)	+ (1)
Hawk Owl (HKO)	v (1)	v (1)			
Common Flicker (FLK)	+ (2)	0.4 (3)	+ (2)		+ (2)
Hairy Woodpecker (HWP)					
N. Three-toed Woodpecker (NWP)					
Alder Flycatcher (AFC)	0.3 (2)	7.9 (4)	0.4 (2)	+ (1)	0.4 (3)
Hammond's Flycatcher (HFC)	0.2 (1)	v (1)	1.3 (2)	+ (2)	0.8 (4)
Olive-sided Flycatcher (OSF)					
Violet-green/Tree Swallow (VTS)	v (1)	v (1)			
Bank Swallow (BSW)		v (1)			
Cliff Swallow (CSW)	v (1)	v (1)			
Gray Jay (GJ)	v (1)	v (3)	0.3 (2)	0.5 (2)	0.4 (4)
Black-capped Chickadee (BCC)		v (1)	+ (3)	0.5 (1)	0.3 (4)
Boreal Chickadee (BOR)		v (3)	v (1)	0.3 (1)	+ (2)
Brown Creeper (BC)					
American Robin (ROB)	1.2 (3)	1.1 (4)	4.8 (3)	1.1 (2)	3.3 (5)
Varied Thrush (VT)			v (2)	0.5 (2)	0.2 (4)
Hermit Thrush (HT)			2.9 (3)	2.2 (2)	2.6 (5)
Swainson's Thrush (SWT)	+ (2)	2.5 (4)	2.9 (3)	6.1 (2)	4.2 (5)
Gray-cheeked Thrush (GCT)	0.2 (2)	1.0 (3)			
Ruby-crowned Kinglet (RCK)	v (1)	v (2)			
Bohemian Waxwing (BOH)	v (3)	v (2)	+ (1)		+ (1)
Orange-crowned Warbler (OCW)	1.5 (3)	5.9 (4)	4.9 (3)	3.5 (2)	4.4 (5)
Yellow Warbler (YW)	0.4 (1)	10.5 (3)	v (1)		v (1)
Yellow-rumped Warbler (YRW)		v (2)	4.9 (3)	5.8 (2)	5.2 (5)
Townsend's Warbler (TW)			v (1)		v (1)
Blackpoll Warbler (BPW)		0.8 (1)			
Northern Waterthrush (NWT)		2.3 (2)			
Wilson's Warbler (WW)			v (1)		v (1)
Rusty Blackbird (RBB)	0.8 (2)	1.0 (3)		v (1)	v (1)
Pine Grosbeak (PGB)	v (2)	v (2)	v (1)	v (1)	v (2)
Common Redpoll (CRP)	0.2 (3)	1.0 (3)	+ (1)	1.0 (1)	0.2 (2)
Pine Siskin (PS)					
White-winged Crossbill (WWCB)		v (1)			
Savannah Sparrow (SAV)	0.9 (2)	3.0 (3)			
Dark-eyed Junco (JCO)	0.8 (2)	2.9 (3)	4.8 (3)	4.9 (2)	4.8 (5)
Tree Sparrow (TSP)	3.2 (2)	1.9 (2)			
White-crowned Sparrow (WCS)	8.3 (3)	4.6 (4)			
Fox Sparrow (FSP)	v (1)	3.0 (3)			
Lincoln's Sparrow (LSP)	8.5 (3)	3.7 (3)			
Overall Mean Density (range)	31.8 (23.6-44.1)	58.0 (41.8-67.7)	27.8 (26.9-28.7)	26.3 (25.7-26.9)	27.2 (26.3-28.7)
Overall Mean Biomass (g/10 ha) (range)	2233 (1198-4050)	3356 (1896-5808)	1749 (1498-2058)	1299 (1212-1386)	1569 (1212-2058)
Mean Number of Breeding Species (range)	10.0 (7-15)	13.8 (8-18)	10.3 (8-13)	11.0 (7-15)	10.6 (7-15)
Mean Breeding Species Diversity (H') (range)	1.756 (1.587-2.071)	2.191 (1.781-2.584)	1.878 (1.761-2.092)	1.920 (1.736-2.104)	1.895 (1.736-2.092)
Mean Evenness (J') (range)	0.785 (0.763-0.828)	0.854 (0.818-0.894)	0.817 (0.695-0.908)	0.835 (0.777-0.892)	0.824 (0.695-0.908)
Mean Dominance (%)	56.0	39.6	41.0	42.1	42.4

Table 3. (cont'd)

	MIXED DECIDUOUS-CONIFEROUS FOREST	CONIFEROUS FOREST		
		White Spruce Dominant	Black Spruce Dominant	All Coniferous Combined
Number of Plots	4	2	2	4
Total Sample Area (ha)	25.7	11.6	7.4	19.0
SPECIES/(ABBREVIATION)				
Mallard (MAL)		+ (1)		
Pintail (PIN)		+ (1)		
Green-winged Teal (GWT)				+ (1)
Sharp-shinned Hawk (SSH)	+ (1)	+ (1)		+ (1)
American Kestrel (KES)	v (1)			
Spruce Grouse (SG)			0.3*(1)	+ (1)
Ruffed Grouse (RG)	+ (1)		v (1)	+ (2)
Sandhill Crane (SHC)				
Common Snipe (SNP)	0.5 (1)		0.9 (1)	0.4 (1)
Solitary Sandpiper (SSP)	v (1)		v (1)	v (1)
Lesser Yellowlegs (LYL)	v (1)		+ (1)	+ (1)
Great Horned Owl (GHO)		+ (2)		+ (2)
Hawk Owl (HKO)				
Common Flicker (FLK)	v (2)	v (1)		v (1)
Hairy Woodpecker (HWP)		+ (1)		+ (1)
N. Three-toed Woodpecker (NWP)		+ (1)	+ (1)	+ (2)
Alder Flycatcher (AFC)	+ (1)			
Hammond's Flycatcher (HFC)				
Olive-sided Flycatcher (OSF)	+ (1)		+ (1)	+ (1)
Violet-green/Tree Swallow (VTS)	v (1)			
Bank Swallow (BSW)				
Cliff Swallow (CSW)				
Gray Jay (GJ)	0.9 (4)	0.8 (2)	0.6 (2)	0.7 (4)
Black-capped Chickadee (BCC)	+ (1)			
Boreal Chickadee (BOR)	1.0 (4)	1.1 (2)	0.5 (1)	0.8 (3)
Brown Creeper (BC)	0.3 (1)	0.8 (1)		0.4 (1)
American Robin (ROB)	1.6 (4)		+ (1)	+ (1)
Varied Thrush (VT)	0.6 (4)	+ (1)		+ (1)
Hermit Thrush (HT)	0.6 (1)	1.3 (1)		0.6 (1)
Swainson's Thrush (SWT)	8.8 (4)	6.1 (2)	1.8 (1)	3.9 (3)
Gray-cheeked Thrush (GCT)	+ (1)		1.4 (2)	0.7 (2)
Ruby-crowned Kinglet (RCK)	1.6 (4)	+ (1)	1.5 (2)	0.8 (3)
Bohemian Waxwing (BOH)	v (2)	v (1)	0.9 (1)	0.4 (2)
Orange-crowned Warbler (OCW)	2.5 (4)			
Yellow Warbler (YW)				
Yellow-rumped Warbler (YRW)	4.8 (4)	0.8 (1)	1.6 (1)	1.2 (3)
Townsend's Warbler (TW)	1.3 (1)	9.8 (2)		4.9 (2)
Blackpoll Warbler (BPW)				
Northern Waterthrush (NWT)	0.5 (1)			
Wilson's Warbler (WW)	v (1)			
Rusty Blackbird (RBB)	+ (1)		v (1)	v (1)
Pine Grosbeak (PGB)	0.1 (2)	v (1)		v (1)
Common Redpoll (CRP)	0.6 (3)	+ (1)	+ (1)	+ (2)
Pine Siskin (PS)		v (1)		v (1)
White-winged Crossbill (WWCB)	v (1)	v (2)	v (1)	v (3)
Savannah Sparrow (SAV)			v (1)	v (1)
Dark-eyed Junco (JCO)	7.2 (4)	3.8 (2)	7.5 (2)	5.6 (4)
Tree Sparrow (TSP)	v (1)			
White-crowned Sparrow (WCS)	0.3 (1)		1.8 (1)	0.9 (1)
Fox Sparrow (FSP)	0.5 (1)		v (1)	v (1)
Lincoln's Sparrow (LSP)	v (1)		v (1)	v (1)
Overall Mean Density	33.1	24.1	18.8	21.5
(range)	(28.6-36.4)	(21.3-26.9)	(15.5-22.1)	(15.5-26.9)
Overall Mean Biomass (g/10 ha)	1744	1265	1005	1135
(range)	(1602-1958)	(1080-1450)	(682-1328)	(682-1450)
Mean Number of Breeding Species	13.3	11.5	9.5	10.5
(range)	(11-20)	(7-16)	(8-11)	(7-16)
Mean Breeding Species Diversity (H')	2.059	1.586	1.686	1.636
(range)	(1.954-2.323)	(1.363-1.808)	(1.489-1.882)	(1.363-1.882)
Mean Evenness (J')	0.822	0.667	0.751	0.714
(range)	(0.754-0.939)	(0.652-0.701)	(0.716-0.785)	(0.652-0.785)
Mean Dominance (%)	46.3	65.9	60.4	60.0

Table 3. (cont'd)

	SCATTERED WOODLAND AND DWARF FOREST		
	White Spruce-Birch Woodland	Black Spruce Bog	Woodland & Dwarf Forest Combined
Number of Plots	1	2	3
Total Sample Area (ha)	1.6	5.9	7.5
SPECIES/(ABBREVIATION)			
Mallard (MAL)			
Pintail (PIN)			
Green-winged Teal (GWT)			
Sharp-shinned Hawk (SSH)			
American Kestrel (KES)			
Spruce Grouse (SG)			
Ruffed Grouse (RG)			
Sandhill Crane (SHC)			
Common Snipe (SNP)		0.6 (1)	0.4 (1)
Solitary Sandpiper (SSP)		v (1)	v (1)
Lesser Yellowlegs (LYL)	0.3	1.2 (1)	0.9 (2)
Great Horned Owl (GHO)			
Hawk Owl (HKO)			
Common Flicker (FLK)	+		+ (1)
Hairy Woodpecker (HWP)			
N. Three-toed Woodpecker (NWP)			
Alder Flycatcher (AFC)		v (1)	v (1)
Hammond's Flycatcher (HFC)			
Olive-sided Flycatcher (OSF)		0.2 (1)	0.1 (1)
Violet-green/Tree Swallow (VTS)			
Bank Swallow (BSW)			
Cliff Swallow (CSW)			
Gray Jay (GJ)	v	0.2 (2)	0.1 (3)
Black-capped Chickadee (BCC)			
Boreal Chickadee (BOR			
Brown Creeper (BC)			
American Robin (ROB)	3.4	1.0 (2)	1.8 (3)
Varied Thrush (VT)		v (1)	v (1)
Hermit Thrush (HT)			
Swainson's Thrush (SWT)	v	2.5 (1)	1.7 (2)
Gray-cheeked Thrush (GCT)	3.4	1.2 (1)	1.9 (2)
Ruby-crowned Kinglet (RCK)	3.4	1.7 (1)	2.2 (2)
Bohemian Waxwing (BOH)	v	+ (1)	+ (2)
Orange-crowned Warbler (OCW)	3.4	0.9 (1)	1.7 (2)
Yellow Warbler (YW)	1.7		0.6 (1)
Yellow-rumped Warbler (YRW)		0.3 (1)	0.2 (1)
Townsend's Warbler (TW)			
Blackpoll Warbler (BPW)			
Northern Waterthrush (NWT)			
Wilson's Warbler (WW)			
Rusty Blackbird (RBB)	3.4		1.1 (1)
Pine Grosbeak (PGB)			
Common Redpoll (CRP)		+ (1)	+ (1)
Pine Siskin (PS)			
White-winged Crossbill (WWCB)			
Savannah Sparrow (SAV)		v (1)	v (1)
Dark-eyed Junco (JCO)	3.4	7.4 (2)	6.1 (3)
Tree Sparrow (TSP)		v (1)	v (1)
White-crowned Sparrow (WCS)	8.4	4.6 (2)	5.9 (3)
Fox Sparrow (FSP)	3.0		1.0 (1)
Lincoln's Sparrow (LSP)	3.4		1.1 (1)
Overall Mean Density	37.3	21.6	26.8
(range)	--	(20.9-22.2)	(20.9-37.3)
Overall Mean Biomass (g/10 ha)	2218	1265	1583
(range)	--	(1126-1404)	(1126-2218)
Mean Number of Breeding Species	12.0	9.0	10.0
(range)	--	(8-10)	(8-12)
Mean Breeding Species Diversity (H')	2.262	1.679	1.873
(range)	--	(1.584-1.773)	(1.584-2.262)
Mean Evenness (J')	0.916	0.771	0.819
(range)	--	(0.688-0.853)	(0.688-0.916)
Mean Dominance (%)	31.6	59.9	44.8

Table 4. Summary of avian habitat productivity and diversity in the Tanana River Valley, Alaska. Data were obtained from 24 plots censused during the breeding seasons of 1975 and 1977. Key to locations: F = Fairbanks, T = Tetlin Junction, R = Riverside Lodge, N = Northway.

	LOCATION	PLOT SIZE (ha)	DENSITY (territories/ 10 ha)	BIOMASS (g/10 ha)	EXISTENCE ENERGY (kcal/10 ha)	DIVERSITY (# of Breeding Species)	(H')	(J')	FIVE MOST ABUNDANT SPECIES
LOW AND MEDIUM SHRUB THICKETS (LMS)									
1. Lowland Low & Medium Willow	N	4.25	44.1	4050	1518	15	2.071	0.765	White-cr. Sparrow, Lincoln's Sparrow, Common Snipe, Tree Sparrow, Lesser Yellowlegs
2. Upland Low & Medium Willow	R	1.61	27.7	1452	635	8	1.587	0.763	White-cr. Sparrow, Lincoln's Sparrow, Orange-cr. Warbler, Am. Robin, Dark-eyed Junco
3. Tussock-Low & Medium Shrub Bog	F	10.00	23.6	1198	516	7	1.610	0.828	Lincoln's Sparrow, White-cr. Sparrow, Tree Sparrow, Common Snipe, Orange-cr. Warbler
MEAN			31.8	2233	890	10.3	1.756	0.785	Lincoln's Sparrow, White-cr. Sparrow, Common Snipe, Tree Sparrow, Lesser Yellowlegs
TALL SHRUB THICKET (TS)									
1. Lowland Tall Alder-Willow	N	3.35	64.3	3544	1464	18	2.364	0.818	Yellow Warbler, Alder Flycatcher, Orange-cr. Warbler, N. Waterthrush, Lincoln's Sparrow
2. Lowland Tall Willow-Poplar	N	1.61	67.7	2176	1141	11	2.036	0.849	Yellow Warbler, Savannah Sparrow, Alder Flycatcher, Orange-cr. Warbler, White-cr. Sparrow
3. Upland Tall Willow	R	1.61	41.8	1896	847	8	1.781	0.856	Dark-eyed Junco, Orange-cr. Warbler, Alder Flycatcher, Swainson's Thrush, White-cr. Sparrow
4. Lowland Tall Alder-Willow	F	10.00	58.1	5808	1968	18	2.584	0.894	Yellow Warbler, Common Snipe, Lincoln's Sparrow, Tree Sparrow, N. Waterthrush
MEAN			58.0	3356	1355	13.8	2.191	0.854	Yellow Warbler, Alder Flycatcher, Orange-cr. Warbler, White-cr. Sparrow, Lincoln's Sparrow
DECIDUOUS FOREST (DF)									
1. Upland Aspen-Poplar	R	1.61	28.7	1498	642	10	2.092	0.908	Dark-eyed Junco, Orange-cr. Warbler, Swainson's Thrush, Hammond's Flycatcher, Yellow-rumped Warbler
2. Upland Aspen #1	R	10.00	27.7	2058	792	13	1.782	0.695	Am. Robin, Yellow-rumped Warbler, Orange-cr. Warbler, Swainson's Thrush, Dark-eyed Junco
3. Upland Aspen #2	N	1.61	26.9	1690	700	8	1.761	0.847	Hermit Thrush, Dark-eyed Junco, Yellow-rumped Warbler, Am. Robin, Orange-cr. Warbler
MEAN Aspen-Dominant			27.8	1749	711	10.3	1.878	0.817	Yellow-rumped Warbler, Orange-cr. Warbler, Dark-eyed Junco, Am. Robin, Swainson's Thrush

Table 4. (cont'd)

	LOCATION	PLOT SIZE (ha)	DENSITY (territories/ 10 ha)	BIOMASS (g/10 ha)	EXISTENCE ENERGY (kcal/10 ha)	DIVERSITY (# of Breeding Species)	(H')	(J')	FIVE MOST ABUNDANT SPECIES
4. Upland Birch #1	R	10.00	26.9	1386	592	15	2.104	0.777	Dark-eyed Junco, Swainson's Thrush, Yellow-rumped Warbler, Orange-cr. Warbler, Common Redpoll
5. Upland Birch #2	R	1.61	25.7	1212	546	7	1.736	0.892	Swainson's Thrush, Yellow-rumped Warbler, Dark-eyed Junco, Hermit Thrush, Orange-cr. Warbler
MEAN Birch-Dominant			26.3	1299	569	11.0	1.920	0.835	Swainson's Thrush, Yellow-rumped Warbler, Dark-eyed Junco, Orange-cr. Warbler, Hermit Thrush
MEAN All Deciduous Combined			27.2	1569	654	10.6	1.895	0.824	Yellow-rumped Warbler, Dark-eyed Junco, Orange-cr. Warbler, Swainson's Thrush, Am. Robin
MIXED DECIDUOUS-CONIFEROUS FOREST (MF)									
1. Upland Aspen-White Spruce	N	1.84	35.9	1786	794	11	1.968	0.821	Swainson's Thrush, Dark-eyed Junco, Orange-cr. Warbler, Yellow-rumped Warbler, Hermit Thrush
2. Upland Birch-White Spruce	N	10.00	36.4	1958	832	14	1.990	0.754	Swainson's Thrush, Yellow-rumped Warbler, Dark-eyed Junco, Townsend's Warbler, Varied Thrush
3. Upland White Spruce-Aspen-Birch	R	2.20	31.6	1630	703	8	1.954	0.939	Dark-eyed Junco, Swainson's Thrush, Yelloe-rumped Warbler, Orange-cr. Warbler, Ruby-cr. Kinglet
4. Lowland White Spruce-Black Spruce-Birch	F	10.00	28.6	1602	689	20	2.323	0.775	Dark-eyed Junco, Swainson's Thrush, Yellow-rumped Warbler, N. Waterthrush, Common Snipe
5. Upland White Spruce-"Toothpick" Birch	N	1.61	0	0	0	0	0	0	
MEAN (excluding MF 5)			33.1	1744	754	13.3	2.059	0.822	Swainson's Thrush, Dark-eyed Junco, Yellow-rumped Warbler, Orange-cr. Warbler, Am. Robin
CONIFEROUS FOREST (CF)									
1. Upland White Spruce #1	T	10.00	26.9	1450	566	16	1.808	0.652	Townsend's Warbler, Swainson's Thrush, Dark-eyed Junco, Boreal Chickadee, Brown Creeper
2. Upland White Spruce #2	T	1.61	21.3	1080	432	7	1.363	0.701	Townsend's Warbler, Swainson's Thrush, Dark-eyed Junco, Hermit Thrush, Boreal Chickadee
MEAN White Spruce-Dominant			24.1	1265	499	11.5	1.586	0.667	Townsend's Warbler, Swainson's Thrush, Dark-eyed Junco, Hermit Thrush, Boreal Chickadee

Table 4. (cont'd)

	LOCATION	PLOT SIZE (ha)	DENSITY (territories/ 10 ha)	BIOMASS (g/10 ha)	EXISTENCE ENERGY (kcal/10 ha)	DIVERSITY (# of Breeding Species)	(H')	(J')	FIVE MOST ABUNDANT SPECIES
3. Upland Black Spruce	T	1.61	15.5	682	312	8	1.489	0.716	Dark-eyed Junco, Swainson's Thrush, Ruby-cr. Kinglet, Gray Jay, Boreal Chickadee
4. Lowland Black Spruce	F	5.75	22.1	1328	563	11	1.882	0.785	Dark-eyed Junco, White-cr. Sparrow, Yellow-rumped Warbler, Gray-cheeked Thrush, Bohemian Waxwing
MEAN Black Spruce-Dominant			18.8	1005	437	9.5	1.686	0.751	Dark-eyed Junco, Swainson's Thrush, White-cr. Sparrow, Yellow-rumped Warbler, Ruby-cr. Kinglet
MEAN All Coniferous Combined			21.5	1135	468	10.5	1.636	0.714	Dark-eyed Junco, Townsend's Warbler, Swainson's Thrush, Yellow-rumped Warbler, White-cr. Sparrow
SCATTERED WOODLAND AND DWARF FOREST (WD)									
1. Lowland White Spruce-Birch Woodland	N	1.61	37.3	2218	937	12	2.262	0.916	White-cr. Sparrow, Dark-eyed Junco, Am. Robin, Ruby-cr. Kinglet, Orange-cr. Warbler
2. Upland Black Spruce Bog (Dwarf Forest)	R	1.61	22.2	1126	496	8	1.773	0.853	Dark-eyed Junco, Swainson's Thrush, White-cr. Sparrow, Ruby-cr. Kinglet Am. Robin
3. Lowland Black Spruce Bog (Dwarf Forest)	F	4.25	20.9	1404	581	10	1.584	0.688	Dark-eyed Junco, White-cr. Sparrow, Gray-cheeked Thrush, Lesser Yellowlegs, Common Snipe
MEAN Dwarf orest (excluding WD 1)			21.6	1265	538	9.0	1.679	0.771	Dark-eyed Junco, White-cr. Sparrow, Swainson's Thrush, Ruby-cr. Kinglet, Lesser Yellowlegs
MEAN All Scattered Woodland and Dwarf Forest Combined			26.8	1583	671	10	1.873	0.819	Dark-eyed Junco, White-cr. Sparrow, Ruby-cr. Kinglet, Gray-cheeked Thrush, Am. Robin

Table 5. Important correlation coefficients (r) between habitat and other variables and avian productivity and diversity variables, upper Tanana River Valley, Alaska, 1977. Statistical significance is indicated as * = $p \leq 0.05$ and ** = $p \leq 0.01$. Selected variables are from Table 1.

	AVIAN COMMUNITY VARIABLES			
HABITAT VARIABLES	Breeding Density	Species Diversity (H')	Breeding Biomass	Breeding Existence Energy (M)
Spatial Heterogeneity (SHET)	0.310	0.189	0.585*	0.470*
Standing Water (WATER)	0.419	0.384	0.755**	0.625**
Single-stemmedness (SS)	-0.489*	-0.250	-0.349	-0.392
Multiple-stemmedness, small (MSS)	0.487*	0.380	0.358	0.398
Distance between stems (DISTANCE)	0.380	0.306	0.609*	0.524*
Distance between trees (TRDISTANCE)	0.283	0.233	0.505*	0.420
% of Stems 4.7-10.0 m tall (HT)	-0.099	-0.378	-0.339	-0.234
% of Stems 2.5-4.6 m tall (HTS)	0.477*	0.351	0.486*	0.476*
% of Foliage >4. m high (FV4)	-0.488*	-0.259	-0.375	-0.425
Brush Density $\leq$1.0 m high (BRUSH)	0.523*	0.138	0.299	0.370
Tree/Shrub Density $\geq$2.54 cm dbh (TRDENS)	-0.552*	-0.396	-0.533*	-0.544*
Tall Shrub Density (DTS)	0.538*	0.358	0.481*	-0.497*
Basal Area, Trees/Shrubs (BASAL)	-0.507*	-0.310	-0.485*	-0.512*
Willow Importance (WILLOW)	0.471*	0.058	0.203	0.303
Poplar Importance (POPLAR)	0.682**	0.419	0.541*	0.598**
Alnus incana Importance (INCANA)	0.415	0.388	0.772**	0.639**
OTHER VARIABLES				
Breeding Density-# Territories	--	0.739**	0.804**	0.915**
Breeding Biomass	0.804**	0.785**	--	0.965**

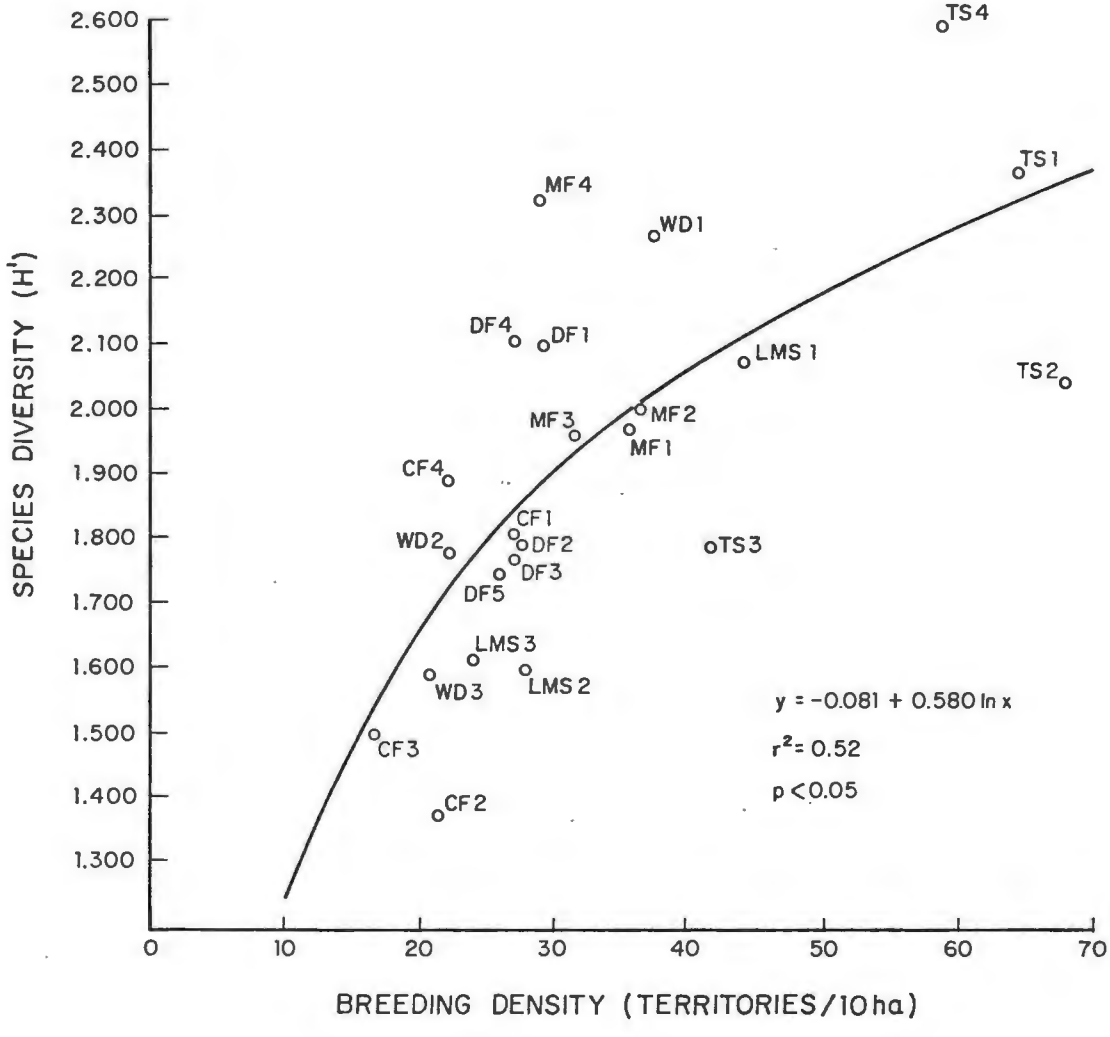

Figure 9. Logarithmic relationship between breeding density and species diversity for 23 bird census plots (MF5 excluded), Tanana River Valley, Alaska, 1975 and 1977. See Table 4 for plot abbreviations.

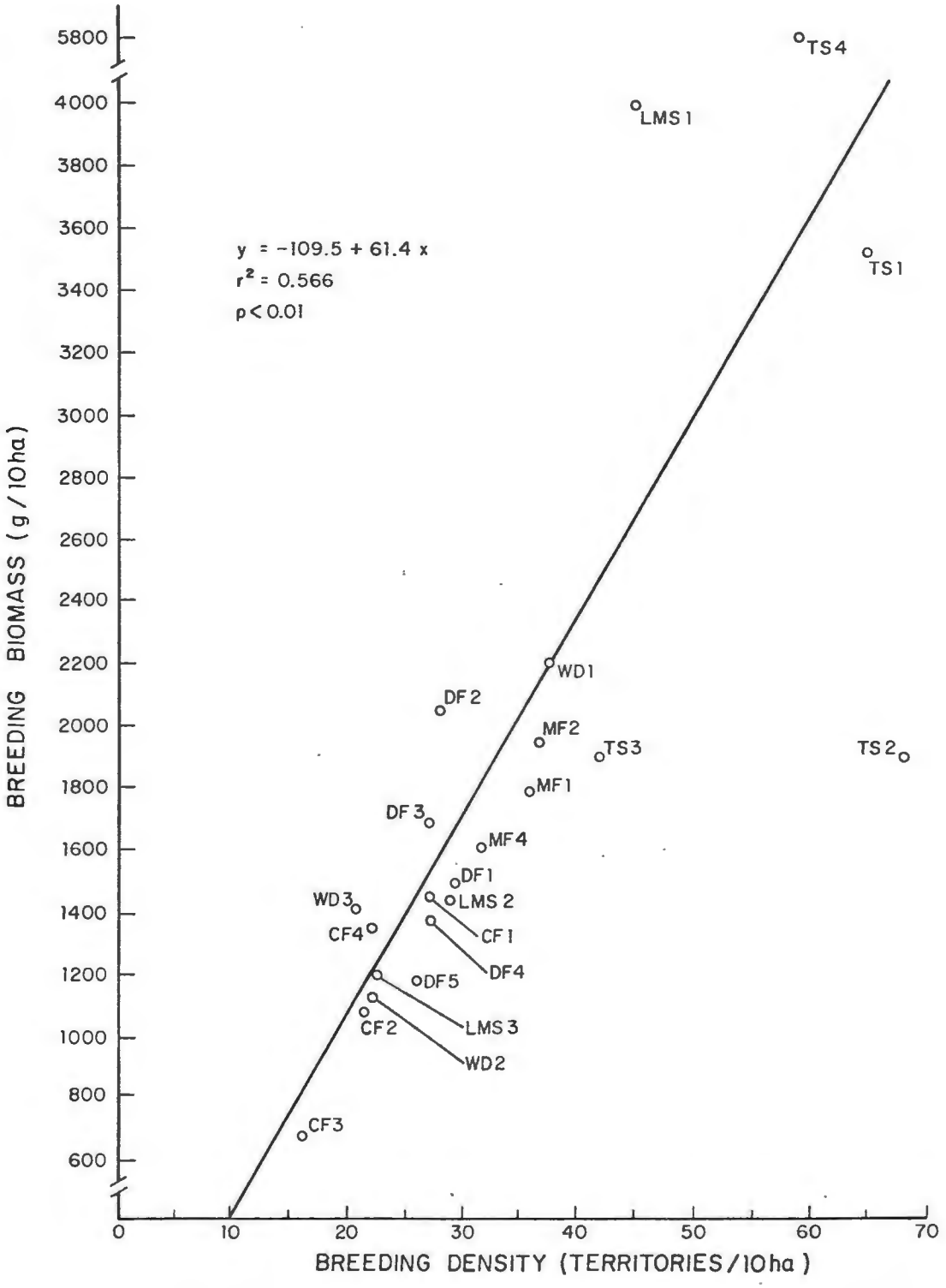

Figure 10. Relationship between breeding density and breeding biomass for 23 bird census plots (MF5 excluded), Tanana River Valley, Alaska, 1975 and 1977. See Table 4 for plot abbreviations.

weight distribution of the avifauna, with a steep slope indicating the presence of large-bodied bird species (Wiens 1975); in the Tanana Valley, a steep slope also occurred in habitats with high breeding density (e.g., Tall Shrub Thickets). The relationship became exponential when breeding density was plotted against existence energy expenditures ($\ln y = \ln 296.68 + 0.027x$, $r^2 = 0.778$, $p < 0.01$) (Fig. 11). The greatest variation in biomass and existence energy also occurred in habitats of high breeding density (see Figs. 10 and 11).

Lowland shrub thickets showed the greatest breeding biomass and the greatest expenditure of existence energy, while coniferous vegetation types showed the lowest. Ranking of habitats and subtypes according to total breeding biomass and total existence energy expenditure was lowland Tall Shrub Thicket > lowland Low and Medium Shrub Thickets > lowland White Spruce-Birch Woodland > Mixed Deciduous-Coniferous Forest > Aspen stands > Birch stands > Black Spruce Bog > White Spruce stands > Black Spruce stands. This ranking generally corresponds to the primary productivity levels found in various interior Alaska forests by K. Van Cleve, C. T. Dyrness, and colleagues at The Biome Center, University of Alaska (pers. comm.): Lowland Balsam Poplar/Alnus incana > Aspen forest > Birch forest > White Spruce forest > Black Spruce bog and forest. We did not census any pure Poplar stands; however, lowland Alnus incana stands (TS1 and TS4) supported the highest avian breeding density, breeding biomass, existence energy, and species diversity in the Tanana River Valley.

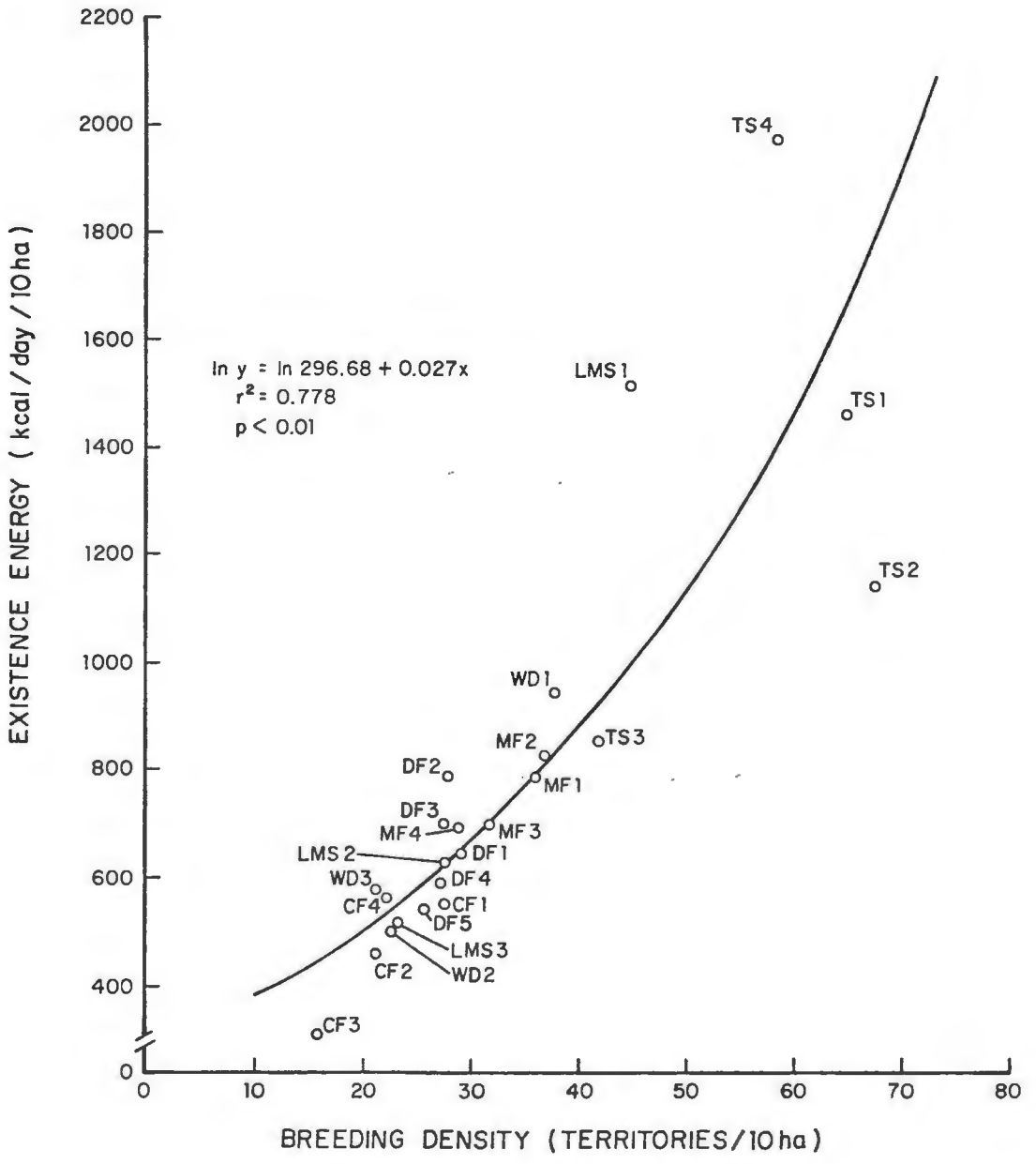

Figure 11. Relationship between breeding density and existence energy on 23 bird census plots (MF5 excluded), Tanana River Valley, Alaska, 1975 and 1977. See Table 4 for plot abbreviations.

According to Van Cleve et al. (pers. comm.), some pure Alnus incana stands have shown primary productivity rates as high or higher than floodplain Balsam Poplar stands. The relatively higher bird productivity observed in Black Spruce Bogs (WD2 and WD3) over White Spruce stands (CF1 and CF2) did not conform to the primary productivity ranking of Van Cleve et al., the disparity probably being caused by the presence of large-bodied waterbirds associated with the wetlands frequently interspersed within Black Spruce bogs.

Population and species composition data are summarized for each habitat and vegetation type in Tables 3 and 4. Density-dominance structures for the habitats are given in Figure 12, and existence energy-dominance structures are given in Figure 13. The original breeding bird census results for the 24 replicate census plots are summarized in Appendix Table A-6.

A comparison of habitats through analysis of existence energy-dominance structure (Fig. 13), partitioning of existence energy among foraging guilds (Table 6 and Fig. 14), and vegetation structure (Fig. 15) explains many of the productivity and diversity differences observed among the major woody avian habitats. The patterns of resource allocation indicate whether avian diversity resulted from the addition of foraging guilds or from the expansion of guilds. Expansion of foraging guilds generally occurred in habitats of high primary productivity--such as Tall Shrub Thickets, where 13 ground-brush foraging species were able to exploit the high energy resources of the vertically-limited

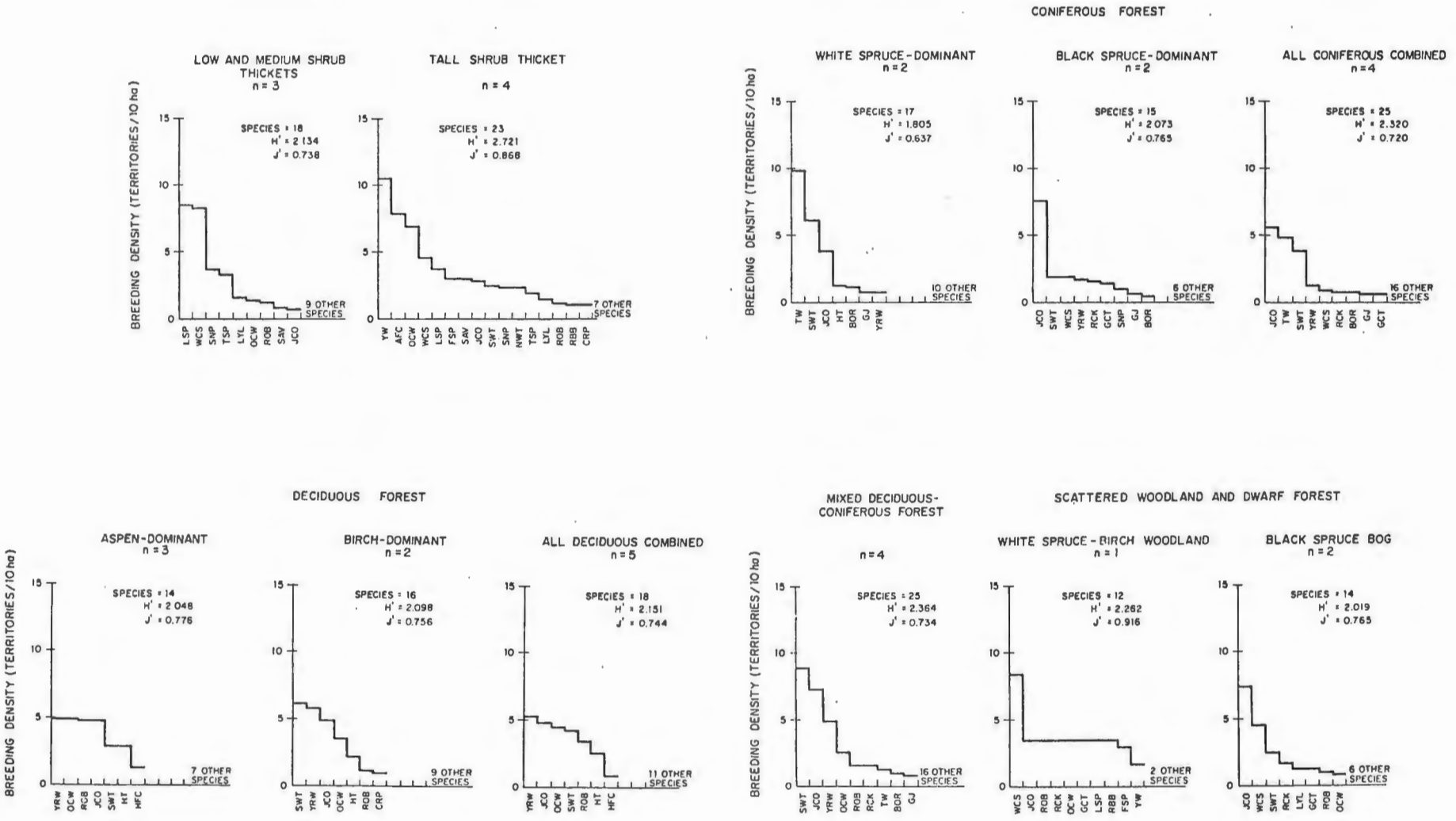

Figure 12. Bird species density-dominance structures for the major woody avian habitats of the Tanana River Valley, Alaska. See Table 3 for species abbreviations.

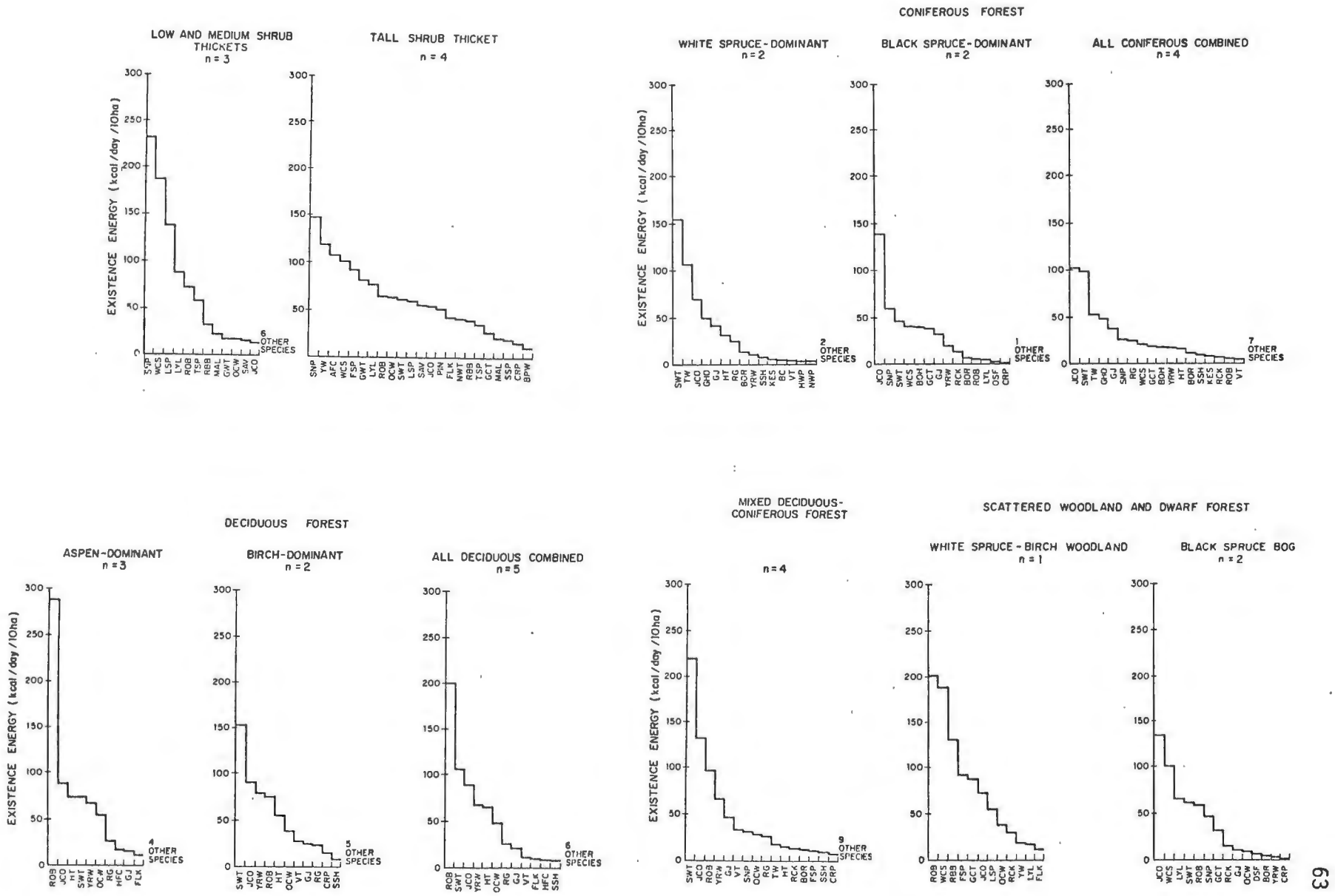

Figure 13. Bird species existence energy-dominance structure for the major woody avian habitats of the Tanana River Valley, Alaska. See Table 3 for species abbreviations.

Table 6. Partitioning of avian existence energy within avian habitats according to foraging guild, Tanana River Valley, Alaska.

	EXISTENCE ENERGY (%)								
	LOW AND MEDIUM SHRUB THICKETS	TALL SHRUB THICKET	DECIDUOUS FOREST		MIXED DECIDUOUS-CONIFEROUS FOREST	CONIFEROUS FOREST		SCATTERED WOODLAND AND DWARF FOREST	
FORAGING GUILD*			Aspen-Dominant	Birch-Dominant		White Spruce-Dominant	Black Spruce-Dominant	White Spruce-Birch Woodland	Black Spruce Bog
Flycatchers	0.7	7.5	3.0	0.4	0.5	0	0.61	0	1.1
Foliage Searchers	2.6	14.5	18.3	23.3	21.4	27.5	9.9	9.2	6.5
Timber Gleaners	0	0	0.1	0.8	0.8	2.0	0.6	0	0
Timber Drillers	0	0	0	0	0	1.8	0.8	0	0
Ground-Brush Foragers	57.3	46.7	78.6	66.6	72.2	56.5	75.8	89.0	73.1
Raptors	0	0	0	8.9	1.2	12.2	0	0	0
Aquatic Foragers	39.4	31.3	0	0	3.9	0	12.3	1.8	19.3

*Species which forage as several differing guilds (e.g., Gray Jay) were excluded

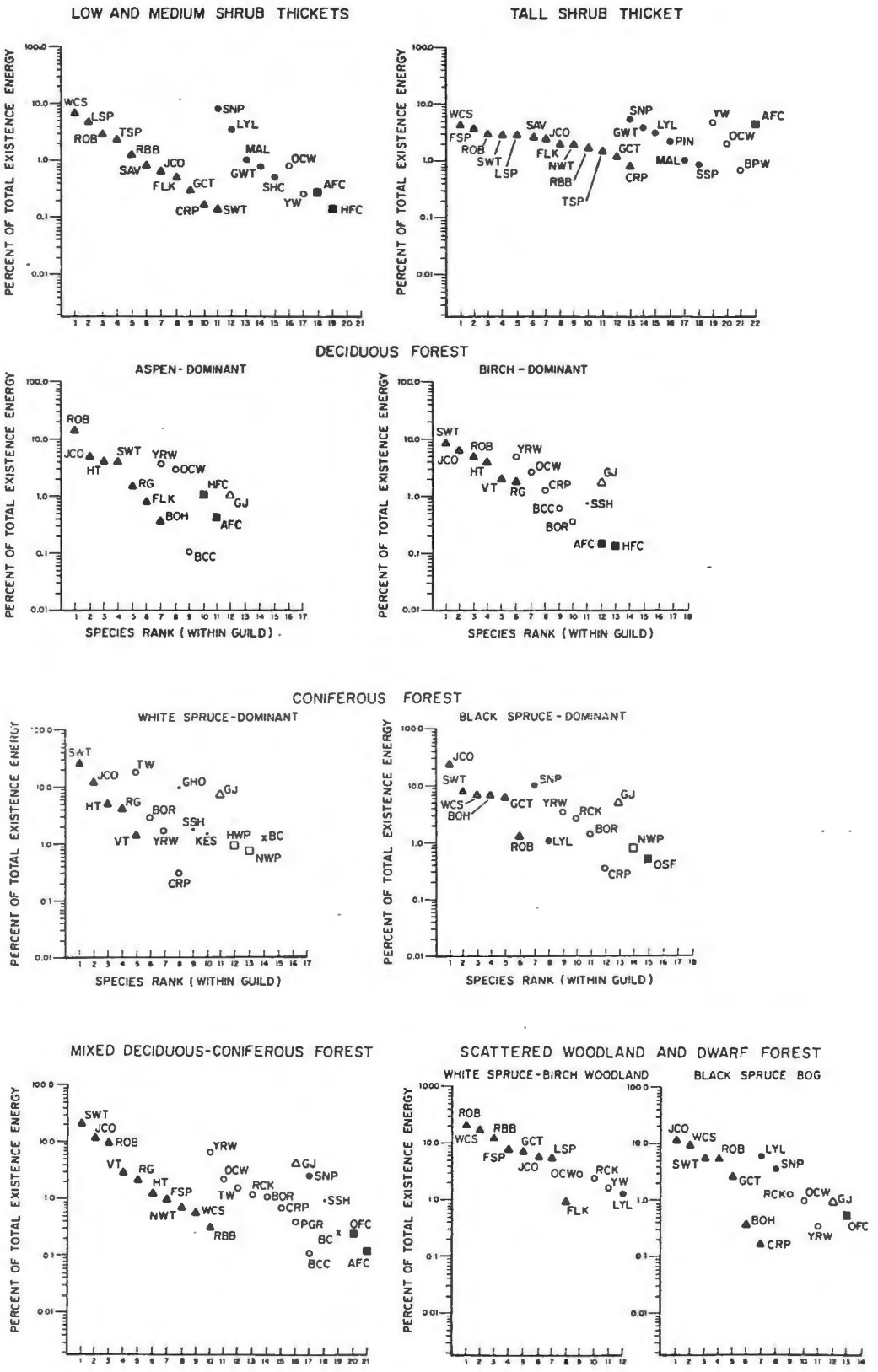

Figure 14. Existence energy-dominance curves for foraging guilds within the major woody avian habitats of the Tanana River Valley, Alaska. See Table 3 for species abbreviations. Key: ▲ = Ground-brush foragers, ○ = Foliage searchers, ● = Aquatic foragers, × = Timber gleaners, □ = Timber drillers, ■ = Flycatchers, • = Raptors, Δ = Multiple guild (Gray Jay).

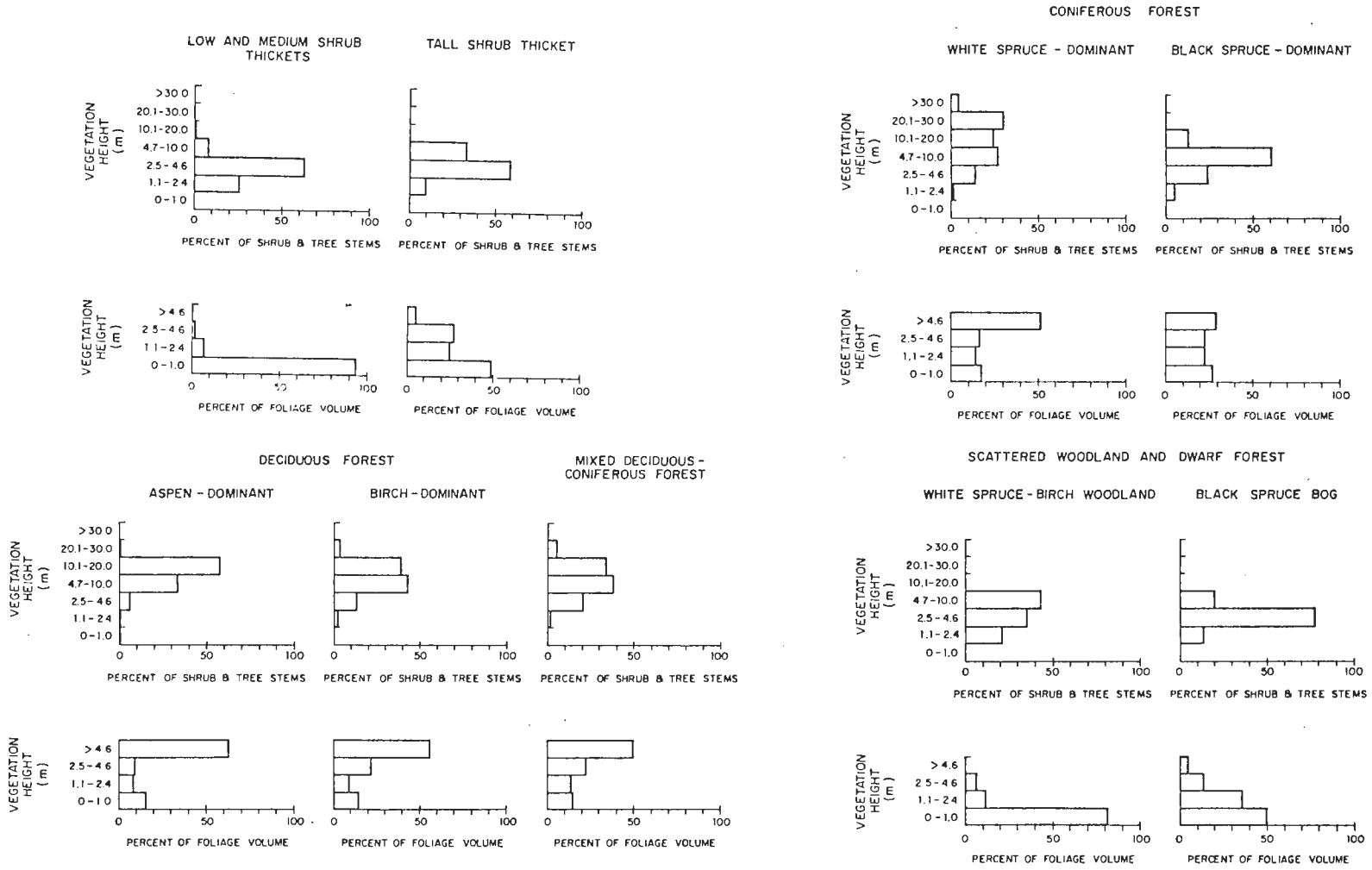

Figure 15. Vegetation structure of major woody avian habitats, upper Tanana River Valley, Alaska.

ground and low shrub vegetation layer (Fig. 14 and Table 6). Addition of guilds occurred in vertically-diverse habitats--such as Mixed Deciduous-Coniferous Forests, where 6 guilds occurred--or in spatially-heterogeneous habitats where several vegetation layers were present in close proximity--such as in lowland taiga mosaics, where 8 guilds occurred on the Fairbanks Wildlife Management Area in 1975 (Spindler, unpubl. data). Willson (1974), in the old field-deciduous forest sere in Illinois, observed guild addition as early successional stages developed shrub and tree layers and guild expansion as the tree layer developed into a dense canopy.

A semilogrithmic plot of existence energy and species rank for each habitat and according to foraging guilds within each habitat (Fig. 14) shows the major patterns of resource division among and within guilds. A straight line suggests either a community of few species or a more diverse community exhibiting competition and niche-pre-emption--with the steepest-sloped lines indicating higher degrees of dominance (MacArthur 1957, 1960; Whittaker 1965, 1975). A sigmoid-like curve, depending on its form, suggests various levels of partial competition, with the more horizontal curves indicating a number of species of intermediate abundance having no great competitive advantage over the others, probably because of niche separation (Whittaker 1965); a few relatively dominant species will cause a more vertical slope at the top of the curve, as will a small number of rare species at the bottom of the curve. The higher the species diversity of the community, the more likely it will exhibit sigmoid dominance curves.

In spite of the fact that only a few foraging guilds in the upper Tanana River Valley were large enough to illustrate curves (ground-brush foragers, foliage-searchers, and aquatic foragers), a range of resource division patterns were visible, and the patterns appeared to differ within the same foraging guild in different habitats.

Breeding Bird Communities

Low and Medium Shrub Thickets

Low and Medium Shrub Thickets supported 7-15 breeding species per 10 ha (average, 10). The habitat was dominated by Lincoln's Sparrow and White-crowned Sparrow, which together comprised over half of the total density. These species, plus Common Snipe, Tree Sparrow, and Lesser Yellowlegs reached their greatest abundance in this habitat. Species diversity was low (only Coniferous Forests were lower), probably because of the low number of breeding species and an uneven abundance distribution, which in turn was largely the result of a relatively simple habitat structure. Biomass and existence energy were variable among replicate census plots, related primarily to whether the plot was in the lowlands or uplands; large-bodied aquatic foraging guild species, especially cranes, waterfowl, and shorebirds, often occurred on lowland plots and resulted in higher biomass and existence energy.

The influence of wetland patches within the lowland Low and Medium Shrub Thickets was crucial to the high productivity of this

habitat. Indeed, without the aquatic forger guild, such Low and Medium Shrub Thickets would have been among the least productive habitats of the Tanana River Valley; one such vegetation type without wetlands was censused in this habitat (LMS3, Lowland Tussock-Low and Medium Shrub Bog), and it showed 70% less total biomass and 66% less total existence energy than a replicate plot with wetlands (LMS1, Lowland Low and Medium Willow) (see Table 4).

Ground-brush foragers and aquatic foragers dominated this habitat, with White-crowned Sparrow and Lincoln's Sparrow dominating the existence energy utilization by the former guild and Common Snipe and Lesser Yellowlegs, the latter. The existence energy-dominance curves were essentially straight (Fig. 14), suggesting niche-pre-emption in the ground-brush forager guild and few species, probably niche-isolated, in the other guilds.

Tall Shrub Thicket

Tall Shrub Thickets provided the most diverse and productive avian habitat in the Tanana River Valley, supporting up to 18 breeding species and densities as high as 67.7 territories per 10 ha (average, 13.8 and 58.0, respectively). The most abundant species were Yellow Warbler, Alder Flycatcher, and Orange-crowned Warbler. These species, plus Northern Waterthrush, Blackpoll Warbler, Fox Sparrow, and Savannah Sparrow, reached their greatest abundance in Tall Shrub Thickets--although the Savannah Sparrow densities appear to be an aberration caused

by edge effect on 1.61 ha-miniplot TS2, adjacent to the Northway airport. The high species diversity (H') values resulted from a high number of breeding species, combined with an even distribution of species abundance (J' was 0.854, the highest of any of the avian habitats). The density-dominance structure was the most even observed (see Fig. 12). The Tall Shrub Thickets also had the highest breeding biomass observed (up to 5808 g/10 ha; average, 3356 g/10 ha) and the highest existence energy expenditure (up to 1968 kcal/day/10 ha; average 1355 kcal/day/10 ha). Biomass was 50% higher and existence energy 52% higher than the next most productive habitat.

The high species diversity and productivity of this habitat undoubtedly results from its high primary productivity, vertical structural diversity, spatial heterogeneity, and the influence of wetlands. The high productivity of the lowland Tall Shrub Thickets was probably maintained in part by continual nutrient exchange in the alluvial wetland system. The presence of nitrogen-fixing and highly-productive Alnus incana, alone, may act as a catalyzing agent for other primary producers in the habitat--notably Willow and Poplar (Van Cleve, pers. comm.).

Four foraging guilds were represented in this habitat, and each, as a unit, attained the highest existence energy expenditure observed for that guild in the Tanana River Valley: ground-brush foragers, aquatic foragers, foliage searchers, and flycatchers. The dominant guild was the ground-brush foragers, comprising almost half of the

existence energy expended; aquatic foragers expended almost a third of the existence energy. One species of each of the four major guilds contributed to the four highest energy users of the habitat: Common Snipe, Yellow Warbler, Alder Flycatcher, and White-crowned Sparrow. The existence energy-dominance curve for the ground-brush foraging guild was sigmoid in shape and horizontal, indicating a high species diversity, with little competitive advantage among a number of intermediate-abundance species; its shape resembles MacArthur's "random niche-boundry" distribution (see Whittaker 1965). The curve for the aquatic foragers was also sigmoid, but steeper, resembling Preston's (1948) lognormal distribution. The steep, straight line formed by the foliage searchers suggests niche-pre-emption, even though the data points were few. A combination of guild addition and guild expansion appears responsible for the high species diversity observed in the Tall Shrub Thickets.

Deciduous Forest

Deciduous Forests, in general, supported intermediate breeding densities (26.3-28.7 pairs/10 ha) and numbers of species (7-15). Eveness of abundance (J'), breeding density, and density of certain bird species (e.g., Dark-eyed Junco, Yellow-rumped Warbler, and Orange-crowned Warbler) were remarkably consistent among replicate plots sampled within this habitat (see Appendix Table A-6). Species diversity, species composition, density-dominance structure, and patterns of resource

division of the two major vegetative types within this habitat--Aspen-dominant stands and Birch-dominant stands--however, were quite different. Aspen stands supported greater density, biomass, and existence energy expenditure, but had fewer species and lower diversity than Birch stands. As with all other avian habitats, ground-brush foragers dominated the expenditure of existence energy; and existence-energy-dominance curves for all guilds were relatively straight, suggesting niche-pre-emption in those guilds with sufficient data points.

In Aspen stands, Yellow-rumped Warbler, Orange-crowned Warbler, American Robin, and Dark-eyed Junco were the most abundant species, comprising 70% of total density. American Robin, Hermit Thrush, and Hammond's Flycatcher reached their greatest abundance in Aspen stands. The density-dominance structure was unique, with the four most abundant species having nearly equal densities (Fig. 12). The existence energy-dominance structure, on the other hand, was overwhelmingly dominated by a single species, American Robin. The open understory and relatively high light levels in Aspen stands resulted in extensive berry-producing dwarf and low shrubs (see Table 2), which were utilized by ground-brush foragers throughout the breeding season. Foliage searchers were limited in Aspen stands because of the lack of mid-story vegetation and the comparatively thin upper canopy.

In Birch stands, the most abundant species was the Swainson's Thrush; this species, plus the next three most abundant ones--Yellow-rumped Warbler, Dark-eyed Junco, and Orange-crowned Warbler--comprised

77% of total density. The Yellow-rumped Warbler and Black-capped Chickadee reached their greatest abundance in Birch stands. The density-dominance structure was characteristic of a diverse community, with an even, gradual decline in species abundance across the graph (Fig. 12).

Slighly lower levels of primary productivity but greater structural diversity are characteristic of Birch stands, compared to Aspen stands, and likely accounted for the correspondingly lower productivity but greater avian species diversity of the Birch stands. Both foliage profile and vegetation height distribution were more diverse in Birch stands than in Aspen stands (Fig. 15). The characteristic mid-story of Alnus crispa and the thick canopy of Birch increased opportunities for the foliage searcher guild. Mesic-site species (e.g., Swainson's Thrush and Dark-eyed Junco) dominated the ground-brush forager guild. Raptors were well-represented, because of breeding Sharp-shinned Hawks and Great Horned Owls.

Mixed Deciduous-Coniferous Forest

Mixed Deciduous-Coniferous Forest was the most diverse and productive of all the forest habitats censused in the Tanana River Valley. This habitat supported the largest number of species, greatest species diversity, and the highest breeding density, biomass, and existence energy utilization. The most abundant species were Swainson's Thrush and Dark-eyed Junco, which together comprised 48% of

the breeding density; the Yellow-rumped Warbler was also numerous. Swainson's Thrush and Varied Thrush reached their greatest abundance in the Mixed Deciduous-Coniferous Forest habitat, and this was the only habitat in which breeding Pine Grosbeaks were found. Large numbers of apparently non-breeding Common Redpolls and White-winged Crossbills used this habitat extensively. Both the density-dominance structure and the existence energy-dominance foraging guild curves were characteristic of diverse communities, the former showing an even, gradual decline in species abundance across the graph (Fig. 12) and the latter, a sigmoid-shaped curve for the two dominant foraging guilds--ground-brush foragers and foliage searchers (Fig. 14).

The combination of deciduous and coniferous life-forms provided a diverse habitat structure, which was utilized by six different foraging guilds. Ground-brush foragers and foliage searchers dominated existence energy, with three ground-brush foragers--Swainson's Thrush, Dark-eyed Junco, and American Robin--utilizing over half (56%) of the total avian existence energy. High species richness was gained through both the addition and expansion of foraging guilds.

One 1.61-ha Mixed Forest miniplot, the Upland White Spruce-"toothpick" Birch (MF5), was excluded from the summary of population data (Tables 3 and 4) because of its unexplained, aberrantly low density; there was no evidence of breeding birds on this plot. Sapling and pole-sized Birch or Aspen stands, resembling "toothpick" stands from a distance, generally had low breeding bird density and diversity, but they were not usually devoid of birds as this one was.

Coniferous Forest

Coniferous Forests, in general, were the least productive of the forest habitats, supporting the lowest breeding density, biomass, and existence energy, and having the lowest species diversity of any of the major avian habitats of the Tanana River Valley (see Table 4). Low primary productivity rates undoubtedly limited avian productivity; however, a thick canopy with a varied, conical structure and an open upper layer provided foraging opportunities for five guilds. The most abundant breeding species were Dark-eyed Junco, Townsend's Warbler (White Spruce only), and Swainson's Thrush, which together comprised 67% of the breeding density. Dark-eyed Junco and Swainson's Thrush, both ground-brush foragers, also overwhelmingly dominated the total existence energy expenditure.

The two major vegetation types within this habitat--White Spruce-dominant stands and Black Spruce-dominant stands--had considerably different numbers of species, species composition, breeding densities, species diversity, and density-dominance structures, with the Black Spruce stands less diverse and less productive than comparably-located (upland/lowland) White Spruce stands.

In White Spruce stands, the Townsend's Warbler, a recent colonizer in interior Alaska (Kessel and Springer 1966), was the most abundant bird; this species, together with the next most abundant ones--Swainson's Thrush and Dark-eyed Junco--comprised 82% of total density. Townsend's Warbler, Brown Creeper, and Boreal Chickadee reached their greatest

abundance in White Spruce stands. Large numbers of White-winged Crossbills, Bohemian Waxwings, Pine Siskins, and Common Redpolls, which were apparently non-breeders, used White Spruce stands extensively during the breeding season. Breeding species diversity was low, with an uneven distribution of species abundance and the dominance of the three most abundant species, which is illustrated in the jagged density-dominance structure in Figure 12. The existence-energy-dominance curves of the major foraging guilds were essentially straight, probably because of the few species in each guild having widely-separated niches.

Three sub-dominant foraging guilds reached their maximum productivity in White Spruce stands: Raptors (Sharp-shinned Hawk, American Kestrel, and Great Horned Owl), Timber Gleaners (Boreal Chickadee, Brown Creeper), and Timber Drillers (Hairy Woodpecker and Northern Three-toed Woodpecker). Foliage searchers reached their maximum dominance (28%) in this vegetation type, apparently because of the deep, extensive, and incised canopy characteristic of climax White Spruce stands. Ground-brush foragers, however, dominated total existence energy--as they did in all avian habitats of the Tanana River Valley.

Black Spruce stands were the least productive of all habitats censused, supporting the lowest breeding density, lowest biomass, and lowest existence energy--a reflection, undoubtedly, of the low primary productivity levels in Black Spruce. A single species, Dark-eyed Junco, dominated the Black Spruce stands and comprised 40% of the total breeding

density. This dominance caused a unique community density-dominance structure, with one dominant species and an even distribution of the remaining, less common species (Fig. 12).

Ground-brush foragers dominated total existence energy expenditure, with lesser allocations to aquatic foragers and foliage searchers. The presence of the aquatic foraging guild was possible because of wet areas within Black Spruce stands undergoing paludification. The existence energy-dominance curve for the ground-brush foragers was sigmoid in shape, while that of the foliage searchers suggested a lognormal distribution.

Scattered Woodland and Dwarf Forest

Scattered Woodland and Dwarf Forest was represented by two distinct subtypes: White Spruce-Birch Woodland and Black Spruce Bog. In general, these subtypes tended to follow their nearest forest counterparts (Mixed Deciduous-Coniferous Forest for Woodland and Black Spruce stands for Dwarf Forest) in community characteristics, except that they supported higher breeding densities, biomasses, and existence energies. The open canopy of this habitat, with its concomitant greater presence of shrub layers (see Table 2 and Fig. 15), added characteristics of the more productive shrub thicket bird communities. Dark-eyed Junco and White-crowned Sparrow were the most abundant species and comprised 45% of total breeding density. Less abundant breeding species found in both subtypes were, in descending order of abundance, Ruby-crowned Kinglet, Gray-cheeked Thrush, American Robin, and Orange-crowned Warbler. Ruby-crowned Kinglets

and Gray-cheeked Thrushes reached their greatest abundance in this habitat.

The White Spruce-Birch Woodland had a much higher number of species, breeding density, biomass, and existence energy expenditure than Black Spruce Bog. The relatively high number of species was made possible by the combination of coniferous and deciduous life-forms with that of shrub thickets. White-crowned Sparrow was the most abundant species, comprising 21% of the breeding density. This dominance resulted in a density-dominance structure similar to that of Black Spruce stands, with one abundant species dominating the density and several equally-abundant species of intermediate density (Fig. 12). The high species diversity value resulted from the combination of the relatively large number of species and the fact that a number of those of intermediate abundance were equally numerous.

Ground-brush foragers reached their maximum dominance in the White Spruce-Birch Woodland, occupying 89% of total existence energy. The existence energy dominance curve for the ground-brush foraging guild was a horizontal, sigmoid line typical of diverse communities.

Black Spruce Bogs, paralleling Black Spruce stands, had a low number of species and exhibited low avian productivity (cf Table 4). Dark-eyed Junco and White-crowned Sparrow were the most abundant species, comprising 60% of total breeding density. No birds achieved their greatest abundance in this Dwarf Forest. The density-dominance structure showed a dominance of two species and a gradual decline in

abundance of species of intermediate density. Ground-brush foragers dominated total existence energy; their existence energy-dominance curve was sigmoid, approaching a lognormal distribution.

Permanent Resident Birds

Permanent resident species on the census plots generally occurred in much lower densities than migrant species. They initiated breeding activities 1 to 3 months earlier, so estimation of their density using territory mapping from mid-May to mid-July was inappropriate. Instead, the mean number of individuals observed per census was used as an index to compare abundance of permanent resident species (Table 7). In contrast to the pattern observed for breeding density (above), the habitats containing coniferous trees supported the highest number of species and greatest densities of permanent residents. White Spruce-dominant forests supported the greatest number of species and greatest density of permanent residents; Black Spruce-dominant forests and Mixed Deciduous-Coniferous Forests supported intermediate densities; Deciduous Forests and Tall Shrub Thickets supported low densities; and Low and Medium Shrub Thickets and Scattered Woodlands and Dwarf Forests supported minimal densities. Boreal Chickadee, Gray Jay, White-winged Crossbill, Great-Horned Owl, and Spruce Grouse were most abundant in Coniferous Forests; Ruffed Grouse were most abundant in Mixed Deciduous-Coniferous Forests; Black-capped Chickadees were most abundant in Deciduous Forests; and Common Redpolls were most abundant in Tall Shrub Thickets.

Table 7. Comparison of abundance of permanent resident breeding bird species among the major woody avian habitats, Tanana River Valley, Alaska, 1975 and 1977. Number of plots and sample area are the same as Table 3. Figures are the mean number of individuals observed per 10 ha, per census. Numerals in parentheses indicate the number of plots in which the species occurred. A "+" denotes breeding in very small numbers.

	LOW AND MEDIUM SHRUB THICKETS	TALL SHRUB THICKET	DECIDUOUS FOREST			MIXED DECIDUOUS-CONIFEROUS FOREST
SPECIES			Aspen-Dominant	Birch-Dominant	All Deciduous Combined	
Spruce Grouse						
Ruffed Grouse			0.3 (1)	0.1 (1)	0.1 (2)	0.7 (1)
Great Horned Owl				1.1 (1)	0.4 (1)	
Hawk Owl	+ (1)	+ (1)				
Hairy Woodpecker						
N. Three-toed Woodpecker						
Gray Jay		0.7 (3)	2.4 (2)	1.2 (2)	1.9 (4)	3.7 (4)
Black-capped Chickadee		0.1 (1)	1.0 (3)	1.0 (1)	1.0 (4)	+ (1)
Boreal Chickadee		0.5 (3)	0.1 (1)	0.3 (1)	0.2 (2)	4.3 (4)
Bohemian Waxwing	1.3 (3)	0.1 (2)	1.4 (1)		0.9 (1)	0.4 (2)
Pine Grosbeak	0.2 (2)	0.5 (2)	0.2 (1)	+ (1)	0.1 (2)	0.3 (2)
Common Redpoll	1.4 (3)	3.1 (3)	1.0 (1)	1.2 (1)	1.1 (2)	1.8 (3)
White-winged Crossbill		0.5 (1)				1.8 (1)
TOTAL INDIVIDUALS	2.9	5.5	6.4	4.9	5.7	13.0
TOTAL NUMBER OF SPECIES	4	8	7	7	8	8

Table 7. (cont'd)

SPECIES	CONIFEROUS FOREST			SCATTERED WOODLAND AND DWARF FOREST	
	White Spruce-Dominant	Black Spruce-Dominant	All Coniferous Combined	White Spruce-Birch Woodland	Black Spruce Bog
Spruce Grouse		2.0 (1)	1.0 (1)		
Ruffed Grouse	0.2 (1)	0.4 (1)	0.3 (2)		
Great Horned Owl	2.2 (2)		1.1 (2)		
Hawk Owl					
Hairy Woodpecker	0.3 (1)		0.1 (1)		
N. Three-toed Woodpecker	0.4 (1)	0.8 (1)	0.6 (2)		
Gray Jay	3.8 (2)	4.6 (2)	4.2 (4)	0.4 (1)	3.0 (2)
Black-capped Chickadee					
Boreal Chickadee	10.0 (2)	2.0 (1)	6.0 (3)		
Bohemian Waxwing	0.3 (1)	1.0 (1)	0.9 (2)	0.9 (1)	0.2 (1)
Pine Grosbeak	+ (1)		+ (1)		
Common Redpoll	1.3 (1)	1.2 (1)	1.2 (2)		0.4 (1)
White-winged Crossbill	5.3 (2)	0.8 (1)	3.0 (3)		
TOTAL INDIVIDUALS	23.8	12.8	18.4	1.3	3.6
TOTAL NUMBER OF SPECIES	10	7	11	2	3

The pattern of permanent resident species abundance during the breeding season appears generally to correspond to their winter season patterns. Wintering birds near Fairbanks tend to be most numerous in White Spruce forests, followed by Black Spruce and mixed White Spruce-Birch forests. Gray Jays, Boreal Chickadees, and Northern Three-toed Woodpeckers generally bred in the same White Spruce-dominated forests in which they wintered, and the Coniferous Forests and Mixed Deciduous-Coniferous Forests, which support Pine Grosbeak, redpolls, and White-winged Crossbills in winter, also support them in summer. The ability of a habitat to support resident wintering species is apparently largely related to the availability of a relatively high abundance of tree seeds, especially White Spruce and Birch, and probably also to the presence of the heavy coniferous canopies which prevent the direct loss of bird body heat by direct radiation to open sky, especially during roosting. Van Cleve et al. (pers. comm.) have found that White Spruce and Birch forests produce the highest above-ground biomass of forest plant growth; and seeds remain readily available in cones and catkins throughout the winter. White Spruce seeds provide more calories (av. 6615 cal/gm dry wt) than Black Spruce seeds (av. 6053 cal/gm dry wt) (Brink and Dean 1966); Paper Birch seeds provide 5637 cal/gm dry wt (av. five samples, range 5586-5710 cal/gm dry wt, Kessel unpubl. data). Brink and Dean (op. cit.) found that Red Squirrels (Tamiasciurus hudsonicus) could maintain or increase body weight when fed a pure diet of White Spruce seeds, but lost weight on Black Spruce seeds.

Annual Variation

The general magnitude of annual variations in population numbers can be determined by comparing numbers of common breeding passerine species between 1971 and 1977 obtained by Kessel from roadside counts through typical interior Alaska vegetation types near Fairbanks (Table 8). Total numbers in the "communities" varied a maximum of 26% over the seven years, while the maximum deviation from the mean for any one year was 17%. Annual variation in individual species differed considerably among species; generally, the most abundant species varied the least. Swainson's Thrush varied a maximum of 52% over the seven years, although the greatest departure from the mean of any one year was only 28%. Other common species which showed relatively small annual variation were Yellow Warbler, White-crowned Sparrow, Fox Sparrow, Northern Water Thrush, and American Robin. The less abundant species showed considerably more variation: Dark-eyed Junco, 126%; Ruby-crowned Kinglet, 121%; Varied Thrush, 100%; Yellow-rumped Warbler, 94%; and Wilson's Warbler, 79%. In view of the variable data for species of low abundance, conclusions regarding density dominance can be made only for the most abundant species in each habitat.

The presence of Dark-eyed Junco as a variable species of low abundance in Table 8 contrasts markedly with the high abundance observed in censuses of forest habitats at Fairbanks in 1975 and in the Tetlin-Northway area in 1977. According to Kessel's Fairbanks data, 1977 was a year of high abundance for Juncos, which could explain much of their

Table 8. Annual variation in numbers of 14 common migratory passerines, based on roadside census counts during the breeding season 1971-77, Fairbanks, Alaska (Kessel, Unpubl. data). Mean numbers of birds per count are followed by standard deviation.

SPECIES	MEAN NUMBERS OF BIRDS PER COUNT							OVERALL	MIN	MAX	RANGE	PERCENT VARIATION	COEFFICIENT OF VARIATION (%)
	1971	1972	1973	1974	1975	1976	1977	($\bar{x}$±std dev)	(a)	(b)	(a-b)	$\left(\frac{a-b}{\bar{x}}\right)$	$\left(\frac{\text{std dev}}{\bar{x}}\right)$
Hammond's Flycatcher	5.7±3.3	7.5±2.8	7.8±2.2	9.0±3.0	5.5±2.5	7.5±3.9	4.5±2.5	6.8±1.6	4.5	9.0	4.5	66.2	23.5
American Robin	17.7±3.8	23.7±6.5	22.7±8.4	24.3±2.1	19.7±3.3	25.7±7.1	34.5±1.5	24.0±5.0	17.7	34.5	14.8	61.7	20.8
Varied Thrush	5.0±2.2	6.6±3.2	7.4±1.4	7.5±1.5	8.8±4.3	2.8±1.9	4.0±0.0	6.0±2.0	2.8	8.8	6.0	100.0	33.3
Swainson's Thrush	37.5±7.5	44.7±14.8	37.0±8.8	35.0±5.0	54.0±10.9	59.3±10.8	57.0±6.0	46.4±9.5	35.0	59.3	24.3	52.4	20.5
Ruby-crowned Kinglet	6.0±0.8	5.7±3.0	3.7±3.3	9.3±4.2	11.7±3.4	4.8±2.2	5.0±0.0	6.6±2.6	3.7	11.7	8.0	121.2	39.4
Orange-crowned Warbler	20.7±4.5	14.8±4.9	8.8±3.1	15.7±4.7	13.8±6.7	16.8±4.7	22.5±2.2	16.1±4.2	8.8	20.7	11.9	73.9	26.1
Yellow Warbler	30.5±3.5	40.7±11.4	39.3±6.0	25.0±0.0	32.3±9.9	27.8±2.3	35.5±6.3	33.0±5.4	25.0	40.7	15.7	47.6	16.4
Yellow-rumped Warbler	9.5±1.5	15.3±5.7	14.8±6.2	20.5±5.2	18.0±1.7	25.4±7.5	14.5±4.5	16.9±4.7	9.5	25.4	15.9	94.1	27.8
Northern Waterthrush	15.0±2.9	20.3±2.9	14.8±2.5	17.0±6.0	23.0±8.6	13.2±5.1	15.5±1.5	17.0±3.2	13.2	23.0	9.8	57.6	18.8
Wilson's Warbler	6.7±0.9	7.2±1.3	4.5±1.4	3.0±0.0	7.0±3.0	4.0±3.0	7.5±0.5	5.7±1.7	3.0	7.5	4.5	78.9	29.8
Savannah Sparrow	5.0±1.4	9.1±3.6	7.8±4.3	7.0±2.0	10.5±2.6	10.4±1.9	6.5±0.5	8.0±1.9	5.0	10.5	5.5	68.8	23.8
Dark-eyed Junco	5.8±0.8	10.6±4.2	8.0±4.2	13.8±2.3	11.4±4.9	14.4±2.4	21.0±3.6	12.1±4.6	5.8	21.0	15.2	125.6	38.0
White-crowned Sparrow	24.3±6.2	30.7±7.6	25.0±7.8	31.5±3.5	39.0±6.5	36.6±11.9	28.0±5.0	30.7±5.1	24.3	39.0	14.7	47.9	16.6
Fox Sparrow	21.3±4.6	31.9±5.3	23.8±7.8	28.3±7.9	20.7±3.7	21.7±8.9	22.0±8.0	24.2±3.9	20.7	31.9	11.2	46.3	16.1
TOTAL NUMBERS	210.7	268.8	225.4	246.9	275.4	270.4	278.0	253.7±24.7	210.7	278.0	67.3	26.5	9.7

predominance on the Tetlin-Northway census plots in 1977. However, Dark-eyed Juncos were abundant in the two forest plots censused at Fairbanks in 1975, a year of average Junco density according to Kessel's data.

The inverse relationship between abundance and annual variation (Fig. 16) was significant, both in linear regression ($y = 32.59-0.415x$, $r2 = 0.433$, $p < 0.02$) and in Spearman's rank correlation (Steel and Torrie 1960) ($r = 0.802$, $p < 0.001$). Such a relationship may be caused by density-dependent regulation limiting and stabilizing breeding population levels for abundant species (Stephen F. MacLean, pers. comm.). In contrast, uncommon species probably are not responding to such density-dependent regulation, and are more likely to be influenced by varying environmental conditions.

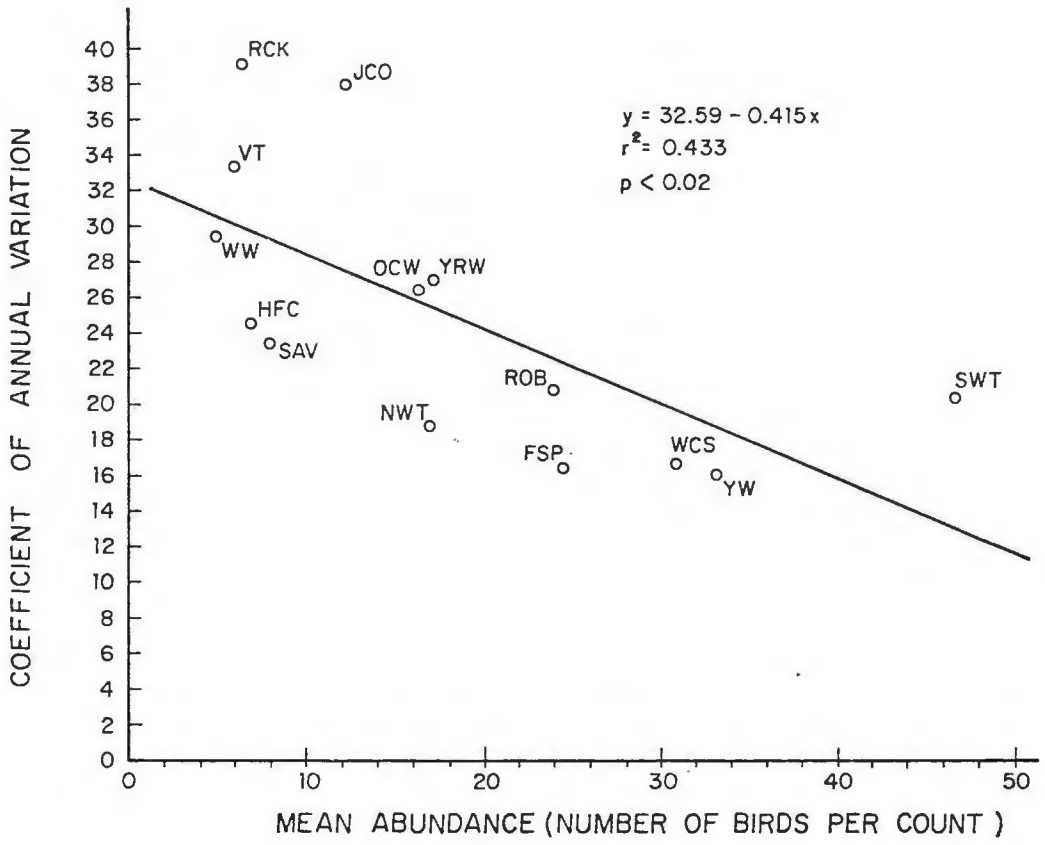

Figure 16. Relationship between abundance and annual variation in 14 common migratory passerines during the breeding season, Fairbanks, Alaska, 1971-1977. Based on roadside counts summarized in Table 8. See Table 3 for species abbreviations.

DISCUSSION, CONCLUSIONS, AND SUMMARY

The wide range of vegetation types within the taiga of the upper Tanana River Valley results in a corresponding variability in breeding bird populations and species composition. Species diversity of an avian community is highly dependent on several components of habitat diversity: vegetation life-form (Pitelka 1941); vertical diversity or number and distribution of vegetation layers (MacArthur and MacArthur 1961, MacArthur 1964, Karr 1968, Willson 1974); horizontal diversity or microspatial heterogeneity (MacArthur 1964, Karr and Roth 1971, Roth 1976); and the macrospatial juxtaposition of dissimilar habitats (Erskine 1977). Diversity is also related to community productivity and standing crop biomass (Pianka 1966 and 1974). Animal population density and productivity are directly related to net primary productivity in the habitat (Odum 1957, Margalef 1963, Varley 1970). Physical factors--e.g., soil temperature, moisutre, pH, nutrient regime, slope, solar radiation--generally control rates of primary production in the vegetation of the Alaska taiga (Van Cleve et al., pers. comm.). In addition, population density and diversity of migratory species may be influenced by food quantity and quality and other conditions elsewhere in a species range (Fretwell 1972) (72% of the breeding birds on the census plots of the upper Tanana River Valley were migratory species).

Differences in breeding density and species composition in the upper Tanana River Valley can be explained largely in terms of differences in primary productivity and habitat structure, respectively. Levels of avian productivity (based on calculations of existence energy utilization derived from breeding density) were generally correlated with levels of primary productivity. The major avian habitats and subtypes, ranked in order of avian productivity were lowland Tall Shrub Thicket, lowland Low and Medium Shrub Thickets, lowland White Spruce-Birch Woodland, Mixed Deciduous-Coniferous Forest, Aspen stands, Birch stands, Black Spruce Bog, White Spruce stands, and Black Spruce. Diversity in habitat structure was generally correlated with avian species diversity, with the highest species diversity occurring in Tall Shrub Thickets, because of vertical structural diversity and spatial heterogenity, and in Mixed Deciduous-Coniferous Forests, because of the variety of life-forms combined with vertical structural diversity and spatial heterogenity. Outside of these two avian habitats, the greatest species diversity was found in the White Spruce-Birch Woodland vegetation type, which combined many of the structural features of the Mixed Deciduous-Coniferous Forest and the Tall Shrub Thicket. High species diversity in these habitats was gained through both the expansion and the addition of foraging guilds.

The breeding density of permanent resident species was nearly the opposite of the pattern for migratory breeding birds, with the greatest density of permanent resident species occurring in White Spruce-dominant

forests and intermediate densities in Black Spruce-dominant forests and in Mixed Deciduous-Coniferous Forests. This density pattern for permanent resident species appears to be related to the ability of these habitats to support wintering populations; these habitats have a relatively high annual production of above-ground plant standing crop biomass and an abundance of available tree seeds.

Annual variation in the abundance of different bird species can be significant. The more abundant species can be expected to vary up to 50% from year to year, whereas the less common species may show more than 100% annual variation. The inverse relationship between abundance and annual variability may be attributable to density-dependent factors regulating breeding density in the abundant species, with density-independent factors showing more influence on the less abundant species.

Habitat characteristics, identified through the use of stepwise multiple regression analyses and correlations (see Table 5), which were associated with high avian productivity included high importance values for Poplar and Alnus incana, open treeless vegetation with the presence of herbs, an edge effect and spatial heterogenity, high diversity of stem height distribution and of tree/tall shrub species, and the presence of water. Other characteristics identified as important, as well as some of the above, are characteristics of the shrub thicket habitats--multiple-stemmedness (= Alnus and Willow), high proportion of stems in the tall shrub layer, and high "brush" (0-1.0 m) density.

Different species of birds select different habitats for their breeding activities, and knowledge of their habitat preferences provide insights into the effect that construction of the Northwest Alaskan Gas Pipeline will have on bird populations in the areas traversed by the pipeline. Through a combination of analysis of variance and multiple stepwise regression analysis, 25 of the habitat variables showed some significance, either positive or negative. Two sets of these variables are particularly instructive when plotted against each other relative to the "mean habitat" in which the bird species was found on the census plots in 1977 ("mean habitat" is the mean of the particular habitat variable on all of the plots on which the species occurred). Figure 17 shows which of the more common avian species will be most affected when construction crosses habitats of deciduous trees and shrubs as opposed to coniferous ones, and vice versa; conversely, depending on the type of tree/shrub vegetation that grows after construction, this figure shows the bird species that will follow. Similarly, Figure 18 shows which avian species will be most affected when construction crosses Low and Medium Shrub Thickets, Tall Shrub Thickets, mature forests, and fully-developed forests. With revegetation after construction, if normal patterns occur, the first birds to recolonize will be those of the Low and Medium Shrub Thickets, then those of the Tall Shrub Thickets, then those of the Tall Shrub-young forest transition, followed, in upland areas, by those of the mature forest, and, finally, those of the fully-developed White Spruce forests.

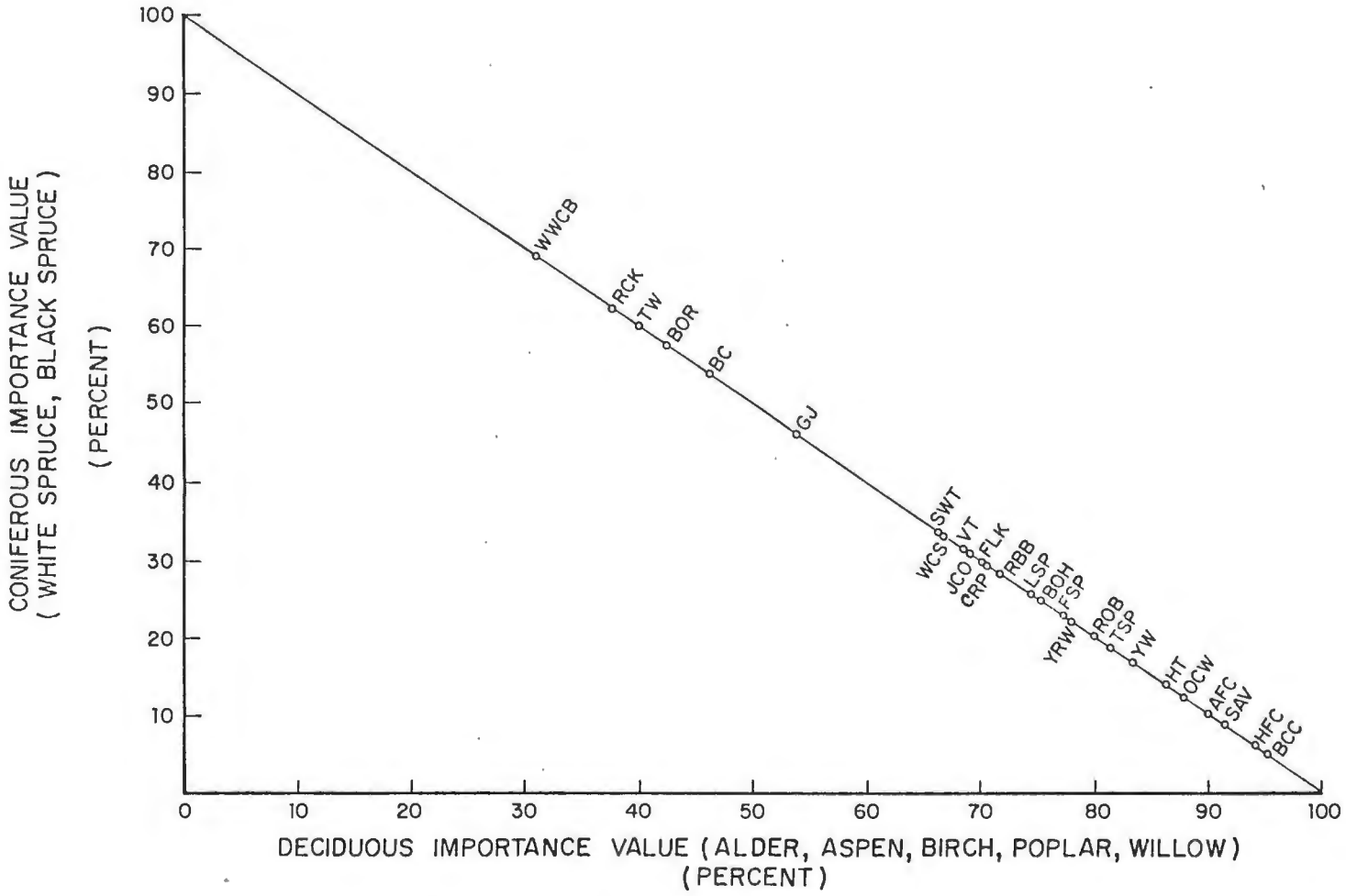

Figure 17. Ordination of 26 bird species on a gradient from pure coniferous to pure deciduous habitat, Tetlin-Northway study area, Alaska, 1977; based on their "mean habitat" relative to the habitat variables of deciduous and coniferous habitats. Importance value of habitat variables is the sum of relative frequency, relative density, and relative dominance of the species, similar to Cottam and Curtis (1956).

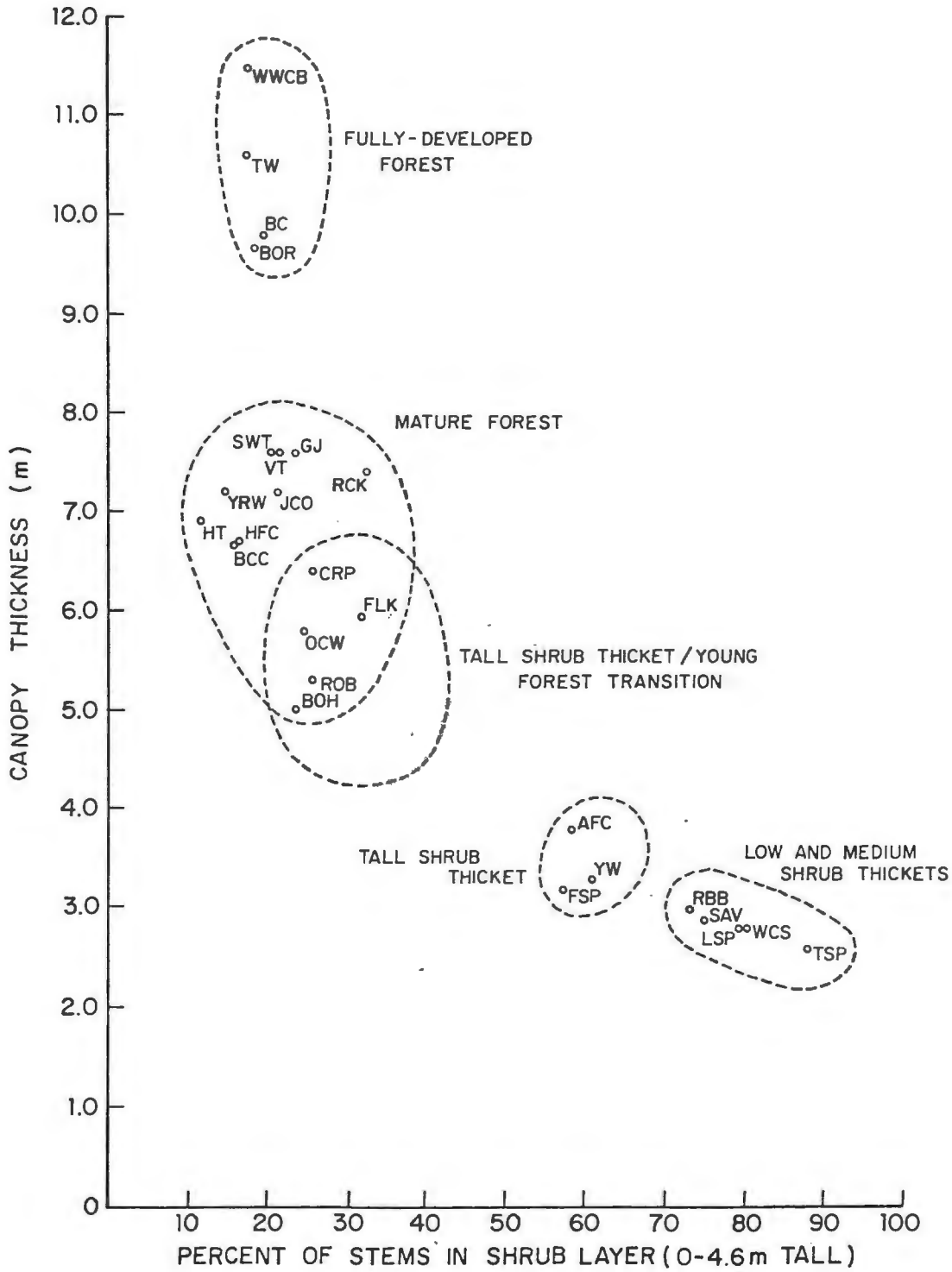

Figure 18. Ordination of 26 bird species from low shrub to fully-developed forest habitat, Tetlin-Northway study area, Alaska, 1977; based on their "mean habitat" relative to the habitat variables of canopy thickness and density of shrub stems.

A section of the old Haines Petroleum Pipeline right-of-way near Mile 1281, Alaska Highway, in August 1977, is shown in Figure 19. Dense grass, mostly Calamagrostis canadensis, covers much of the pipeline in the Tetlin-Northway area, a vegetation type little used by birds. The right-of-way makes a sharp edge-effect with the surrounding vegetation; mostly shrub cover of low and medium-height in bog areas, tall shrub in creek bottoms, and various forests in many upland seres.

Figure 19. Haines Petroleum Pipeline right-of-way near Mile 1281, Alaska Highway, August 1977. Note the sharp contrast in vegetation at the edge of the pipeline right-of-way; here, a luxuriant grass cover of Calamagrostis canadensis abuts on Tall Shrub Thicket.

ACKNOWLEDGMENTS

We would like to thank the Natives of Northway and Tetlin for permission to locate bird census plots on their village and tribal lands, respectively. Thanks are also extended to local residents James and Debbie Harbison and Terry Brigner of Alaska Highway Milepost 1281, Dave and Laureen Stout of Milepost 1264, and Floyd Miller, Herb Stevens, and Vivian LeBlanc of Northway for the information, suggestions, and advice they provided. Dr. Stephen F. MacLean, University of Alaska, provided helpful insights during discussion on aspects of data analysis, as did Dr. Keith Van Cleve, University of Alaska, during discussions of habitat productivity. Finally, special thanks and appreciation go to Michele Mouton for her patience and assistance during all phases of the project.

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APPENDIX

Appendix Table A-1. Summary of tree and shrub ages for the 18 Tetlin-Northway bird census plots. Based on increment borer samples taken August-November 1977.

Plot	Mean Age	Std Dev	Maximum Age	n
Lowland Low & Medium Willow Thickets	148.0	55.1	200	6
Upland Low & Medium Willow Thickets	44.4	10.0	60	9
Lowland Tall Alder-Willow Thicket	81.9	36.7	180	7
Lowland Tall Willow-Poplar Thicket	26.6	4.3	36	10
Upland Tall Willow Thicket	41.7	14.2	65	11
Upland Aspen-Poplar Forest	99.8	3.1	105	6
Upland Aspen Forest #1	96.3	7.4	107	14
Upland Aspen Forest #2	59.1	7.8	72	9
Upland Birch Forest #1	84.4	20.8	125	14
Upland Birch Forest #2	58.1	9.1	76	10
Upland Aspen-White Spruce Forest	63.1	11.0	80	11
Upland Birch-White Spruce Forest (E-side)	105.6	16.9	130	7
Upland Birch-White Spruce Forest (W-side)	56.5	4.7	60	7
Upland White Spruce-Aspen-Birch Forest	53.5	5.7	57	4
Upland White Spruce-"Toothpick" Birch Forest	49.9	5.3	75	8
Upland White Spruce Forest #1	165.5	16.9	200	15
Upland White Spruce Forest #2	159.6	15.3	185	7
Upland White Spruce Forest	153.6	51.5	250	7
Lowland White Spruce-Birch Woodland	124.0	66.6	190	5
Upland Black Spruce Bog	56.3	6.6	65	7

Appendix Table A-2. Weights of common interior Alaska breeding birds, obtained from University of Alaska Museum specimens collected during the breeding season, from West and DeWolfe (1974, Table 5) and from calculations based on Carbyn (1971, Table 1).

Species	Weight (g)	Source
Mallard	1117.8	UAM (Univ. Alaska Museum)
Pintail	856.1	UAM
Green-winged Teal	336.8	UAM
American Wigeon	815.6	UAM (905.2), LSU (726.0)
Northern Shoveler	609.9	UAM (775.7), LSU (444.0)
Sharp-shinned Hawk	160.0	UAM
American Kestrel	124.5	UAM
Spruce Grouse	561.2	UAM
Ruffed Grouse	593.6	UAM
Sandhill Crane	2481.0	UAM
Common Snipe	97.3	UAM
Solitary Sandpiper	51.5	UAM
Lesser Yellowlegs	80.5	UAM
Northern Phalarope	33.4	UAM
Mew Gull	432.8	UAM
Great Horned Owl	1416.5	UAM
Hawk Owl	341.7	UAM
Common Flicker	177.0	UAM
Hairy Woodpecker	74.0	UAM
Downy Woodpecker	25.8	UAM
Northern Three-toed Woodpecker	56.9	UAM
Alder Flycatcher	12.6	UAM (12.3), Carbyn (12.0) West & DeWolfe (13.6)
Hammond's Flycatcher	11.0	UAM
Olive-sided Flycatcher	34.1	UAM
Tree Swallow	18.0	UAM (18.4), LSU (17.6)

Appendix Table A-2. (cont'd)

Species	Weight (g)	Source
Bank Swallow	17.3	UAM
Cliff Swallow	18.3	UAM
Gray Jay	72.3	UAM
Black-capped Chickadee	11.7	UAM
Boreal Chickadee	11.5	UAM (12.1), Carbyn (11.0)
Brown Creeper	7.8	UAM
American Robin	88.0	UAM, Carbyn (88.0)
Varied Thrush	78.5	UAM
Swainson's Thrush	28.0	UAM (27.4), West & DeWolfe (26.8), Carbyn (31.0)
Hermit Thrush	27.0	UAM
Gray-checked Thrush	29.5	UAM (30.1), Carbyn (29.0)
Ruby-crowned Kinglet	7.0	UAM (6.3), Carbyn (8.0), West & DeWolfe (6.6)
Bohemian Waxwing	59.3	UAM (60.6), Carbyn (58.0)
Orange-crowned Warbler	9.5	UAM (9.8), West & DeWolfe (8.3)
Yellow Warbler	9.7	UAM (10.0), West & DeWolfe (9.4)
Yellow-rumped Warbler	12.5	UAM (13.0), West & DeWolfe (12.3), Carbyn (12.0)
Townsend's Warbler	9.4	UAM
Blackpoll Warbler	12.4	UAM (12.8), Carbyn (12.0)
Northern Waterthrush	17.3	UAM (17.0), LSU (17.6)
Wilson's Warbler	7.7	UAM (7.8), West & DeWolfe (7.6)
Rusty Blackbird	48.9	UAM
Pine Grosbeak	59.7	UAM
Common Redpoll	14.2	UAM
Pine Siskin	12.2	UAM
White-winged Crossbill	24.4	UAM
Savannah Sparrow	18.0	UAM
Dark-eyed Junco	18.6	UAM (18.4), West & DeWolfe (18.5), Carbyn (19.0)

Appendix Table A-2. (cont'd)

Species	Weight (g)	Source
Tree Sparrow	17.9	UAM
White-crowned Sparrow	24.0	UAM (23.7), West & DeWolfe (25.0)
Fox Sparrow	36.6	
Lincoln's Sparrow	15.8	UAM (15.7), Carbyn (16.0)

Appendix Table A-3. Chronology of six months of field work, 1977, Tetlin Junction-Northway study area, Alaska.

17 May	Commenced field work, most trees and shrubs not yet green Larger lakes still ice-covered, rivers and ponds ice-free
18 May	Selected potential bird census plot locations
21 May	Began surveying census plots
28 May	Began censusing plots Most tree, shrub, and herbaceous vegetation had green foliage
2 June	Dark-eyed Junco nest with eggs White-crowned Sparrow nest with eggs Tree Sparrow nest with eggs
4 June	First Fox Sparrow fledglings Lesser Yellowlegs nest with eggs
6 June	Orange-crowned Warbler nest with eggs
10 June	Hatching Dark-eyed Junco
13 June	Boreal Chickadee observed feeding young, still in nest cavity Black-capped Chickadee adult observed entering nest cavity
14 June	Pintail nest with eggs First Dark-eyed Junco fledgling
15 June	First hatching Lesser Yellowlegs First Rusty Blackbird fledgling Common Flicker nest with eggs First hatching Orange-crowned Warbler
16 June	First Varied Thrush fledgling First brood of Lesser Scaup
19 June	First Tree Sparrow fledglings
21 June	First Hermit Thrush nest with eggs
25 June	Mallard brood First hatched Yellow Warbler
26 June	Alder Flycatcher nest with eggs

Appendix Table A-3. (cont'd)

27 June	First Orange-crowned Warbler fledglings
	Horned Grebe nest with eggs
28 June	First Swainson's Thrush fledglings
	Pintail brood
29 June	First Savannah Sparrow fledglings
	First Ruffed Grouse young out of nest
2 July	First Bohemian Waxwing fledglings
4 July	First Yellow-rumped Warbler fledgling
	First brood Green-winged Teal
5 July	First flight-capable immature Sandhill Cranes
6 July	First Red-necked Grebe brood
	First Northern Shoveler brood
	First Bufflehead brood
	First Horned Grebe brood
	Flightless, molting adult Mallard seen
	First Canvasback brood seen
7 July	Juvenal Gray Jay molting to first winter plumage
	Gray Jay family groups dispersing; young independent
	First Brown Creeper fledglings
8 July	Boreal Chickadee fledgling
	First Townsend's Warbler fledgling
	First Arctic Loon young
	First Greater Scaup brood
	First Common Goldeneye brood
	First Bonaparte's Gull young
	First Arctic Tern young
10 July	American Wigeon brood
	First flight-capable Lesser Yellowlegs young
13 July	Ruby-crowned Kinglet fledglings
17 July	Rusty Blackbird adults molting to fall plumage
	First White-winged Scoter brood
18 July	Cliff Swallows feeding young
23 July	Semipalmated Plover young

Appendix Table A-3. (cont'd)

24 July	First fall migrant--Baird's Sandpiper, Least Sandpiper First flightless adult and immature Canada Geese First Whistling Swan--lone straggler
25 July	First flight-capable immature Common Snipe
27 July	First Blue-winged Teal brood
2 Aug	Last Olive-sided Flycatcher
10 Aug	Last Mew Gull
14 Aug	Last Hammond's Flycatcher Last Townsend's Warbler
16 Aug	Last Alder Flycatcher Last Cliff Swallow
18 Aug	Last Solitary Sandpiper
21 Aug	Last Spotted Sandpiper Last Bank Swallow
24 Aug	Last Orange-crowned Warbler
1 Sept	Last Common Flicker
2 Sept	Last Sharp-shinned Hawk
3 Sept	Last Brown Creeper
10 Sept	Last Belted Kingfisher
11 Sept	Last Arctic Loon Last White-fronted Goose Last Green-winged Teal
12 Sept	Last Hermit Thrush Last Northern Shrike
16 Sept	Last Red-necked Grebe Last Horned Grebe Last Pintail Last American Wigeon

Appendix Table A-3. (cont'd)

16 Sept	Last Northern Shoveler
	Last Canvasback
	Last Lesser Scaup
	Last Bufflehead
18 Sept	Last Common Snipe
	Last Swainson's Thrush
	Last Yellow-rumped Warbler
	Last Wilson's Warbler
19 Sept	First snowfall at Riverside Lodge
	Last Common Goldeneye
	Last Blue-winged Teal
	Last American Kestrel
21 Sept	Height of autumn foliage color on deciduous trees
22 Sept	Last Merlin
	Last Peregrine Falcon
23 Sept	Last Bald Eagle
	Last Varied Thrush
	Last Ruby-crowned Kinglet
	Last Water Pipit
	Last White-crowned Sparrow
27 Sept	Last Sandhill Crane
	Last Pine Siskin
	Last Fox Sparrow
1 Oct	Most leaves off deciduous trees and shrubs
	Last Golden Eagle
8 Oct	Last Marsh Hawk
13 Oct	Last Rusty Blackbird
14 Oct	Last Canada Goose
17 Oct	Last Whistling Swan
18 Oct	First heavy snowfall (= 10 cm), first lasting snow cover
	Tanana River frozen completely
	Last Red-breasted Merganser
19 Oct	Last Rough-legged Hawk

Appendix Table A-3. (cont'd)

27 Oct	Last Tree Sparrow
28 Oct	Last Starling First Black-billed Magpie
29 Oct	Last Dark-eyed Junco
30 Oct	Last American Robin
3 Nov	Last observation of waterfowl--3 Mallards on Tanana River
4 Nov	Last Snow Buntings
13 Nov	Depart Riverside Lodge Field Station

Appendix Table A-4. Bird nests found in Tetlin Junction-Northway study area, 1977.

Species	Date Found	No. Eggs/Young	Status	Hatching Date	Fledging Date	Habitat
Dark-eyed Junco	2 June	5	incubating		16 June	ground, under *Ledum* bush, Birch-White Spruce forest
White-crowned Sparrow	2 June	5	incubating	11 June		ground, in sedge tussock, under *Betula nana*, Low-Medium willow shrub.
Tree Sparrow	2 June	5	incubating	12 June	19 June	ground, in base of *Salix novae-angliae* bush, Low-Medium willow shrub
Lesser Yellowlegs	4 June	4	incubating	15 June		ground, at base of *Salix novae-angliae* bush, Low-Medium willow shrub
Dark-eyed Junco	10 June	4	hatched			ground, under grass tussock, Aspen-Poplar forest
Pintail	13 June	5	incubating			ground, steep gravel berm of Alaska Highway, 10 m from highway, near sedge wetlands
Black-capped Chickadee	13 June					6 m high in rotted Paper Birch trunk, Paper Birch forest
Boreal Chickadee	13 June		hatched			8 m high in rotted Paper Birch trunk, Paper Birch forest
Common Flicker	15 June	?	incubating	26 June		3 m high in rotted Balsam Poplar trunk, Tall Willow shrub
Orange-crowned Warbler	6 June	4	incubating	15 June	27 June	ground, under *Vibernum edule* bush, in grass clump, open Paper Birch-White Spruce forest
Hermit Thrush	21 June	4	incubating	2 July	12 July	ground, under White Spruce re-growth in open field, surrounded by White Spruce-Aspen forest
Yellow Warbler	25 June	4	brooding		29 June	2 m high in *Salix arbusculoides* bush in open Tall Willow stand
Yellow Warbler	26 June	4	brooding		30 June	3 m high in *Salix arbusculoides* bush in dense Tall Willow/Alder stand
Alder Flycatcher	26 June	4	incubating			1 m high in *Alnus crispa* growing in standing water, Tall Willow/Alder stand
Horned Grebe	27 June	3	incubating	6 July		ground, *Equisetum fluviatile* island at pond edge
Hermit Thrush	30 June	4	incubating	8 July		ground, surrounded by *Epilobium angustifolium* and *Calamagrostis canadensis*, in Paper Birch forest
Dark-eyed Junco	1 July	4	incubating	7 July		ground, under grass clump in open White Spruce regrowth, surrounded by mature White Spruce forest
White-crowned Sparrow	5 July	4	incubating			ground, at base of *Betula nana*, Low-Medium willow shrub
Orange-crowned Warbler	9 July	3	incubating			ground, in grass clump in open, young Aspen stand
Red-necked Grebe	7 July	3	incubating			on floating *Nuphar polysepalum* (Pond Lily) in shallow pond
Lesser Scaup	10 July	8	incubating			in sedge marsh, atop tussock, 1 m from pond edge, 0.25 m above water level

Appendix Table A-5. Climatic characteristics at Northway, Alaska, May-September 1977. (Source: U.S. NOAA 1977)

	May	June	July	August	September	October
Temperature						
Mean maximum temperature (°F)	55.9	65.7	70.4	72.2	53.5	29.9
Mean minimum temperature (°F)	33.3	43.5	46.2	45.5	32.3	13.5
Mean temperature (°F)	44.6	54.6	58.3	58.9	42.9	21.7
Departure from normal (°F)	+0.2	-1.3	-0.2	+5.3	+1.1	-0.1
Precipitation						
Total (inches)	1.98	2.14	0.97	0.62	1.51	0.29
Departure from normal (inches)	+1.18	+0.24	-1.56	-1.02	+0.39	-0.24
Number of days with >0.10 inches	9	8	3	3	1	0
Day of greatest precipitation	5/26	6/21	7/15	8/26	9/22	10/18
(Inches on that day)	0.45	0.50	0.35	0.25	1.12	0.70

Appendix Table A-6. Breeding bird density and presence of non-breeding birds on 24 census plots, Tanana River Valley, Alaska. Breeding densities are expressed in numbers of territories/10 ha and are based on six to eight censuses on each plot during the breeding season (May-June). Plot sizes varied from 1.61 to 10.0 ha. Fairbanks plots (F) were censused in 1975; Tetlin Junction (T), Riverside Lodge (R), and Northway (N) plots were censused in 1977. Key: + = small portion of a breeding territory on census plot, counted as 0.1 in density and diversity calculations; v = a non-breeding visitor to plot; * = deletion from biomass and existence energy calculations, because of disproportionate influence caused by family of heavy-bodied birds.

	LOW AND MEDIUM SHRUB THICKETS		
Plot:	Lowland Low & Med Willow	Upland Low & Med Willow	Lowland Tussock-Low & Med Shrub Bog
Location:	N	R	F
Species / Size (ha):	4.25	1.61	10.00
Mallard	+		
Pintail			
Green-winged Teal	+		
Sharp-shinned Hawk			
American Kestrel			
Spruce Grouse			
Ruffed Grouse			
Sandhill Crane			+
Common Snipe	8.2	0.5	2.0
Solitary Sandpiper	v		
Lesser Yellowlegs	4.7		
Great Horned Owl			
Hawk Owl	v		
Common Flicker	+		v
Hairy Woodpecker			
Northern Three-toed Woodpecker			
Alder Flycatcher	+		1.0
Hammond's Flycatcher		v	
Olive-sided Flycatcher			
Violet-green/Tree Swallow	v		v
Bank Swallow	v		
Cliff Swallow	v		
Gray Jay		v	
Black-capped Chickadee			
Boreal Chickadee			
Brown Creeper			
American Robin	1.2	2.3	v
Varied Thrush			
Hermit Thrush			
Swainson's Thrush	+		v
Gray-cheeked Thrush	v	0.5	
Ruby-crowned Kinglet	v		
Bohemian Waxwing	v	v	v
Orange-crowned Warbler	+	2.3	2.0
Yellow Warbler	1.2		
Yellow-rumped Warbler			
Townsend's Warbler			
Blackpoll Warbler			
Northern Waterthrush			
Wilson's Warbler			
Rusty Blackbird	2.4		v
Pine Grosbeak	v	v	
Common Redpoll	v	0.5	v
Pine Siskin			
White-winged Crossbill			
Savannah Sparrow	3.5		v
Dark-eyed Junco		2.3	v
Tree Sparrow	4.7		5.0
White-crowned Sparrow	9.4	10.0	5.5
Fox Sparrow	v		
Lincoln's Sparrow	8.2	9.3	8.0
Total Density (territories/10 ha)	44.1	27.7	23.6
Total Biomass (g/10 ha)	4050	1452	1198
Total Existence Energy (k cal/10 ha)	1518	635	516
Total Species; Breeding Species	26;15	12;8	16;7
Species Diversity (H')	2.071	1.587	1.610
Species Evenness (J')	0.785	0.763	0.828
Dominance (%)	39.9	71.0	57.2

Appendix Table A-6. (cont'd)

	TALL SHRUB THICKET			
Plot:	Lowland Tall Alder-Willow	Lowland Tall Willow-Poplar	Upland Tall Willow	Lowland Tall Alder-Willow
Location:	N	N	R	F
Species Size (ha):	3.35	1.61	1.61	10.00
Mallard	+			v
Pintail				1.0
Green-winged Teal	+			2.0
Sharp-shinned Hawk				
American Kestrel				
Spruce Grouse				
Ruffed Grouse				
Sandhill Crane				
Common Snipe	1.5			7.5
Solitary Sandpiper	v	v		2.0
Lesser Yellowlegs	3.0	0.4		2.0
Great Horned Owl				
Hawk Owl	v			
Common Flicker	1.0		0.5	v
Hairy Woodpecker				
Northern Three-toed Woodpecker				
Alder Flycatcher	10.5	9.8	9.6	1.5
Hammond's Flycatcher				v
Olive-sided Flycatcher				
Violet-green/Tree Swallow				v
Bank Swallow				
Cliff Swallow	v			
Gray Jay	+	v	v	v
Black-capped Chickadee				v
Boreal Chickadee	v	v		v
Brown Creeper				
American Robin	1.5	0.4	2.4	v
Varied Thrush				
Hermit Thrush				
Swainson's Thrush	4.2	v	4.8	1.0
Gray-cheeked Thrush	+	+		4.0
Ruby-crowned Kinglet	v			v
Bohemian Waxwing	v			v
Orange-crowned Warbler	6.0	7.9	9.6	v
Yellow Warbler	16.4	15.7		10.0
Yellow-rumped Warbler	v			v
Townsend's Warbler				
Blackpoll Warbler				3.0
Northern Waterthrush	4.8			4.5
Wilson's Warbler				
Rusty Blackbird	3.0	v		1.0
Pine Grosbeak	v			v
Common Redpoll	v	3.9		+
Pine Siskin				
White-winged Crossbill		v		
Savannah Sparrow	v	11.8		v
Dark-eyed Junco	v		9.6	2.0
Tree Sparrow	1.5			6.0
White-crowned Sparrow	3.0	7.9	4.8	1.0
Fox Sparrow	3.0	5.9		3.0
Lincoln's Sparrow	4.5	3.9	0.5	6.5
Total Density (territories/10 ha)	64.3	67.7	41.8	58.1
Total Biomass (g/10 ha)	3544	2176	1896	5808
Total Existence Energy (k cal/10 ha)	1464	1141	847	1968
Total Species; Breeding Species	29;18	17;11	9;8	32;18
Species Diversity (H')	2.364	2.036	1.781	2.584
Species Evenness (J')	0.818	0.849	0.856	0.894
Dominance (%)	41.8	40.6	45.9	30.1

Appendix Table A-6. (cont'd)

		DECIDUOUS FOREST				
	Plot:	Upland Aspen-Poplar	Upland Aspen #1	Upland Aspen #2	Upland Birch #1	Upland Birch #2
	Location:	R	R	N	R	R
Species	Size (ha):	1.61	10.00	1.61	10.00	1.61
Mallard						
Pintail						
Green-winged Teal						
Sharp-shinned Hawk					+	
American Kestrel						
Spruce Grouse						
Ruffed Grouse			+		+	
Sandhill Crane						
Common Snipe						
Solitary Sandpiper						
Lesser Yellowlegs						
Great Horned Owl						0.3*
Hawk Owl						
Common Flicker		0.3	+			
Hairy Woodpecker						
Northern Three-toed Woodpecker						
Alder Flycatcher		1.3		0.4	+	
Hammond's Flycatcher		3.8	+		+	v
Olive-sided Flycatcher						
Violet-green/Tree Swallow						
Bank Swallow						
Cliff Swallow						
Gray Jay			0.5	0.4	1.0	v
Black-capped Chickadee		0.3	+	v	1.0	
Boreal Chickadee			v		0.5	
Brown Creeper						
American Robin		3.1	6.5	4.9	0.5	1.6
Varied Thrush			v	v	1.0	v
Hermit Thrush		2.6	+	6.1	1.0	3.3
Swainson's Thrush		3.8	4.5	0.4	5.5	6.6
Gray-cheeked Thrush						
Ruby-crowned Kinglet						
Bohemian Waxwing			+			
Orange-crowned Warbler		5.1	5.5	4.1	4.5	3.0
Yellow Warbler			v			
Yellow-rumped Warbler		3.3	6.0	5.3	5.0	6.6
Townsend's Warbler			v			
Blackpoll Warbler						
Northern Waterthrush						
Wilson's Warbler			v			
Rusty Blackbird					v	
Pine Grosbeak			v		v	
Common Redpoll			+		1.0	
Pine Siskin						
White-winged Crossbill						
Savannah Sparrow						
Dark-eyed Junco		5.1	4.0	5.3	5.5	4.3
Tree Sparrow						
White-crowned Sparrow						
Fox Sparrow						
Lincoln's Sparrow						
Total Density (territories/10 ha)		28.7	27.7	26.9	26.9	25.7
Total Biomass (g/10 ha)		1498	2058	1690	1386	1212
Total Existence Energy (k cal/10 ha)		642	792	700	592	546
Total Species; Breeding Species		10;10	19;13	10;8	17;15	10;7
Species Diversity (H')		2.092	1.782	1.761	2.104	1.736
Species Evenness (J')		0.908	0.695	0.847	0.777	0.892
Dominance (%)		35.5	45.1	42.4	40.9	43.2

Appendix Table A-6. (cont'd)

		MIXED DECIDUOUS-CONIFEROUS FOREST				
	Plot:	Upland Aspen-White Spruce	Upland Birch-White Spruce	Upland White Spruce-Aspen-Birch	Lowland White Spruce-Black Spruce-Birch	Upland White Spruce-"Toothpick" Birch
	Location:	N	N	R	F	N
Species	Size (ha):	1.84	10.00	2.20	10.00	1.61
Mallard						
Pintail						
Green-winged Teal						
Sharp-shinned Hawk			+			v
American Kestrel					v	
Spruce Grouse						
Ruffed Grouse			+			
Sandhill Crane						
Common Snipe					2.0	
Solitary Sandpiper					v	
Lesser Yellowlegs					v	
Great Horned Owl						
Hawk Owl						
Common Flicker			v		v	
Hairy Woodpecker						
Northern Three-toed Woodpecker						
Alder Flycatcher					+	
Hammond's Flycatcher						
Olive-sided Flycatcher					0.5	
Violet-green/Tree Swallow					v	
Bank Swallow						
Cliff Swallow						
Gray Jay		0.4	1.0	1.5	0.5	v
Black-capped Chickadee					+	
Boreal Chickadee		1.3	+	1.5	1.0	
Brown Creeper			1.0			
American Robin		2.2	1.0	3.0	+	
Varied Thrush		0.4	2.0	v	+	
Hermit Thrush		2.2				
Swainson's Thrush		10.8	11.0	5.9	5.0	
Gray-cheeked Thrush					0.5	
Ruby-crowned Kinglet		2.2	+	3.0	1.0	
Bohemian Waxwing			v		v	
Orange-crowned Warbler		4.4	1.5	3.9	+	
Yellow Warbler						
Yellow-rumped Warbler		2.2	6.5	5.9	4.5	
Townsend's Warbler			5.0			
Blackpoll Warbler						
Northern Waterthrush					2.0	
Wilson's Warbler			v		v	
Rusty Blackbird					+	
Pine Grosbeak			v		0.5	v
Common Redpoll		1.0	1.0		0.5	
Pine Siskin						
White-winged Crossbill		v	v			
Savannah Sparrow						
Dark-eyed Junco		8.8	6.0	6.9	7.0	
Tree Sparrow					v	
White-crowned Sparrow					1.0	
Fox Sparrow					2.0	
Lincoln's Sparrow					v	
Total Density (territories/10 ha)		35.9	36.4	31.6	28.6	0
Total Biomass (g/10 ha)		1786	1958	1630	1602	0
Total Existence Energy (k cal/10 ha)		794	832	703	689	0
Total Species; Breeding Species		12;11	19;14	9;8	29;20	3;0
Species Diversity (H')		1.968	1.990	1.954	2.323	0
Species Evenness (J')		0.821	0.754	0.939	0.775	0
Dominance (%)		54.6	48.1	40.5	42.0	0

Appendix Table A-6. (cont'd)

		CONIFEROUS FOREST			
	Plot:	Upland White Spruce #1	Upland White Spruce #2	Upland Black Spruce	Lowland Black Spruce
	Location:	T	T	T	F
Species	Size (ha):	10.00	1.61	1.61	5.75
Mallard					
Pintail					
Green-winged Teal					
Sharp-shinned Hawk		+			
American Kestrel		+			
Spruce Grouse				0.5*	
Ruffed Grouse		+		v	
Sandhill Crane					
Common Snipe					1.7
Solitary Sandpiper					v
Lesser Yellowlegs					0.2
Great Horned Owl		+	+		
Hawk Owl					
Common Flicker		v			
Hairy Woodpecker		+			
Northern Three-toed Woodpecker		+		+	
Alder Flycatcher					
Hammond's Flycatcher					
Olive-sided Flycatcher					v
Violet-green/Tree Swallow					
Bank Swallow					
Cliff Swallow					
Gray Jay		1.0	0.5	1.0	0.2
Black-capped Chickadee					
Boreal Chickadee		2.0	+	1.0	
Brown Creeper		1.5			
American Robin					0.2
Varied Thrush		+			
Hermit Thrush			2.5		
Swainson's Thrush		7.0	5.1	3.6	
Gray-cheeked Thrush				+	2.6
Ruby-crowned Kinglet		+		2.0	0.9
Bohemian Waxwing		v			1.7
Orange-crowned Warbler					
Yellow Warbler					
Yellow-rumped Warbler		1.5			3.1
Townsend's Warbler		9.5	10.0		
Blackpoll Warbler					
Northern Waterthrush					
Wilson's Warbler					
Rusty Blackbird					v
Pine Grosbeak		v			
Common Redpoll		+			0.2
Pine Siskin		v			
White-winged Crossbill		v	v	v	
Savannah Sparrow					v
Dark-eyed Junco		3.5	3.0	7.2	7.8
Tree Sparrow					
White-crowned Sparrow					3.5
Fox Sparrow					v
Lincoln's Sparrow					v
Total Density (territories/10 ha)		26.9	21.3	15.5	22.1
Total Biomass (g/10 ha)		1450	1080	682	1328
Total Existence Energy (k cal/10 ha)		566	432	312	563
Total Species; Breeding Species		21;16	8;7	10;8	17;11
Species Diversity (H')		1.808	1.363	1.489	1.882
Species Evenness (J')		0.652	0.701	0.716	0.785
Dominance (%)		48.3	70.9	69.7	51.1

Appendix Table A-6. (cont'd)

Species	Plot:	SCATTERED WOODLAND AND DWARF FOREST		
		Lowland White Spruce-Birch Woodland	Upland Black Spruce Bog	Lowland Black Spruce Bog
	Location:	N	R	F
	Size (ha):	1.61	1.61	4.25
Mallard				
Pintail				
Green-winged Teal				
Sharp-shinned Hawk				
American Kestrel				
Spruce Grouse				
Ruffed Grouse				
Sandhill Crane				
Common Snipe				1.2
Solitary Sandpiper				v
Lesser Yellowlegs		0.3		2.3
Great Horned Owl				
Hawk Owl				
Common Flicker		+		
Hairy Woodpecker				
Northern Three-toed Woodpecker				
Alder Flycatcher			v	
Hammond's Flycatcher				
Olive-sided Flycatcher			0.3	
Violet-green/Tree Swallow				
Bank Swallow				
Cliff Swallow				
Gray Jay		v	0.3	+
Black-capped Chickadee				
Boreal Chickadee				
Brown Creeper				
American Robin		3.4	1.7	0.2
Varied Thrush			v	
Hermit Thrush				
Swainson's Thrush		v	5.0	
Gray-cheeked Thrush		3.4		2.3
Ruby-crowned Kinglet		3.4	3.3	
Bohemian Waxwing		v		+
Orange-crowned Warbler		3.4	1.7	
Yellow Warbler		1.7		
Yellow-rumped Warbler				0.5
Townsend's Warbler				
Blackpoll Warbler				
Northern Waterthrush				
Wilson's Warbler				
Rusty Blackbird		3.4		
Pine Grosbeak				
Common Redpoll				+
Pine Siskin				
White-winged Crossbill				
Savannah Sparrow				v
Dark-eyed Junco		3.4	6.6	8.2
Tree Sparrow			v	
White-crowned Sparrow		8.4	3.3	5.9
Fox Sparrow		3.0		
Lincoln's Sparrow		3.4		
Total Density (territories/10 ha)		37.3	22.2	20.9
Total Biomass (g/10 ha)		2218	1126	1404
Total Existence Energy (k cal/10 ha)		937	496	581
Total Species; Breeding Species		15;12	11;8	12;10
Species Diversity (H')		2.262	1.773	1.584
Species Evenness (J')		0.916	0.853	0.688
Dominance (%)		31.6	52.3	67.5

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