HABITAT CHARACTERISTICS FOR BIRD SPECIES OF SPECIAL CONCERN AND THEIR IMPORTANCE IN HABITAT RECLAMATION

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PAPER I

HABITAT CHARACTERISTICS OF YELLOW RAIL, UPLAND SANDPIPER, SHARP-TAILED SPARROW, AMERICAN BITTERN, AND SHARP-TAILED GROUSE TERRITORIES

INTRODUCTION

A major reason for the population decline of many species over the past 100 years is the loss or change in habitat characteristics or complexes required by those species. Unfortunately, a thorough understanding of specific habitat requirements for many of these species is still lacking. Often wildlife managers or experienced naturalists recognize specific habitat components or configurations that a species needs within its breeding habitat, but quantification of these requirements, their objective determination, or a process to incorporate this information into a management framework are nearly non-existent.

We studied habitat relationships of five species: the yellow rail (Coturnicops noveboracensis), sharp-tailed sparrow (Ammodramus caudacutus), upland sandpiper (Bartramia longicauda), American bittern (Botaurus lentiginosus), and sharp-tailed grouse (Tympanuchus phasianellus). Each of these species, except the sharp-tailed grouse, have status of special concern in Minnesota (Minnesota Department of Natural Resources 1983). This study is the second year of an investigation initiated in 1983 that assessed habitat characteristics of the yellow rail, sharp-tailed sparrow, and upland sandpiper (Niemi and Hanowski 1983). Our objectives for this study were to: (1) locate new territories for the yellow rail, sharp-tailed sparrow, and upland sandpiper; (2) locate territories for the American bittern and sharp-tailed grouse; (3) sample habitat characteristics within each of those territories located; (4) analyze these habitat data to identify similar and different characteristics in the territories of these species; and (5) identify differences and similarities in territories of the yellow rail, sharp-tailed sparrow and upland sandpiper sampled in 1983 and 1984.

STUDY AREAS

Territories for the five species were located primarily in northwestern Minnesota and in Aitkin County (Figure 1, Table 1). Because we studied territories of the yellow rail, upland sandpiper, and sharp-tailed sparrow in 1983, different territories were measured in 1984 for these species.

METHODS

We visited potential nesting areas for each species in early June. We wanted to locate at least four areas per species where singing males were observed for the yellow rail, upland sandpiper, sharp-tailed sparrow, and American bittern and two territories for the sharp-tailed grouse.

Because these species are of special concern in Minnesota, we chose to collect vegetation data during the post-breeding season. We felt that the benefits of sampling during the nesting season did not warrant potentially jeopardizing nesting success. We measured vegetation with the same methods used in 1983 (Niemi and Hanowski 1983) (Appendix 1). Briefly, the following characteristics were measured: (1) percent ground cover including any vegetation < 10 cm; (2) density and vertical distribution of graminoids (grasses and sedges) > 10 cm high; (3) density, vertical distribution, and species composition of forbs (plants > 10 cm); (4) water depth; and (5) density, vertical distribution, and species composition of phanerophytes [shrubs, forbs, or graminoids that are > 30 cm high and are present

Figure 1. Location of yellow rail (1983 ● and 1984 ○), sharp-tailed sparrow (1983 ■ and 1984 □), upland sandpiper (1983 ★ and 1984 ☆), American bittern (✱), and sharp-tailed grouse (✪) territories.

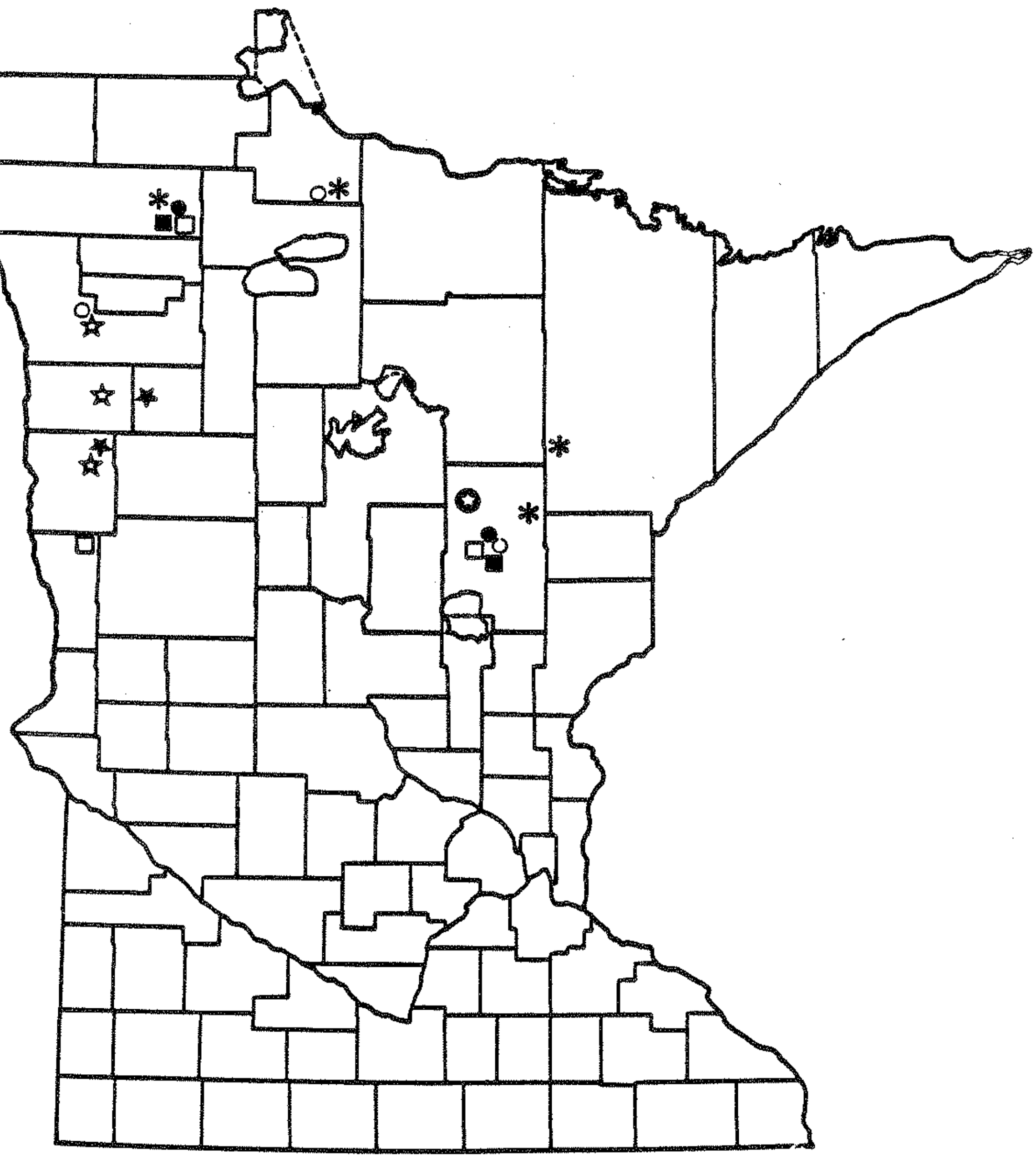


Table 1. Location of each species territories in 1983 and 1984.

Species	Year	Location
Yellow Rail	1983	Aitkin Co. NW 1/4 Sec 32 T~~1~~48N R23W
	1983	Aitkin Co. NW 1/4 Sec 5 T~~1~~47N R23W
	1983	Marshall Co. SW 1/4 Sec 21 T156N R14W R41W
	1983	Marshall Co. SE 1/4 Sec 20 T156N R41W
	1984	Aitkin Co. NE 1/4 Sec 6 T~~1~~47N R41W R23W
	1984	Lake of the Woods Co. NW 1/4 Sec 23 T157N R31W
	1984	Polk Co. SE 1/4 Sec 17 T149N R45W
	1984	Polk Co. NE 1/4 Sec 20 T149N R45W
Upland Sandpiper	1983	Clay Co. NE 1/4 Sec 5 T141N R45W
	1983	Clay Co. SE 1/4 Sec 5 T141N R45W
	1983	Clay Co. SE 1/4 Sec 5 T141N R45W
	1983	Mahnomen Co. SE 1/4 Sec 6 T145N R41W
	1984	Wilkin Co. SW 1/4 Sec 9 T134N R45W
	1984	Polk Co. NW 1/4 Sec 28 T149N R45W
	1984	Norman Co. NE 1/4 Sec 23 T143N R45W
	1984	Norman Co. SE 1/4 Sec 23 T143N R45W
Sharp-tailed Sparrow	1983	Aitkin Co. NW 1/4 Sec 32 T~~1~~48N R23W
	1983	Aitkin Co. SW 1/4 Sec 32 T148N R23W
	1983	Marshall Co. SE 1/4 Sec 20 T156N R41W
	1983	Marshall Co. SW 1/4 Sec 20 T156N R41W
	1984	Aitkin Co. NW 1/4 Sec 32 T47N R23W
	1984	Marshall Co. SW 1/4 Sec 20 T156N R42W
	1984	Marshall Co. SW 1/4 Sec 20 T156N R42W
	1984	Wilkin Co. SW 1/4 Sec 9 T134N R45W
American Bittern	1984	St Louis Co. N 1/4 Sec 7 T52N R21W
	1984	Marshall Co. SW 1/4 Sec 20 T156N R42W
	1984	Aitkin Co. NE 1/4 Sec 14 T48N R22W
	1984	Lake of the Woods Co. SW 1/4 Sec 23 T157N R31W
Sharp-tailed Grouse	1984	Aitkin Co. NE 1/4 Sec 14 T50N R26W
	1984	Aitkin Co. NW 1/4 Sec 13 T50N R26W

annually (Mueller-Dombois and Ellenberg 1974)]. Ten point samples were located and measured every 10 m along a randomly selected 100 m transect within the territories of each species.

We also continued our experimentation with a visual approach to habitat assessment at each territory (e.g., see Haila et al. 1980). The following habitat characteristics were estimated: (1) overall height of the vegetation (m); (2) distance of the initial observation of the individual to the nearest edge of the habitat (m); (3) size of the habitat (ha); (4) mean water depth (cm); (5) graminoid (a) density, a relative number from 0-10 with 10 being most dense, (b) height (cm), and (c) dominance (%), and (d) dispersion, a relative number (0-10) with 0 being a uniform distribution and 10 representing one clump.

For both data sets we examined the mean, median, range, minimum, maximum, skewness, kurtosis (e.g., the relative peakedness or flatness of the curve defined by the distribution of each variable), and the coefficient of variation for each habitat variable. We used principal component analysis (PCA) to explore the covariation of the habitat data for both sampling methods. We were interested in how the vegetation data could be reduced to fewer descriptive variables with minimal loss in describing bird-habitat associations. For the yellow rail, sharp-tailed sparrow, and upland sandpiper we calculated separate principal component analyses for 1983 and 1984, and also for the pooled 1983 and 1984 data. All PCA analyses were calculated with the Statistical Package for the Social Sciences (SPSS) subprogram FACTOR with the PA 1 method and no rotation (Nie et al. 1975). We used stepwise discriminant function analysis (DFA) to identify differences in habitat characteristics between species. All DFA calculations were performed using SPSS subprogram DISCRIMINANT and Wilk's lambda as the discriminant criterion (Nie et al. 1975).

RESULTS

Five days were spent searching potential habitats in Aitkin, Itasca, Cass, and Crow Wing Counties for the target species. An additional five days were needed to visit sites in northwestern Minnesota, including the Agassiz National Wildlife Refuge and several Nature Conservancy and Department of Natural Resources land preserves. We successfully located four different territories in 1984 from those found in 1983 for the yellow rail, sharp-tailed sparrow, and upland sandpiper (Figure 1). The four territories of the American bittern were each located in different counties and the two sharp-tailed grouse territories were both located in Aitkin County.

Species habitat characteristics. The first two principal components accounted for 52% of the variation in the PCA for data that included all 5 species for the pooled data of 1983 and 1984 (n=301). PC 1 was related (left to right in Figure 2) with increasing vegetation height, a higher density of phanerophytes, more standing water, and with decreasing ground cover (Table 3). We interpret this axis as being a gradient that proceeds from dry prairie to hydric shrub swamp. PC 2 accounted for 16% of the variation in the data and was positively related with a higher density of graminoids, forbs, and phanerophytes. We interpret this axis as reflecting increasing overall vegetation biomass. The American bittern, yellow rail, and sharp-tailed

Figure 2. Distribution of five bird species (YRAIL = yellow rail, USAND = upland sandpiper, SHTSP = sharp-tailed sparrow, ABIT = American bittern, and GROUSE = sharp-tailed grouse) with the first two principal components for the detailed (A) and visual data (B).

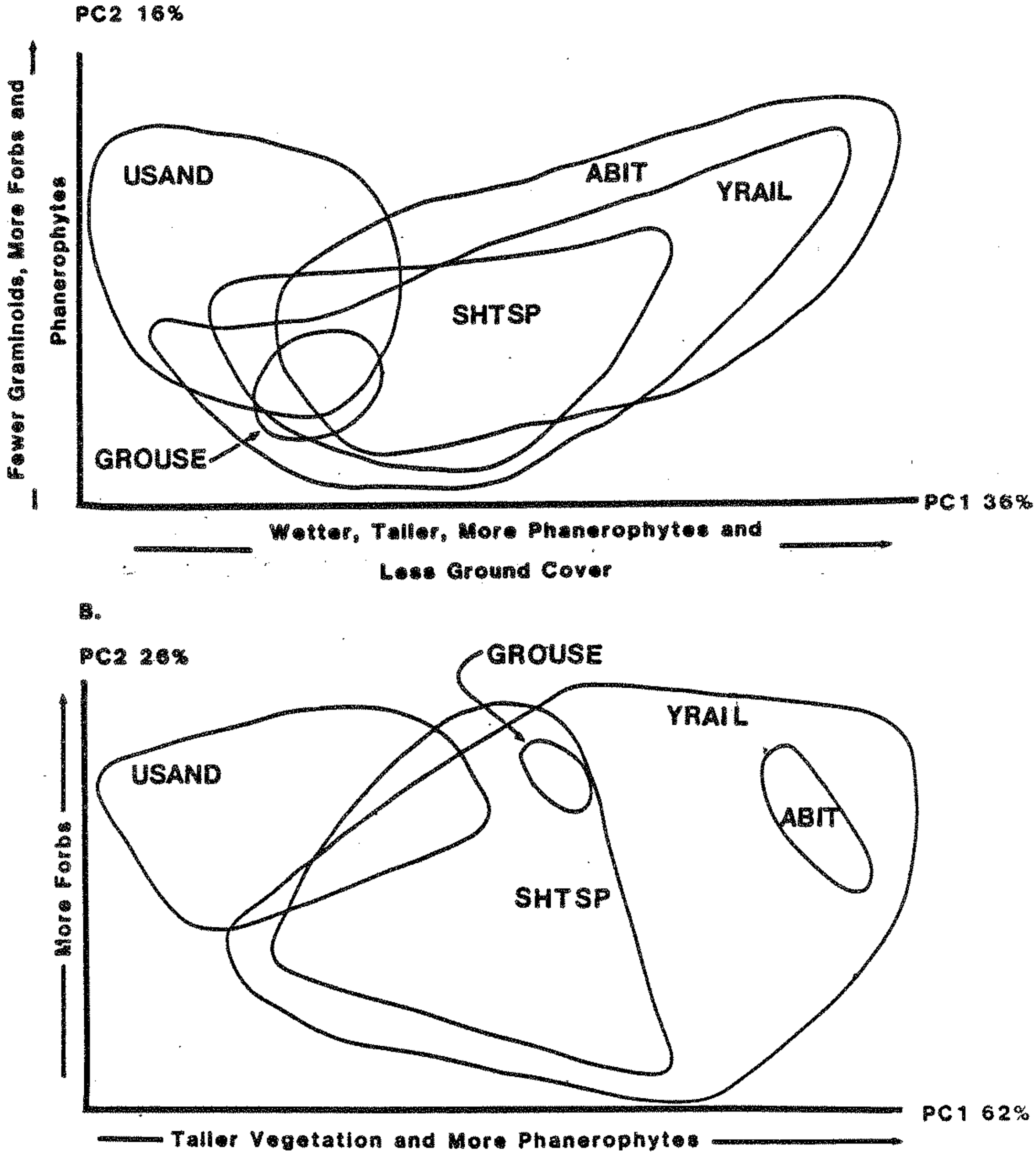


Table 2. Sample size and mean (or median) for habitat variables of the five bird species for 1983, 1984 and the two combined.

	Yellow Rail			Sharp-tailed Sparrow			Upland Sandpiper			American Bittern	Sharp-tailed Grouse
Habitat Variable	1983	1984	83&84	1983	1984	83&84	1983	1984	83&84	1984	1984
N	41	40	81	40	40	80	40	40	80	40	20
Overall Height (m)	1.3	0.8	1.1	1.2	0.8	1.0	0.8	0.6	0.7	1.5	0.7
Vegetation Height (cm)	130.0	95.4	112.7	111.3	105.8	108.6	79.3	74.4	76.9	146.2	86.1
Ground Cover (%)	15.7	26.5	21.0	13.8	7.8	10.8	34.9	32.6	33.7	7.3	52.5
Water Depth (cm)	7.6	4.0	5.8	7.7	0.5	3.9	0	0	0	8.3	0.2
Phanerophyte Height (cm)	95.7	32.2	64.3	44.6	41.7	43.1	24.2	0.4	3.0	98.8	50.2
Graminoid Hits 0-30 cm	16.8	29.6	23.1	18.6	13.5	16.0	27.2	33.8	30.5	12.3	27.2
Graminoid Hits 31-60 cm	14.2	24.6	19.3	15.9	16.3	16.1	6.3	7.7	7.0	9.2	18.7
Graminoid Hits 61-100 cm	10.6	1.6	6.2	8.9	7.5	8.3	0	0	0	3.8	2.0
Forb Hits 0-30 cm	0.5	0.7	0.6	0.4	1.4	0.9	6.1	2.0	4.0	1.0	0.5
Forb Hits 31-60 cm	0.1	0	0	0.2	0.1	0.1	3.2	0.5	1.8	0.2	0.1
Forb Hits 61-100 cm	0.5	0	0	0	0	0	0.4	0	0	0.1	0.3
Phanerophyte Hits 0-30 cm	0.5	0.1	0.3	0	0.5	0.2	0.1	0	0	1.1	0
Phanerophyte Hits 31-60 cm	1.0	0	0.5	0	0.2	0.1	0	0	0	1.8	0
Phanerophyte Hits 61-100 cm	1.7	0	0.8	0	0	0	0	0	0	2.4	0
Graminoid Density* (m^2)	220.1	450.1	330.1	148.2	219.6	190.6	1321.4	946.7	1110.2	111.1	453.0
Forb Density* (m^2)	8.3	9.8	9.2	0.1	51.1	16.7	157.1	38.0	69.5	3.6	16.6
Phanerophyte Density* (5 m^2)	29.5	0.1	1.9	0.1	0.1	0.1	0.1	0	0	167.0	0

*Medians

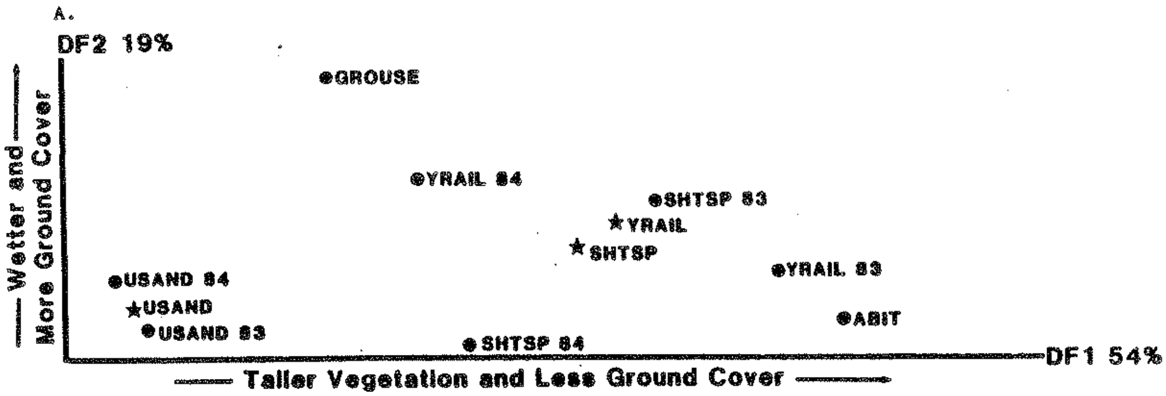
Table 3. Correlation coefficients of the habitat variables with the first three principal components derived from the pooled habitat data for all five species.

Habitat Variables		Principal Components 1	2	3
Overall Height		.789	-.012	.359
Vegetation Height		.552	-.156	.511
Ground Cover		-.639	.093	.042
Water Depth		.721	-.177	-.099
Graminoid Hits	(0-30 cm)	-.623	-.334	-.244
	(31-60 cm)	-.021	-.762	.126
	(61-100 cm)	.415	-.493	.547
Graminoid Density		-.687	.007	-.011
Forb Hits	(0-30 cm)	-.497	.564	.388
	(31-60 cm)	-.327	.539	.422
Forb Density		-.541	.528	.288
Phanerophyte Hits	(0-30 cm)	.513	.374	-.249
	(31-60 cm)	.649	.447	-.221
	(61-100 cm)	.648	.394	-.040
Phanerophyte Height		.678	-.019	.041
Phanerophyte Density		.782	.367	-.120
Explained Variation %		35.7	15.7	8.2
Cumulative Variation %			51.4	59.7

sparrow occurred in wet areas with tall vegetation. The upland sandpiper occurred in dry sites with relatively high ground cover. Sharp-tailed grouse territories were located in drier sites with relatively high densities of graminoids, but relatively few forbs and phanerophytes (Table 2 and 3, Figure 2). In general, habitats of the sharp-tailed sparrow, yellow rail, and American bittern overlapped considerably according to the first two principal components (Figure 2).

Discriminant function 1 (DF1) for the analysis of habitat differences between all the species was related with vegetation height and ground cover (Figure 3). The American bittern was found in areas of relatively tall vegetation (mean = 1.5 m), the yellow rail and sharp-tailed sparrow in areas with similar vegetation height (mean = 1.1 m and 1.0 m respectively), and the sharp-tailed grouse and upland sandpiper in short vegetation (mean = 0.7 m for each species). DF 2 primarily separated the sharp-tailed grouse habitats from the upland sandpiper. The main discriminating variables were ground cover and water depth. The sharp-tailed grouse occurred in wet areas with a high percentage of ground cover (Figure 3). Pair-wise DFA's showed that habitats where each species was located were significantly different ($P < 0.001$) from one another (Table 4, Figure 3). In the DFA for all five species, we calculated that 77% of all sample points (232 of 301) were correctly classified as belonging to that species habitat (Table 6). More than 80% of the habitat points were correctly classified for all species, except the yellow rail in which 54% were correctly classified. Nineteen percent of yellow rail sample points, were classified as

Figure 3. Relationships of habitat structure between five bird species and between 1983 and 1984 (YRAIL) = yellow rail, USAND = upland sandpiper, SHTSP = sharp-tailed sparrow, ABIT = American bittern, and GROUSE = sharp-tailed grouse) according to the first two discriminant functions of vegetation variables for the detailed vegetation data (A) and visual data (B).



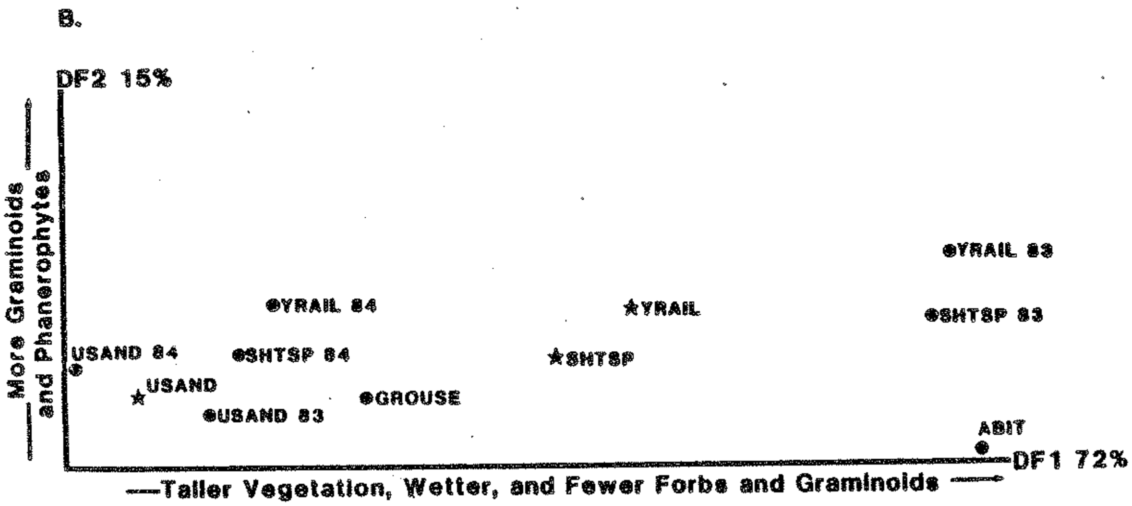


Table 4. Standardized canonical discriminant function coefficients from the discriminant analysis (DFA) of all 5 species and pair-wise comparisons for 3 species. Only those variables with coefficients > 0.2 were included for the respective discriminant function.

Habitat Variable		All Species DF1	All Species DF2	Yellow Rail vs. Sharp-tailed Sparrow DF1	Yellow Rail vs. Upland Sandpiper DF1	Sharp-tailed Sparrow vs. Upland Sandpiper DF1
Overall height		.679	-.208	-.327	-	.474
Vegetation height		-.125	.091	.358	.237	-.188
Ground cover		-.277	.777	.763	-	-.579
Water depth		-.073	.941	.658	.414	.241
Graminoid hits	(1-30 cm)	-.018	-.006	.187	-	-
	(31-60 cm)	.288	.394	.194	.544	.302
	(61-100 cm)	.265	-.148	-.382	.333	.597
Graminoid density		-.099	-.144	.386	-	-.123
Forb hits	(0-30 cm)	.049	-.315	-.159	-	-.135
	(31-60 cm)	-.181	-.116	-	-.204	-.329
Forb density		-.131	-.055	-	-.241	.619
Phanerophyte Hits	(0-30 cm)	-.162	.129	-	-.249	-
	(31-60 cm)	.151	-.196	-	-	-
Phanerophyte height		.339	.057	.154	.319	.459
Phanerophyte density		.231	-.301	.583	.206	-
Chi-square of Wilks lamda		1213*	736*	100*	219*	242*
Variation explained		54	19	100	100	100

*P < 0.001

belonging to the American bittern, 16% to the sharp-tailed sparrow, and 7% and 4% to the sharp-tailed grouse and upland sandpiper respectively (Table 6).

Yearly Habitat Variation. Discriminant function analysis between the 1983 and 1984 habitat data for the yellow rail, sharp-tailed sparrow, and upland sandpiper territories indicated that the habitat where each species was found were different between years ($P < 0.001$) (Table 5). The main discriminating variables in each case were the overall height of the vegetation and water depth (Figure 3 and 4, Table 2).

Mints (Labiaceae Family), goldenrod (Solidago spp.), and bedstraw (Galium spp.) were the most common forbs in all species habitats in 1983 and 1984. Three species' habitats, the yellow rail, sharp-tailed sparrow, and American bittern, included forb species that are commonly found in hydric habitats (e.g., Sparganium spp., Sagittaria spp.). In contrast, forb species in upland sandpiper habitats were those commonly found on dry prairie sites (e.g., Chanelirium luteum and Zizea aurea) (Table 7).

Willows (Salix spp.) and cattail (Typha latifollia) were the most common phanerophytes im the hydric habitats occupied by the yellow rail, sharp-tailed sparrow, and American bittern (Table 7). Willows were also common in the sharp-tailed grouse territories, along with bog birch (Betula pumila) and meadow-sweet (Spirea alba). Few phanerophytes (0.1 - 0/5m^2) were found in the upland sandpiper habitats.

Visual Method. Although the sample size was small with our visual method, the comparative results of the PCA indicated that

Table 5. Standardized canonical discriminant function coefficients from the discriminant analysis (DFA) of pair-wise comparisons for each of three species between 1983 and 1984. Only those variables with coefficients > 0.2 were included for the respective discriminant function.

	Yellow Rail	Sharp-tailed Sparrow	Upland Sandpiper
Habitat Variable	DF1	DF1	DF1
Overall height	1.05	.969	1.05
Vegetation height	-.451	-	-.494
Ground cover	-	.531	-.259
Water depth	-.606	.842	-
Graminoid hits (1-30 cm)	.307	-	-
Graminoid hits (31-60 cm)	-.433	.294	-
Graminoid hits (61-100 cm)	.474	-.622	-
Graminoid density	-.364	-.231	.383
Forb hits (0-30 cm)	-	-.228	.289
Forb hits (31-60 cm)	-	.395	
Forb density	-.397	-	.488
Phanerophyte hits (0-30 cm)	-	-	-
Phanerophyte hits (31-60 cm)	.519	-	-
Phanerophyte height	.496	.276	.436
Phanerophyte density	-	-.469	-
Chi-square Wilks lamda	103*	137*	87*
Variation explained	100	100	100

P < 0.001

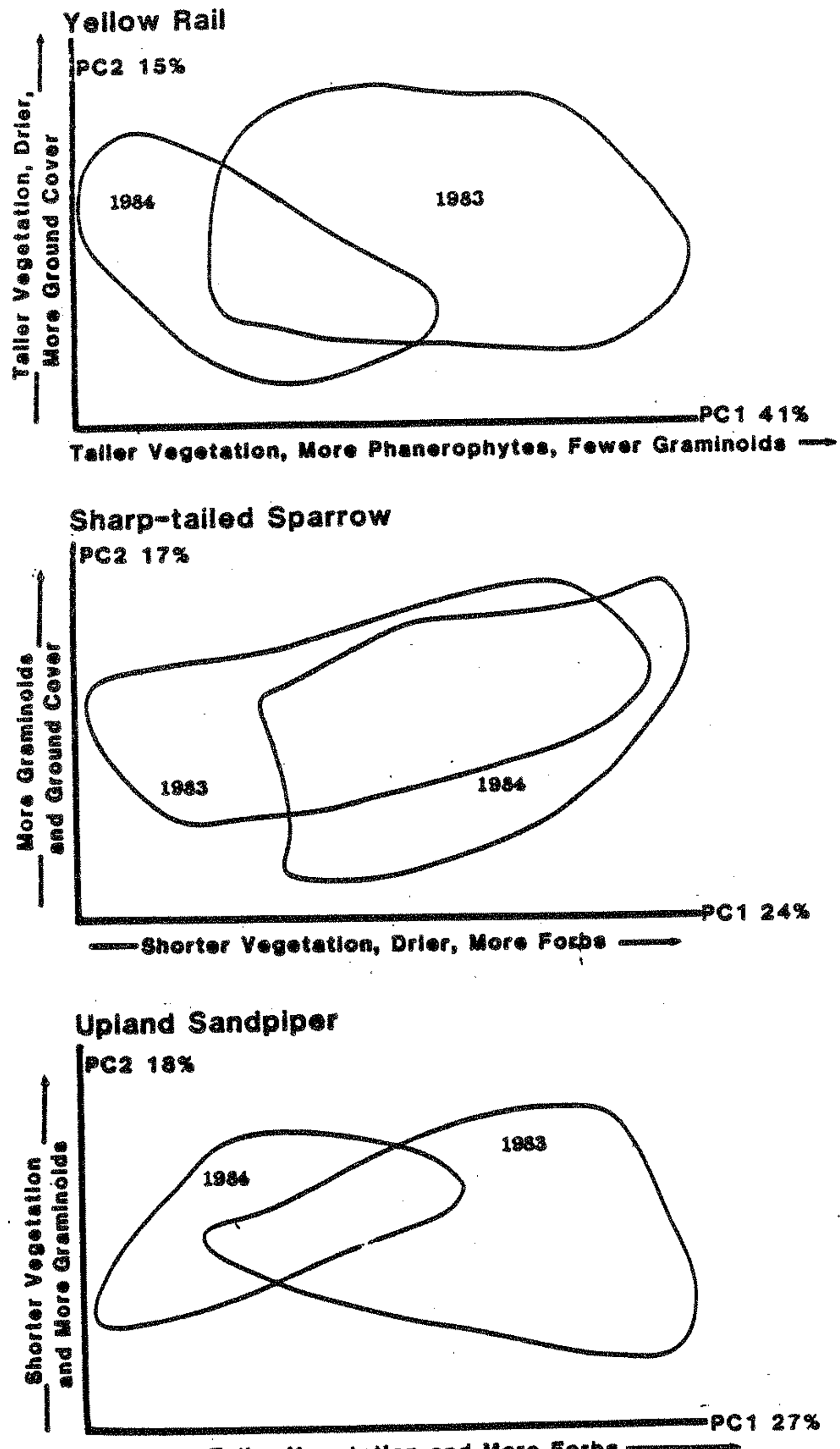
Table 6. Predicted group (percent) for each species habitat data using the discriminant function analysis. On average, 77% of all groups were correctly classified.

Actual Group	N	Yellow Rail	Sharp-tailed Sparrow	Upland Sandpiper	American Bittern	Sharp-tailed Grouse
Yellow Rail	81	54	16	4	19	7
Sharp-tailed Sparrow	80	8	81	2.5	6	2.5
Upland Sandpiper	80	3	6	86	0	5
American Bittern	40	5	8	0	87	0
Sharp-tailed Grouse	20	0	0	5	0	95

Table 7. Percent of forbs (A) and phanerophytes (B) within the territorial habitats of 5 species. Only those species with values > 3% were included.

	Yellow Rail			Sharp-tailed Sparrow			Upland Sandpiper			American Bittern	Sharp-tailed Grouse
	1983	1984	83&84	1983	1984	83&84	1983	1984	83&84	1984	1984
A. Forb Species											
Sparganium spp.	-	-	-	-	10	-	5	-	-	4	-
Sagittaria spp.	11	-	5	-	-	-	-	-	-	-	-
Calla palustris	12	-	6	-	-	-	-	-	-	-	-
Chanelirium luteum	-	-	-	-	-	-	-	4	2	-	-
Iris versicolor	-	5	3	1	-	-	-	-	-	2	2
Caltha palustris	2	-	1	-	-	-	-	-	-	3	-
Chamaedaphne calyculuta	-	-	-	-	-	-	-	-	-	9	-
Thalictrum spp.	-	-	-	-	-	-	1	24	12	-	-
Rosaceae Family	-	-	-	-	-	-	-	6	3	-	-
Rubus spp.	-	-	-	-	2	1	-	-	-	7	-
Potentilla palustris	-	3	1	1	-	-	-	-	-	1	-
Impatiens spp.	-	-	-	-	-	-	-	-		6	-
Apocynum spp.	-	15	7	-	1	1	-	7	3	-	-
Leguminoseae Family	-	-	-	-	-	-	4	-	2	-	-
Trifolium spp.	-	-	-	1	-	1	22	-	11	-	-
Violaceae Family	-	-	-	-	-	-	-	1	1	-	14
Umbelliferae Family	19	-	9	5	-	-	1	16	8	-	-
Zizea aurea	-	1	1	-	-	-	1	16	8	-	-
Lysmachia thyrsiflora	11	19	15	-	-	-	-	-	-	-	-
Labiaceae Family	35	28	32	76	55	66	1	22	11	42	56
Galium spp.	6	6	6	1	4	3	28	11	19	2	4
Composite Family	-	-	-	-	-	-	6	-	3	-	-
Petasites spp.	-	3	2	-	-	-	-	-	-	12	-
Solidago spp.	4	12	8	-	14	7	31	6	19	5	18
Cirsium spp.	-	3	1	5	7	6	1	2	1	-	-
Fern	-	4	2	-	17	8	-	-	-	7	6
B. Phanerophyte species	1983	1984	83&84	1983	1984	83&84	1983	1984	83&84	1984	1984
Spirea spp.	-	2	1	-	3	1	-	-	-	1	22
Umbelliferae spp.	-	5	2	-	17	9	-	-	-	-	-
Typha latifolia	74	19	47	-	26	13	-	-	-	38	-
Phragmites communis	-	-	-	6	8	7	-	-	-	6	-
Salix spp.	26	74	50	79	46	63	100	-	50	34	59
Alnus spp.	-	-	-	-	-	-	-	-	-	8	-
Betula pumila	-	-	-	-	-	-	-	-	-	13	17
Populus tremuloides	-	-	-	15	-	7	-	-	-	-	2
Cornus spp.	-	-	-	-	-	-	-	100	50	-	-

Figure 4. Distribution of three bird species in 1983 and 1984 with the first two principal components.



the variation in species habitats could be explained with essentially the same variables as in the PCA of the detailed data set (Figure 2). The species were distributed along PC1 in the same relative position with both data sets. Similarly, the DFA of the visual data gave results that agree with the more detailed method (Figure 3).

DISCUSSION

Among the ultimate goals of management for wildlife species of special concern is to (1) predict whether an area is suitable habitat for a species, or (2) identify what habitat characteristics are lacking in an area that would otherwise be a satisfactory breeding habitat for a species. Here we pursued these goals by using two multivariate statistical techniques that address distinct aspects of these problems. Principal component analysis illustrates how the habitat characteristics are interrelated (e.g., if shrub density increases then how does the density of graminoids or forbs vary with shrub density?) and how the habitat data may be simplified by reducing it to a smaller number of independent factors. In contrast, discriminant function analysis identifies what habitat characteristics in the territories of the five species are different from one another. More importantly, DFA allows the classification of a vegetation sample in terms of the probability that it belongs to the habitat for one of the species. For example, we can consider this to represent the equivalent of what is the probability that a given area is suitable habitat for a species. These two statistical methods are powerful techniques for objectively determining the habitat requirements for these species.

The results of the habitat analyses indicated that the three species that occurred in wetland habitats (yellow rail, sharp-tailed sparrow, and American bittern) had habitat characteristics that overlapped with each other in the habitat space represented by the principal components. The habitats of these three species were very different from the upland sandpiper and sharp-tailed grouse because they occurred in more xeric habitats. This may indicate that the three former species could co-occur in similar habitat types and we have observed this in the field. However, the DFA indicated that all three species' habitats were different from each other. This suggests that each species occurs in habitats with similar vegetation structure but each species may be responding independently to specific microhabitat characteristics within these habitats. For example, the data indicated that the sharp-tailed sparrow preferred wetland areas that had moderate graminoid densities, low phanerophyte densities, and high forb densities compared with the other two species. Furthermore, the microhabitats associated with the sharp-tailed sparrow were relatively distinct in comparison with those habitats for the other species. For example, 81% of the habitat sample points for the sharp-tailed sparrow were correctly classified, but only 54% of yellow rail habitat samples were classified correctly. The American bittern, like the sharp-tailed sparrow, was easier to classify with 87% of the habitat samples correctly classified. This species occupies wetland areas with tall vegetation (e.g., alder and willow shrubs), deep water (8.3 cm standing water), and a high density of phanerophytes such as willows in comparison with the yellow rail and sharp-tailed sparrow.

The upland sandpiper occupied distinctly different habitats than the other four species and it is unlikely that this species could co-occur with any of the other species. The sharp-tailed grouse also appeared to be specific in its habitat requirements, but the sample size was relatively small for this species and all samples were collected within a relatively small (250 ha) geographic area. Based on our experience (Niemi and Hanowski 1984) in the Red Lake Peatland, we believe that the sharp-tailed grouse occurs in a wider range of habitats than indicated here. A larger sample size is necessary to more clearly identify the suitable range of habitats it occupies.

The preliminary results of our habitat analysis to predict the probability of finding a species in an area are encouraging, but we feel that more data is required to develop a bonafide prediction model. For example, the habitat data collected in 1983 were different in 1984 for all three species (yellow rail, upland sandpiper, sharp-tailed sparrow) considered in 1983. We do not suggest that a species selects different habitats each year. These differences are probably related to: (1) differential growth of vegetation between years, (2) different phenological times of sampling between years, and (3) inherent differences between the geographic sites sampled in 1983 and 1984. To improve the prediction model, we need to assess yearly variation in vegetation growth to account for differences between years. These data would be useful to identify what habitat characteristics are constant in a species territory from year to year. For example, those habitat characteristics that remain relatively constant from year to year may be more important to a species than those characteristics that fluctuate.

Our experimentation with the visual approach to habitat assessment was encouraging. As in 1983, comparisons with the more detailed method using the same statistical techniques revealed similar interpretations. How sensitive this technique is to subtle habitat differences in habitat characteristics between species and how precise it is to the collection of habitat data by different observers is unknown. However, the method permits the rapid collection of data and allows for the collection of data during the nesting period.

Ultimately the habitat data for these species will be useful in the overall management of the species population and also for planning reclamation of mined peatlands. For example, four of the five species considered here are associated with wetland and/or peatland habitat types and we feel that careful planning of peatland reclamation may enhance the colonization of these sites by those species. In addition, the prediction model to assess the probability that a specific area may be suitable habitat for a particular species may enable wildlife managers to assess potential habitat for a species.

SUMMARY

Sixteen new territories were located for four species of special concern in Minnesota (the yellow rail, sharp-tailed sparrow, upland sandpiper, and American bittern) and two territories of the sharp-tailed grouse. The habitat characteristics of each territory were measured with two methods

and these data were analyzed to identify similar and different characteristics within the territories of each species. We also compared the habitat data collected in 1983 and 1984 for the yellow rail, sharp-tailed sparrow, and upland sandpiper. Results of these analyses indicated that all species selected habitats that were different from each other ($P < 0.05$). Furthermore, the analyses illustrated that territories of the five species were distributed along an environmental gradient from dry prairies to wetland shrub. The upland sandpiper occurred in the driest sites, the yellow rail and sharp-tailed sparrow occurred in the wettest sites with the fewest phanerophytes, and the American bittern was found in the wettest sites with the highest density of phanerophytes.

Results of the analyses of species' territories sampled in 1983 and 1984 indicated that the territories were different for each species (yellow rail, sharp-tailed sparrow, and upland sandpiper). Each species occupied drier sites and areas with shorter vegetation in 1984 than in 1983. We suggest that this is due to annual differences in vegetation growth rather than annual shifts in habitat preferences. Based on these results, we will assess yearly and seasonal variation in vegetation growth in 1985.

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Appendix 1. Description of habitat variables collected within habitats of 3 bird species.

VARIABLE	DESCRIPTION
Overall height	Average height of vegetation in 100 m^2 surrounding point
Vegetation height	Tallest vegetation in m^2 surrounding point
Ground cover	Percent of green vegetation less than 10 cm high in m^2 surrounding point
Water depth	Depth in center of point
Phanerophyte density	Density of phanerophytes > 30cm high and < 2.5 cm dbh measured by point-centered quarter method
Phanerophyte height	Average height of the four phanerophytes measured for variable phanerophyte density
Phanerophyte hits	Number of hits measured in 0-30 cm, 31-60 cm, and 61-100 cm height intervals
Forb density	Density of forbs > 10 cm high measured by point-centered method
Forb hits	Number of hits measured in 0-30 cm, 31-60 cm, and 61-100 cm height intervals
Graminoid density	Density of graminoids > 10 cm high measured by point-centered method
Graminoid hits	Number of hits measured in 0-30 cm, 31-60 cm, and 61-100 cm height intervals

PAPER II.

BIRD SPECIES AND COMMUNITIES IN ALTERED AND NATURAL PEATLANDS OF NORTHERN MINNESOTA

INTRODUCTION

Peat is utilized as an energy source in many parts of the World, but in the United States development has primarily been in the area of horticulture (Moore and Bellamy 1974). However, rising energy costs and the depressed economic status of northern Minnesota have accelerated the efforts to develop millions of acres of peatlands. In contrast with the potential economic benefit of peat, these areas provide habitat for hundreds of wildlife and plant species, as well as being important in hydrological regimes. The ecological impact of peatland alterations are currently unknown, but need to be addressed in order to assess the economic benefits of development with the ecological consequences of alteration. A further item that needs attention is the potential reclamation of mined areas which may include enhancing the recolonization of these sites by specific wildlife species [e.g., species of special concern (Minnesota DNR 1983)].

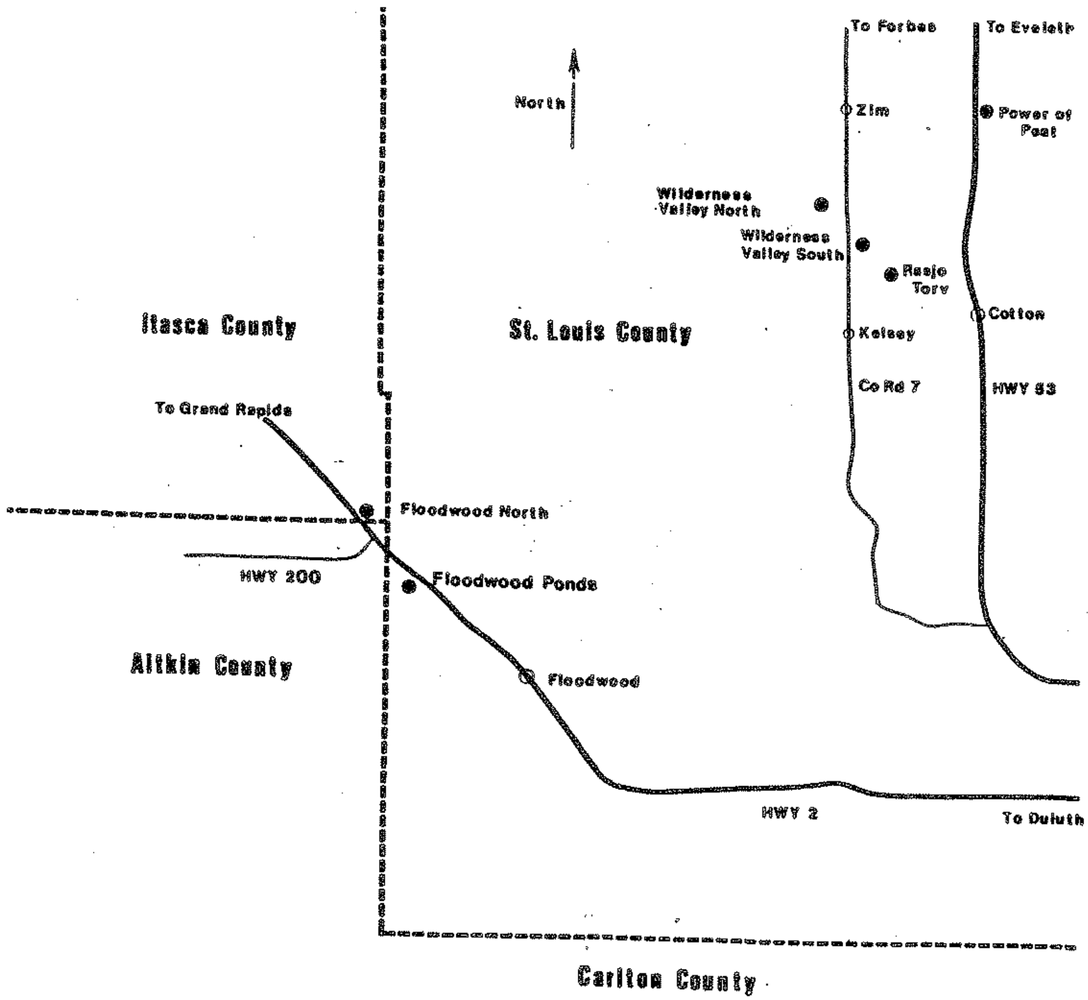
In the process of recommending specific reclamation procedures for a wildlife species, it is important to fully understand the habitat characteristics required by these species for survival. We have initiated an ecological monitoring program to describe the habitat needs of special concern species in Minnesota (see Part I of this report) that are associated with peatland habitats. This information, with data gathered on bird and habitat associations of altered peatlands, will allow us to recommend suitable reclamation for mined peatlands. The specific objectives of this portion of the study were to: (1) determine present avian species composition and relative abundance at previously altered peatland sites in northern Minnesota; (2) identify general habitat affinities for avian species that occur on these sites; (3) compare avian species composition and relative abundance of these sites with unaltered peatland sites in Minnesota; and (4) incorporate habitat data of bird species of special concern in Minnesota to aid in the development of reclamation plans for peatlands.

STUDY AREAS

Following a field reconaissance with DNR personnel in May 1984, six areas were chosen for study (Figure 1): Rasjo Torv, Power-O-Peat, Floodwood North, Floodwood Ponds, Wilderness Valley North, and Wilderness Valley South. Specific placement of transects at each study site was determined after aerial reconaissance and transects were placed to traverse both altered and natural peatland habitats.

The Rasjo Torv site is located about 10 km northwest of Cotton (Figure 1) and was used to monitor the impact of an ongoing 160 acre peat mining operation on the surrounding bird communities. We established four - 1 km transects in a square around the mining site and 150 m in from the edge of the cleared area (Appendix 1a). The south transect passed through a high shrub habitat of alder (Alnus spp.) and willow (Salix spp.). The west transect traversed an open tamarack (Larix laricina) area with scattered black spruce (Picea mariana) that changed gradually into a dense, closed tamarack and spruce forest to the north. The north transect differed from the west in that the trees were taller (mean about 15 m), denser, and the predominant

Figure 1. Location of study areas in northern Minnesota.



species was black spruce. The tree height, density, and species composition changed to a shorter, more open, predominantly tamarack area from west to east as one approached the north-south ditch. The ditch bordered the east edge of the cleared area. The east transect ran through a moderate to dense stand of tamarack and black spruce. This peatland is predominantly composed of reed-sedge peat with a thin surface layer of sphagnum moss (Minnesota DNR 1985).

The Power-O-Peat site is located about 15 km north of Cotton along U.S. Highway 53 (Figure 1). The mining site, initially developed in 1953 is a privately owned 500 acre area but also includes 9100 acres of adjacent state land. This area is presently being mined and disturbance is high. One - 1.5 km transect was run in the post mined area (Appendix 1b). This site represents conditions that would be most likely to occur following the nearly complete removal of commercial peat from a peatland. The removal of peat down to one meter above mineral soil results in a substrate with highly decomposed peat that is also high in nutrients and is close to the prevailing water table. Presumably, the resulting shallow pools and "mud flats" provide favorable conditions for revegetation (Minnesota DNR 1985). Water was drained from the mined area by a north ditch and it was evident that the water level changed considerably with the season and with precipitation.

The Floodwood Ponds site is about 8 km northwest of Floodwood along U.S. Highway 2 (Figure 1). Mining operations, initiated in the early 1950's, have produced small open water pools and one small cattail (Typha spp.) and willow area. The mining site is surrounded by a closed black spruce forest on three sides. The area to the south has been cleared of vegetation but not mined. This site represents conditions that may result from hydraulic mining of peat (Minnesota DNR 1985). A one km transect that encircled the ponds was run in this area (Appendix 1c).

The Floodwood North site is 16 km northwest of Floodwood along U.S. Highway 2. This area presently is open with a few scattered shrubs (Betula pumila and B. papyrifera) and Ericaceae species. A ditch bordered by alder and willow was cut along the west edge of the site. This site represents conditions that can result following the mining of peat from a raised bog in which sphagnum moss peat is not completely removed. As indicated by this site, this results in surface conditions that are very acidic, nutrient poor and, because of the adjacent ditches, unusually dry. This extremely harsh environment results in the occurrence of sparse vegetation cover even after as much as twenty years (Minnesota DNR 1985). A 0.75 - km transect was used to census this area (Appendix 1d).

The Wilderness Valley North site is located about 11 km south of Forbes (Figure 1). This area was monitored to document bird populations in a relatively undisturbed open sedge site. A 0.5 km transect was run on the west edge of the mined area (Appendix 1e).

The Wilderness Valley South study area is about 2 km north of Sax (Figure 1). Two 1-km transects were run in this area: one through the area south of the east-west ditch and one to the north (Appendix 1f). These sites represent conditions that may exist following the mining of a peatland where a substantial layer of reed-sedge peat remains. The surface conditions are much less acidic and relatively high in nutrients compared to sphagnum moss peat. These sites are presumably relatively easy to revegetate although the resulting vegetation type is dependent on the extent of drainage or depth of the water table (Minnesota DNR 1985). The south transect traversed a xeric area of grass/sedge with north-south ditches colonized by alder and willow. A portion of the transect ran through a short and dense stand of aspen (Populus tremuloides) and bog birch. The north transect traversed a hydric shrub area with scattered tamarack. The ditches in this area ran east to west.

Several remote areas in the Red Lake Peatland and Roseau area were also visited by helicopter on 11-12 June 1984. These areas were mostly open peatland habitats (e.g., fen and open spruce) or circular island habitats. A general reconaissance of each area (1/2 - 1 hour) was conducted and bird species and habitat affinities were noted.

METHODS

The breeding bird populations at each site were censused twice during the breeding season using the line transect method (Emlen 1971, Järvinen and Väisänen 1975). Species composition and relative abundance of breeding birds were assessed and habitat affinity for each species was noted. Densities for each species and for each site were calculated with the formula presented by Järvinen and Väisänen (1977) (Appendix 2). For those species where a correction coefficient could not be calculated, we used a value of k = 1 as suggested by Järvinen and Väisänen (1983). With this information we estimated densities for each species in each habitat where it occurred. We used rarefaction (James and Rathbun 1981) to determine the number of species to be expected if the areas censused were of equal size. This calculation was necessary because we wanted to compare species richness between transects that were of different lengths to control for the "species - area effect" (the function that more species are observed as the area censused increased). The number of species expected/hectare were calculated from original rarefaction curves for the number of species expected/individuals (from the raw data) (Figure 2), and then calculating the number of individuals/hectare (Figure 3).

RESULTS

Northwestern Minnesota peatlands. Three distinct peatland habitat types were visited in northwestern Minnesota: open sedge, open spruce, and closed spruce (including ovoid and circular islands). Nine species were observed in the open sedge habitat, two species in the open spruce habitat, and thirteen species in the closed spruce habitat (Table 1). Three species of special concern (MDNR 1983) were observed in the open sedge habitat including: (1) eight Wilson Phalaropes [six on one site (SE 1/4 Sec 3 TI55N R33W) and two on another (SE 1/4 Sec 35 TI59N R36W)]; (2) a new Minnesota location for the yellow rail (SE 1/4 Sec 35 TI59N R36W), and (3) a possible location of a sandhill crane nest was located on the edge of a spruce ovoid island (SW 1/4 Sec 36 TI56N R36W).

Figure 2. Rarefaction curves for the expected number of species/individuals for disturbed (——) and undisturbed (- - -) peatland habitats.

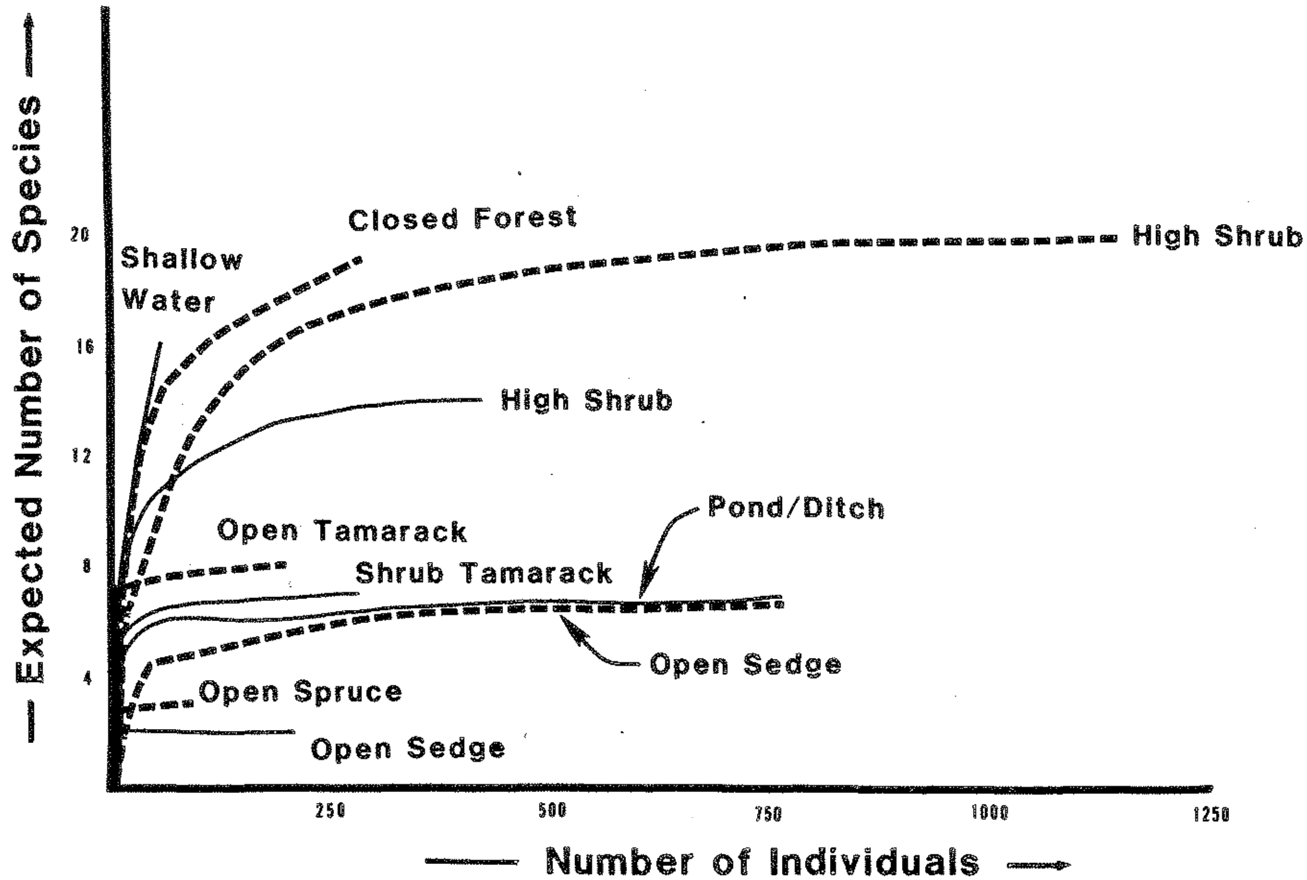


Figure 3. The number of individuals/area for disturbed (——) and undisturbed (- - -) peatland habitats.

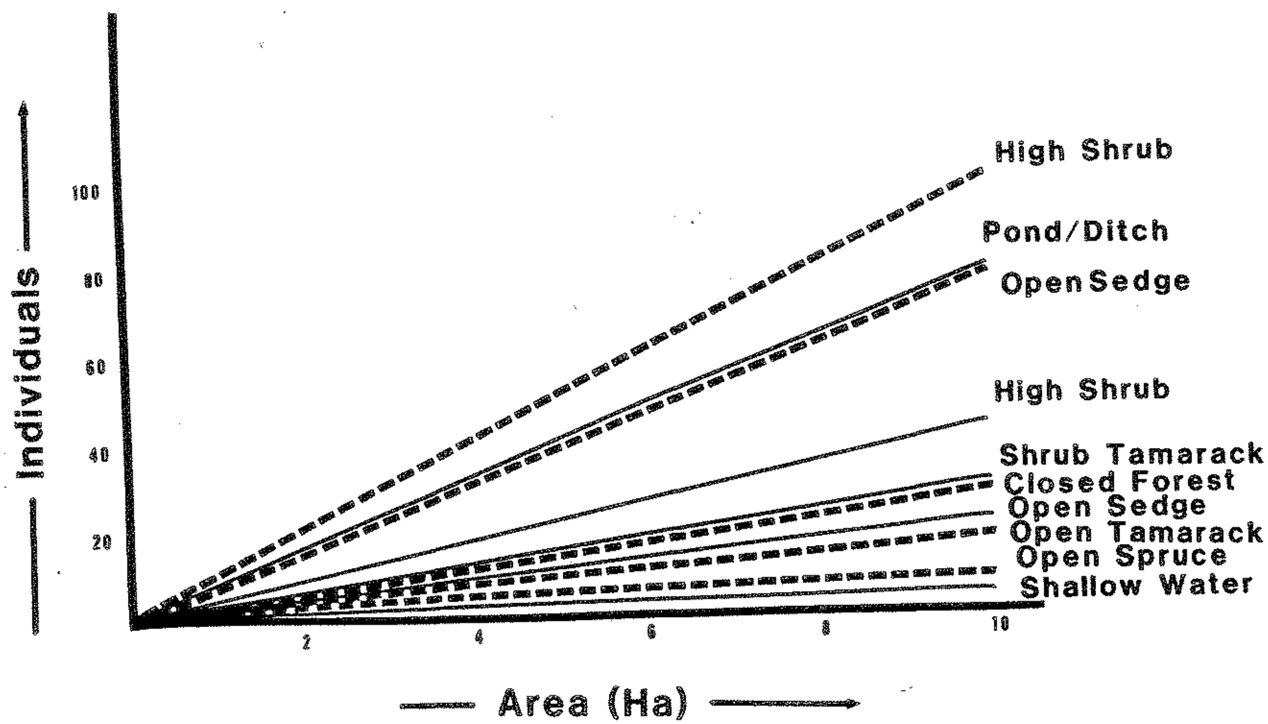


Table 1. Species observed in remote areas of Red Lake Peatland by habitat. Species of special concern in Minnesota are indicated by an *.

Species	Habitat		
	Open Sedge	Open Spruce	Closed Spruce
Northern Harrier	X		
Yellow Rail*	X		
Sora	X		
Common Snipe	X		
Wilson's Phalorope*	X		
Sandhill Crane*	X		
Yellow-bellied Flycatcher			X
Gray Jay			X
Boreal Chickadee			X
Golden-crowned Kinglet			X
Ruby-crowned Kinglet			X
Sedge Wren	X		
Hermit Thrush			X
Nashville Warbler			X
Yellow-rumped Warbler			X
Palm Warbler			X
Connecticut Warbler			X
Chipping Sparrow			X
Savannah Sparrow		X	
Le Conte's Sparrow	X		
Lincoln's Sparrow		X	
White-throated Sparrow			X
Dark-eyed Junco			X
Bobolink	X		
Total Species	9	2	13

Bird density in natural and altered peatlands. Predominant species in the natural open sedge areas were the Savannah sparrow (Ammodramus sandwichensis) and Le Contes sparrow (A. leconteii) and the sedge wren (Cistothorus platensis) (Table 2 and 3). Sparrows were also most prevalent in high shrub areas but here more species were present including the clay-colored sparrow (Spizella pallida), song sparrow (Melospiza melodia), and swamp sparrow (M. georgiana). The sedge wren was also common in this habitat along with the alder flycatcher (Empidonax alnorum) and two warbler species: the yellow warbler (Dendroica petechia) and the common yellowthroat (Geothlypis trichas) (Table 2 and 3). The Nashville warbler (Vermivora ruficapilla), yellow-rumped warbler (Dendroica coronata), palm warbler (D. palmarum), and Connecticut warbler (Oporornis agilis), and the Lincoln's sparrow (Melospiza lincollni) were the most common species in the open spruce and open tamarack habitats. These warbler species were also the most common species in the closed spruce forest. Other species that were also commonly found in the closed spruce habitat included the chickadee (Parus atricapillus), boreal chickadee (P. borealis), blue jay (Cyanocitta cristata), gray jay (Perisoreus canadensis), golden-crowned kinglet (Regulus satrapa), ruby-crowned kinglet (R. calendula) and the chipping sparrow (Spizella passerina).

The species composition of the altered areas were similar to those found in physiognomically-similar natural areas (Table 2). Two mined habitat types, the shallow water and pond/ditch, are not common in natural peatland areas. Species composition of these areas included species typically associated with

Table 2. Mean number of individuals observed per km in two censuses of each study area in June 1984.

Species	Study Area					
	Floodwood N	Floodwood Pond	Wilderness N	Wilderness S	Power of Peat	Rasjo Torv
Great Blue Heron	-	-	-	-	1.0	-
Green-winged Teal	-	-	-	-	1.0	-
Mallard	-	1.0	-	-	1.0	-
Blue-winged Teal	1.3	0.5	-	-	2.7	-
Northern Harrier	-	-	1.0	-	-	0.5
Killdeer	-	-	-	-	3.4	-
Spotted Sandpiper	-	-	-	-	2.7	-
Common Snipe	-	-	-	1.5	0.3	1.0
Black Tern	-	-	-	-	0.7	-
Mourning Dove	-	-	-	-	-	0.5
Eastern Kingbird	-	0.5	-	-	0.7	-
Yellow-bellied Flycatcher	-	-	-	-	-	3.5
Alder Flycatcher	-	-	-	6.5	-	7.0
Least Flycatcher	-	-	-	0.5	-	-
Tree Swallow	-	-	-	-	2.3	1.5
Cliff Swallow	-	-	-	-	3.4	-
Barn Swallow	-	-	-	-	3.4	-
Gray Jay	-	-	-	-	-	1.0
Blue Jay	-	-	-	-	-	0.5
American Crow	-	-	-	-	0.3	0.5
Black-capped Chickadee	-	-	-	-	-	0.5
Boreal Chickadee	-	-	-	-	-	0.5

	Study Area					
Species	Floodwood N	Floodwood Pond	Wilderness N	Wilderness S	Power of Peat	Rasjo Torv
Sedge Wren	-	0.5	20.0	10.5	-	16.0
Golden-crowned Kinglet	-	-	-	-	-	0.5
Ruby-crowned Kinglet	-	-	-	-	-	0.5
Veery	-	-	-	3.0	-	-
Hermit Thrush	-	-	-	-	-	3.0
American Robin	-	-	-	1.0	-	0.5
Gray Catbird	-	-	-	2.5	-	2.0
Solitary Vireo	-	-	-	-	-	0.5
Red-eyed Vireo	-	-	-	0.5	-	-
Nashville Warbler	-	-	-	1.5	-	10.5
Yellow Warbler	-	-	-	2.5	-	6.5
Chestnut-sided Warbler	-	-	-	1.0	-	1.0
Yellow-rumped Warbler	-	-	-	-	-	5.0
Pine Warbler	-	-	-	-	-	0.5
Palm Warbler	-	-	-	-	-	8.0
Connecticut Warbler	-	-	-	-	-	10.2
Common Yellowthroat	0.7	2.0	8.0	15.5	1.7	18.5
Rose-breasted Grosbeak	-	-	-	-	-	0.5
Chipping Sparrow	-	-	-	-	-	3.0
Clay-colored Sparrow	-	-	1.0	6.0	-	6.5
Savannah Sparrow	-	-	6.0	6.5	1.3	2.5
LeConte's Sparrow	-	-	5.0	7.0	-	2.5
Song Sparrow	9.0	2.5	2.0	7.5	3.4	6.0

	Study Area					
Species	Floodwood N	Floodwood Pond	Wilderness N	Wilderness S	Power of Peat	Rasjo Torv
Lincoln's Sparrow	-	-	-	1.0	-	4.5
White-throated Sparrow	-	-	-	-	-	3.0
Swamp Sparrow	-	1.5	-	9.5	0.3	7.0
Dark-eyed Junco	-	-	-	-	-	2.0
Bobolink	-	-	1.0	-	-	-
Red-winged Blackbird	-	6.0	-	0.5	3.3	0.5
Brown-headed Cowbird	1.3	-	-	2.0	1.0	-
American Goldfinch	-	-	-	1.0	0.3	0.5
Total Species	4.0	8.0	8.0	21.0	20.0	37.0
Total Individuals	12.3	14.0	44.0	88.0	34.2	138.7

Table 3. Species densities (pairs/km^2) and habitat affinities for undisturbed and disturbed peatland areas.

Species	Undisturbed					Disturbed					
						Xeric			Hydric		
	Open[1] Sedge	High[2] Shrub	Open[2] Spruce	Open[2] Tamarack	Closed[2] Forest	Open[3]	Open[4] Sedge	High[4] Shrub	Shrub[4] Tamarack	Shallow[5] Water	Pond[6] Ditch
Great Blue Heron	-	-	-	-	-	-	-	-	-	0.7	-
Green-winged Teal	-	-	-	-	-	-	-	-	-	1.5	-
Mallard	-	-	-	-	-	-	-	-	-	0.7	27.5
Blue-winged Teal	-	-	-	-	-	-	-	-	-	1.9	83.2
Northern Harrier	1.6	2.1	-	-	-	-	-	-	-	-	-
Killdeer	-	-	-	-	-	-	-	-	-	2.5	-
Spotted Sandpiper	-	-	-	-	-	-	-	-	-	1.5	-
Common Snipe	-	1.8	-	-	-	-	-	-	81.2	11.0	-
Black Tern	-	-	-	-	-	-	-	-	-	1.0	-
Mourning Dove	-	-	-	1.8	-	-	-	-	-	-	-
Eastern Kingbird	-	-	-	-	-	-	-	-	-	1.0	-
Yellow-bellied Flycatcher	-	-	-	-	14.2	-	-	-	-	-	1.1
Alder Flycatcher	-	114.9	-	-	-	-	-	-	39.3	-	-
Least Flycatcher	-	-	-	-	-	-	-	74.2	-	-	-
Tree Swallow	-	5.9	-	-	-	-	-	-	-	3.6	-
Cliff Swallow	-	-	-	-	-	-	-	-	-	2.4	-
Barn Swallow	-	-	-	-	-	-	-	-	-	2.1	-
Gray Jay	-	-	-	-	30.9	-	-	-	-	-	-
Blue Jay	-	-	-	-	14.1	-	-	-	-	-	-

	Undisturbed					Disturbed					
						Xeric			Hydric		
Species	Open[1] Sedge	High[2] Shrub	Open[2] Spruce	Open[2] Tamarack	Closed[2] Forest	Open[3]	Open[4] Sedge	High[4] Shrub	Shrub[4] Tamarack	Shallow[5] Water	Pond[6] Ditch
American Crow	-	-	-	-	1.4	-	-	-	-	0.4	-
Black-capped Chickadee	-	-	-	-	13.2	-	-	-	-	-	-
Boreal Chickadee	-	-	-	-	15.7	-	-	-	-	-	-
Sedge Wren	367.0	224.3	-	-	-	-	114.0	-	42.0	-	-
Golden-crowned Kinglet	-	-	-	-	7.8	-	-	-	-	-	-
Ruby-crowned Kinglet	-	-	-	-	0.7	-	-	-	-	-	-
Veery	-	-	-	-	-	-	-	45.0	-	-	-
Hermit Thrush	-	-	-	-	3.8	-	-	-	-	-	-
American Robin	-	-	-	-	0.7	-	-	-	-	-	-
Gray Catbird	-	3.7	-	-	-	-	-	58.9	-	-	-
Solitary Vireo	-	-	-	-	0.7	-	-	-	-	-	-
Red-eyed Vireo	-	-	-		-	-	-	0.9	-	-	-
Nashville Warbler	-	17.5	-	26.0	26.0	-	-	37.1	-	-	-
Yellow Warbler	-	114.0	-	-	-	-	-	4.9	-	-	-
Chestnut-sided Warbler	-	3.6	-	-	-	-	-	3.0	-	-	-
Yellow-rumped Warbler	-	-	-	31.0	31.0	-	-	-	-	-	-
Palm Warbler	-	-	30.0	30.0	9.6	-	-	-	-	-	-
Connecticut Warbler	-	-	-	15.5	46.7	-	-	-	-	-	-
Common Yellowthroat	6.3	95.8	-	10.8	-	-	-	-	-	-	-
Rose-breasted Grosbeak	-	6.2	-	-	-	-	-	-	-	-	-
Chipping Sparrow	-	-	-	-	39.5	-	-	-	-	-	-

	Undisturbed					Disturbed					
						Xeric			Hydric		
Species	Open[1] Sedge	High[2] Shrub	Open[2] Spruce	Open[2] Tamarack	Closed[2] Forest	Open[3]	Open[4] Sedge	High[4] Shrub	Shrub[4] Tamarack	Shallow[5] Water	Pond[6] Ditch
Clay-colored Sparrow	-	71.6	-	-	-	-	-	3.6	14.2	-	-
Savannah Sparrow	40.5	19.5	19.5	-	-	-	-	20.3	-	-	-
LeConte's Sparrow	321.9	82.2	-	-	-	-	97.9	-	-	-	-
Song Sparrow	37.1	90.0	-	18.4	-	-	-	40.8	-	22.9	213.9
Lincoln's Sparrow	-	6.1	40.0	40.0	-	-	-	-	1.8	-	-
White-throated Sparrow	-	-	-	-	2.7	-	-	-	-	-	-
Swamp Sparrow	-	115.1	-	-	-	-	-	-	57.9	-	93.9
Dark-eyed Junco	-	-	-	-	15.3	-	-	-	-	-	-
Bobolink	1.6	-	-	-	-	-	-	-	-	-	-
Red-winged Blackbird	-	1.8	-	-	-	-	-	-	-	2.9	289.9
Brown-headed Cowbird	-	19.8	-	-	-	-	-	25.1	-	-	-
American Goldfinch	-	1.8	-	-	-	-	-	67.5	-	-	-
Total Species	7	20	3	8	19	0	2	14	7	16	7
Total Individuals (pairs/km^2)	776.0	997.7	89.5	173.5	281.8	0	211.9	424.8	282.4	57.3	786.6

1 Wilderness Valley North

2 Rasjo Torv

3 Floodwood north

4 Wilderness Valley South

5 Power-O-Peat

6 Floodwood North and Floodwood Pond

aquatic environments such as ducks, heron, shorebirds, and the red-winged blackbird (Agelaius phoeniceus). No species were found in the north Floodwood open habitat type (Table 2). The only species that were observed near this site were those associated with the ditch that traversed the area.

Bird Density of natural and altered peatlands. In the natural peatland habitats we observed the lowest bird densities in the open spruce (89.5 pairs/km^2) and highest in the high shrub (997.7 pairs/km^2) (Table 3). The open sedge habitat had the second largest density (776.0 pairs/km^2) and the open tamarack and closed forest had similar densities (173.5 and 281.8 pairs/km^2) respectively (Table 3).

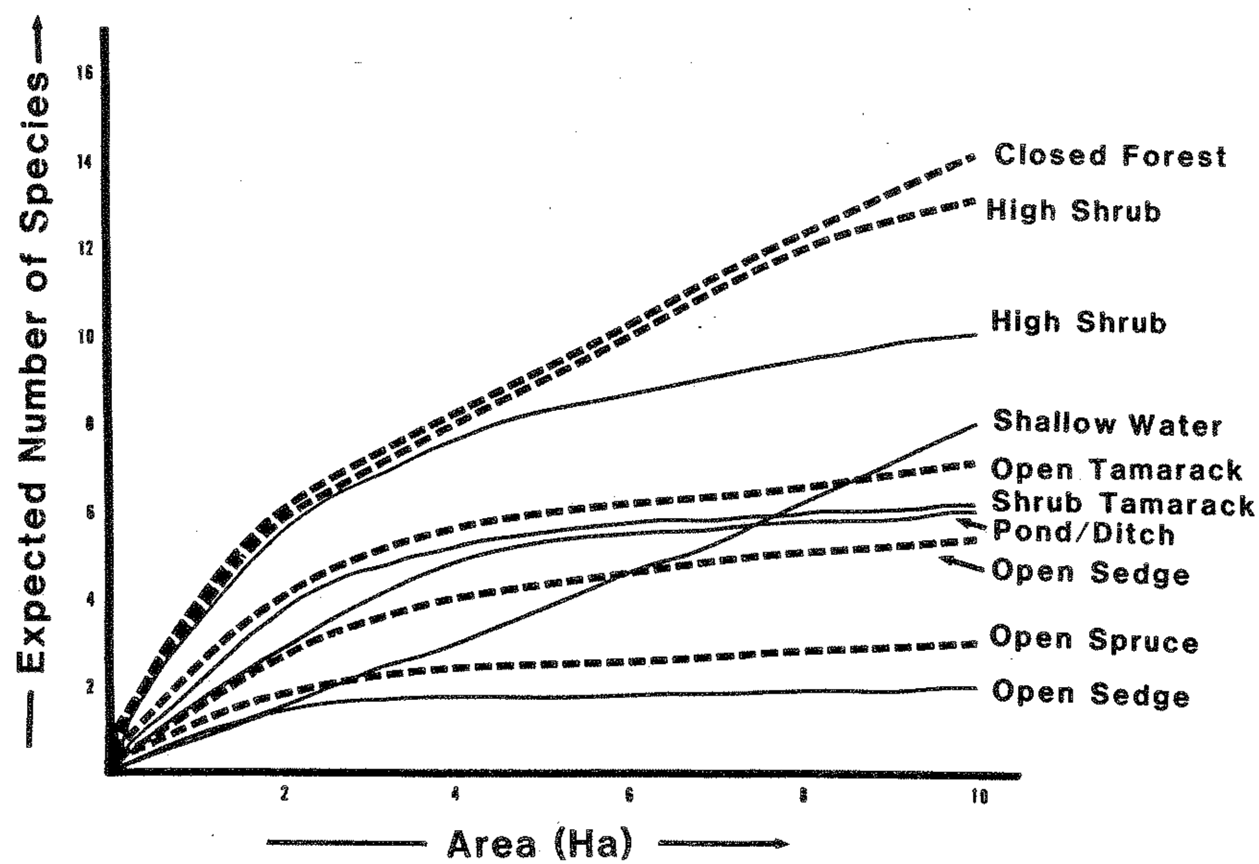
Bird densities in the altered peatland habitats were lower as compared to densities in similar natural peatland habitats (Figure 3, Table 3). The open sedge altered habitat had a density that was 73% lower than the natural habitat (212 versus 776 pairs/km^2) and the high shrub altered habitat had a density that was 57% lower than a similar natural habitat (425 versus 998 pairs/km^2) (Table 3). In general, hydric altered habitats had higher bird densities than the xeric altered habitats (Table 3). The highest density of the altered peatlands was associated with the pond/ditch community (768.6 pairs/km^2).

Species Richness of natural and altered peatlands. For the natural habitats, most species were observed in the closed spruce (19) and high shrub (20) areas (Table 3). The open spruce had the fewest species (3) compared with the other habitats. The number of species observed in the open sedge and open tamarack were similar (7 and 8 species respectively) (Table 3). Species richness, like density was lower in altered sites as compared to similar natural habitats (Table 3, Figure 2). For example, 70% fewer species were found in the open sedge altered habitat as compared to the natural habitat (2 versus 7) and 30% fewer species in the altered high shrub habitat than the natural area (14 versus 20). In general, hydric natural habitats had higher species richness than the xeric altered sites. In addition, the open habitat had no species present. The rarefaction curves, calculated to predict the number of species expected/area sampled substantiated the results of the raw data (Figure 2, 3, and 4).

DISCUSSION

Northwestern Minnesota peatland preserves. We censused for the first time, the open fen lawns in the western water track in the Red Lake Peatland. Based on our brief reconnaissance and the probability of detecting these two rare species, we believe that two bird species of special concern occur commonly in these habitats [yellow rail and Wilson phalarope (*Phalaropus tricolor*)]. If these species are common here and given the size of this peatland area, it is possible that a large portion of the Minnesota population of these species are found within this area. The ovoid type islands in the northwestern Minnesota peatlands are also unique to peatlands in Minnesota. These areas are similar in structure and species composition with the spruce peatland habitats (Niemi and Hanowski 1983) and they may be important as nesting areas for the sandhill crane (*Grus canadensis*).

Figure 4. Rarefaction curves for the expected species/area relationship for disturbed (——) and undisturbed (- - -) peatland habitats.



Species composition of natural and altered peatlands. The species composition of the natural peatland areas censused here were similar to those found in the Red Lake Peatland (Niemi and Hanowski 1983). Furthermore, the species found in the natural sites were similar to those described by Erskine (1977) for Canada, but much different from those described for peatland communities by Brewer (1967) and Ewert (1982) in Michigan.

Three of the altered peatland sites had vegetation structure that was atypical of peatland habitats. The species composition of these sites were also not typical of peatland communities. For example, several species that occurred in the shallow water and pond/ditch communities are not generally found in natural peatland habitats [e.g., great blue heron (Ardea herodias), blue-winged teal (Anas discors), killdeer (Charadrius vociferus), spotted sandpiper (Actitis macularia), and red-winged blackbird]. Overall, the bird species composition of these sites is not similar to natural peatlands as compared with three of the other altered habitats (open sedge, high shrub, shrub tamarack). Only one site, Wilderness Valley North had vegetation and species composition similar to a natural peatland area. For example, this site had Lincoln's sparrow present which we believe is one of the most endemic peatland species in Minnesota (Niemi et al. in prep.).

Species Richness of Natural and Altered Peatlands. The number of species present in natural peatland habitats is positively correlated with habitat complexity (McArthur and McArthur 1961, Niemi and Hanowski in prep.). For example, adding a shrub or tree layer to an open habitat results in an increase in species.

This pattern of increasing species richness, from open to closed habitats was evident here also and showed a pattern similar to what we found in the Red Lake Peatland (Niemi and Hanowski 1983). The altered peatland habitats showed a similar pattern but the absolute number of species present was less than what was found in similarly-structured natural habitats. The differences in the absolute number of species present were probably due to slight differences in habitat structure between the altered and natural sites. For example, although we compared "similar" altered and natural peatland habitats, these habitats were not identical. Differences in habitat complexity and vegetation biomass between sites affected species richness. We empirically observed that the total vegetation biomass of the altered sites was less than the biomass of the natural sites. This is due to the removal of vegetation during mining and its relatively slow growth following mining.

Bird density of natural and altered peatlands. The density of birds in natural peatland habitats unlike species richness, is less related to vegetational complexity, but is more-related with the trophic status of the habitat (Niemi and Hanowski in prep.). For example, nutrient-rich habitat types (e.g., high shrub and open fen) have relatively high densities in comparison with nutrient-poor habitat types (e.g., closed and open spruce). Both the natural and altered peatland sites show this pattern of higher densities in areas with minerotrophic conditions. For example, most individuals were observed in the high shrub and open sedge natural habitats and in the pond/ditch and high shrub altered habitats. These areas represent habitat types with higher pH and more nutrients than the open and closed forested habitats.

Shallow water habitats. In contrast with the other altered peatland habitats, the shallow water habitats did not follow the patterns of species richness or density that were typical with natural peatlands. For example, the shallow water habitat at the Power-O-Peat site had a higher species richness than expected based on the relatively simple vegetational structure of the site. However, the density was lower than what we expected based on the presumably high trophic status of this site. The high species richness and low density of this site can be attributed to the large number of species that used the mudflat areas available for feeding sites (e.g., swallows and great blue heron) but did not nest there.

Peatland Reclamation. In general, peatlands that provide habitat for species of special concern in Minnesota are of primary interest. For peatlands, these habitats include the open fen (sedge) and shrub habitat types because they are used by the following species that have been identified as special concern species by the Minnesota DNR (1983): yellow rail, Wilson's phalarope, American bittern, sandhill crane, short-eared owl, and sharp-tailed sparrow. We recommend that wildlife reclamation plans of peatlands should strive to benefit these species. This study indicates that reclaiming mined sites to sedge-shrub, minerotrophic conditions would be most beneficial to these species of special concern in Minnesota. This type of habitat is present at the Wilderness Valley South site and, apparently this developed in a natural way.

Suitable development of reclamation plans for a particular mined site will be dependent on the condition of the site before and after mining. For example, the trophic status of the peatland before mining and the amount of peat harvested are important factors to consider. Clearing the vegetation and then removing the top layer of peat in an ombrotrophic (low nutrient) bog resulted in a condition like that found at the Floodwood North site. This area is almost void of vegetation, has very little surface water, and does not support a bird population. In contrast, the Wilderness Valley South site has a substantial layer of reed-sedge peat remaining, a minerotrophic condition, and supports a bird population that is similar to a natural peatland habitat. The factors that contribute to the differential development and redevelopment of these peatlands such as hydrological regime and the surrounding landscape are important to understand in order to control the peatland redevelopment. In addition, it is important to know the specific habitat requirements of the species of special concern. With this information (see Paper 1 of this report) we can develop a predictive model based on discriminant function analyses of the habitat data. With this model, we can predict the probability that a site could provide suitable nesting habitat for a particular species.

SUMMARY

We assessed bird species composition and relative density in altered and natural peatlands in northern Minnesota. Bird density, and species richness were lower in altered sites as compared to physiognomically-similar natural sites.

Minerotrophic peatlands (open fen and shrub habitats) had higher densities but lower species richness than ombrotrophic peatlands. Two altered sites (open water and shallow water habitats) had species richness and density patterns that were not similar with natural peatland populations. Some peatland habitat types (e.g., open fen and shrub) provide essential habitats for species of special concern in Minnesota and we recommnend that these be identified and possibly preserved. In addition, reclamation plans for altered peatlands that provide an opportunity for wildlife reclamation could strive to create conditions that are suitable for these species. In general, these areas should be minerotrophic with a layer of peat remaining above the mineral soil, and a water level that is maintained at or above the surface of the peat. In the next two years we will develop a model to predict the probability that specific peatland habitats are suitable for specific species.

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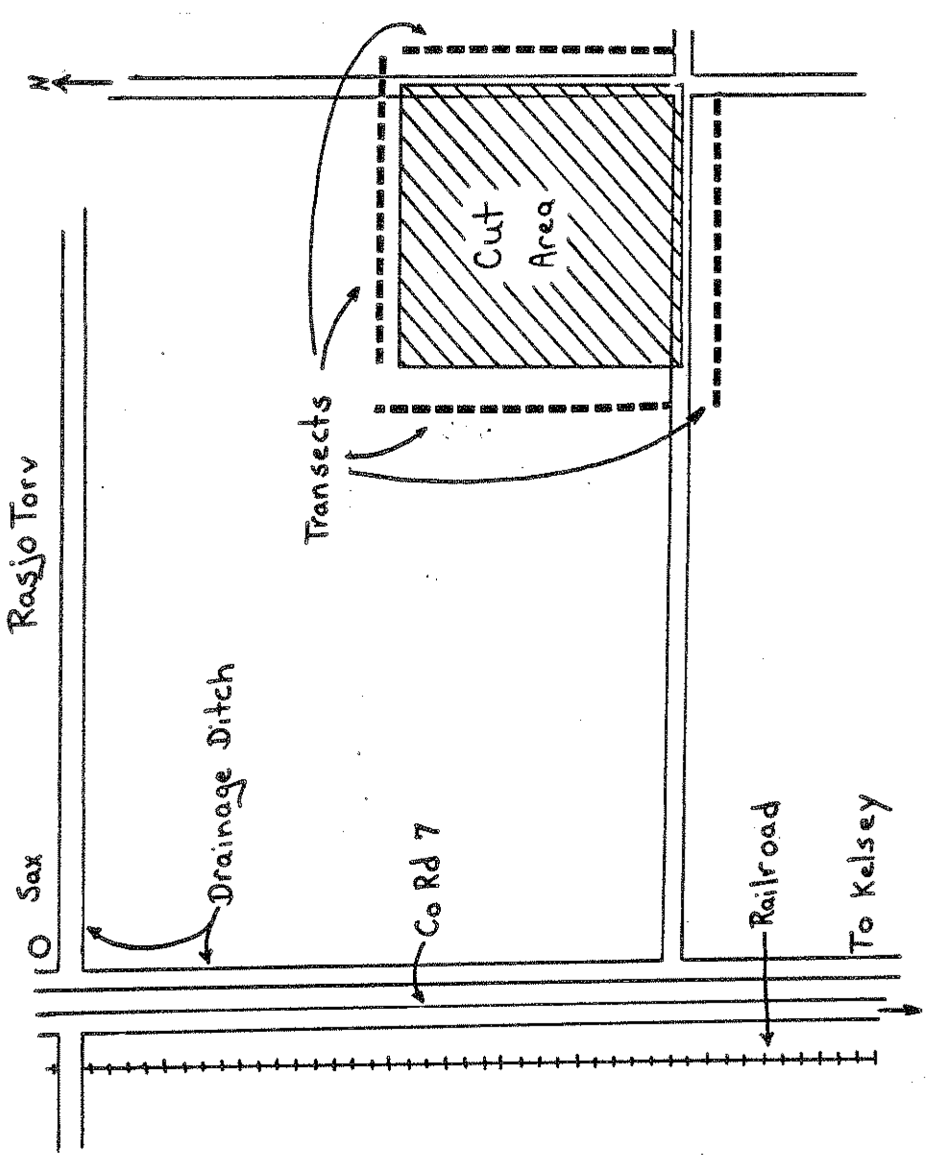
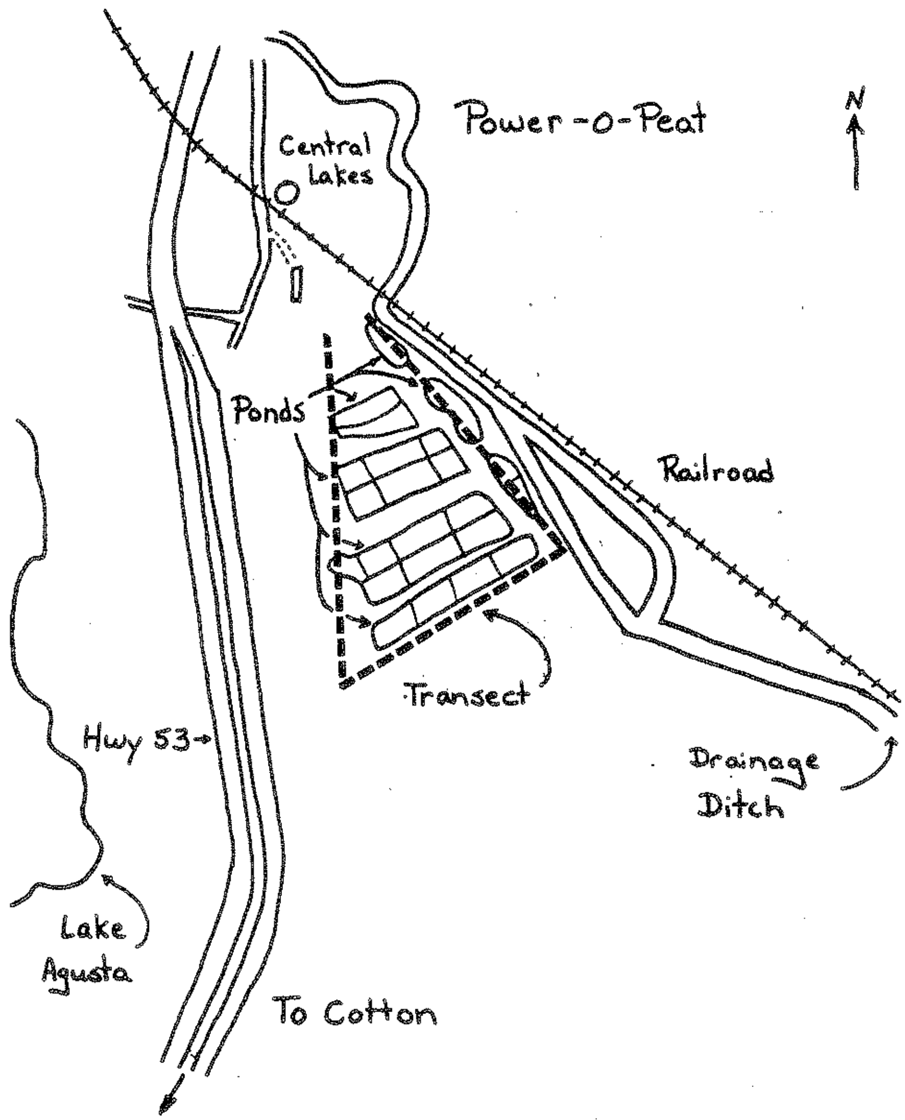
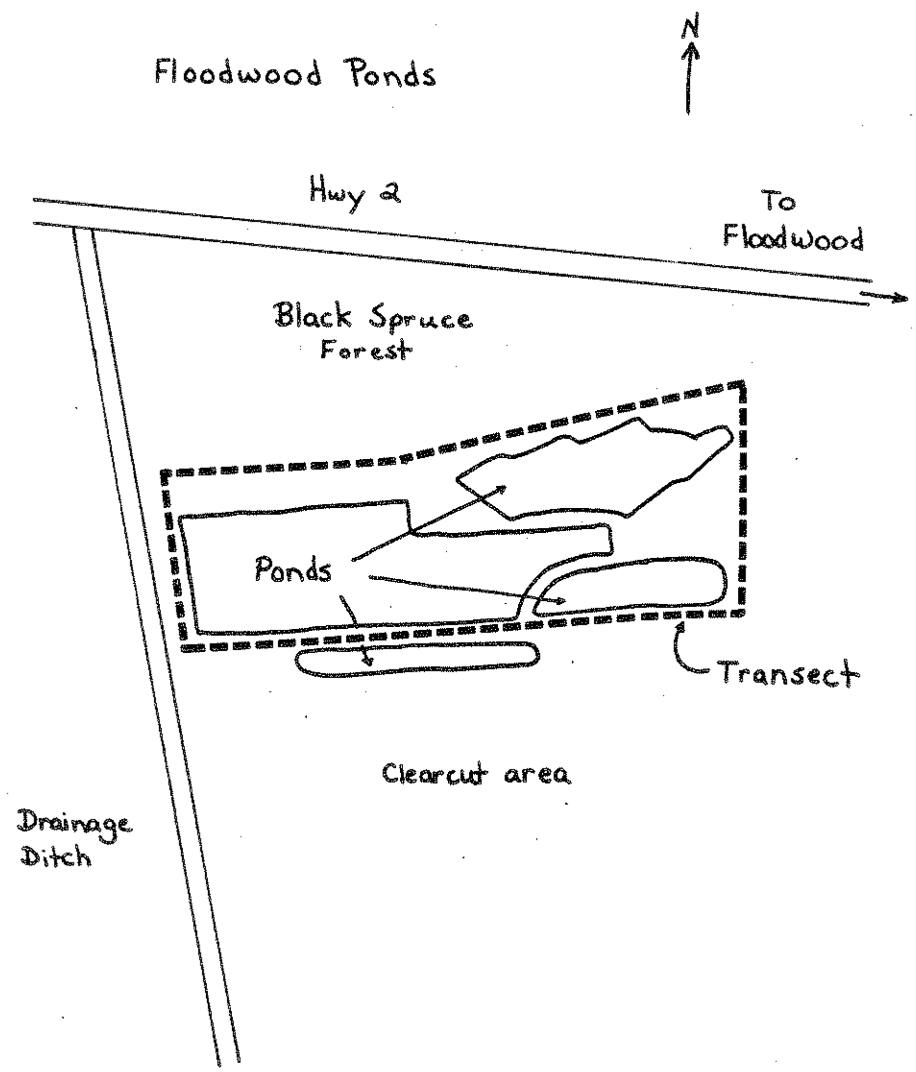
Appendix 1a. Location of study transect at the Rasjo Torv site.



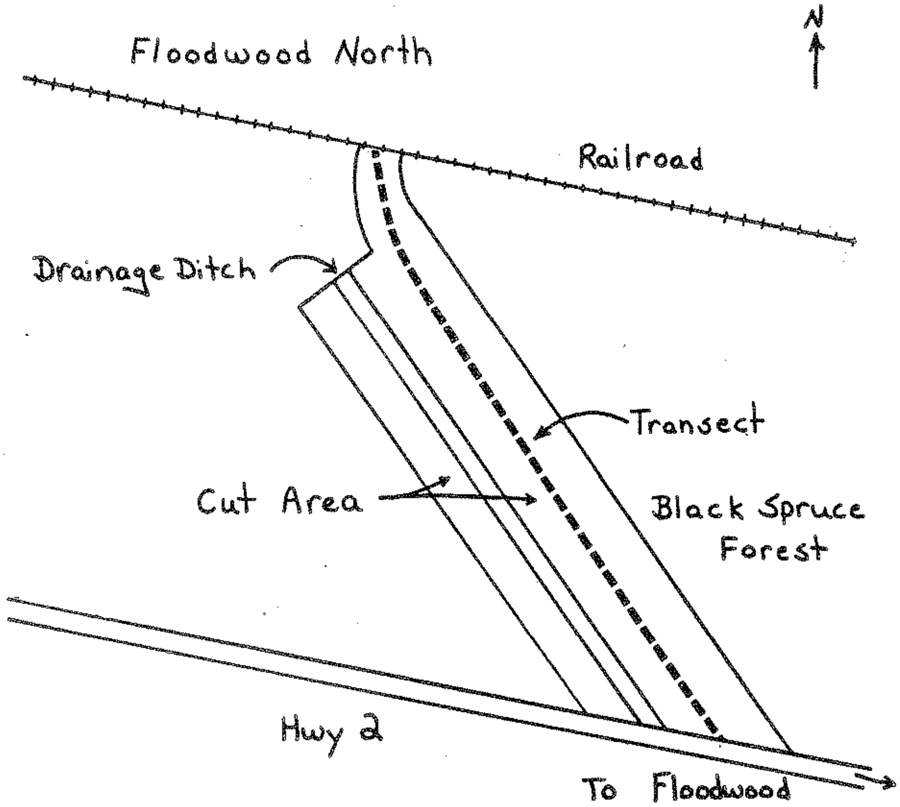
Appendix 1b. Location of study transect at the Power-O-Peat site.



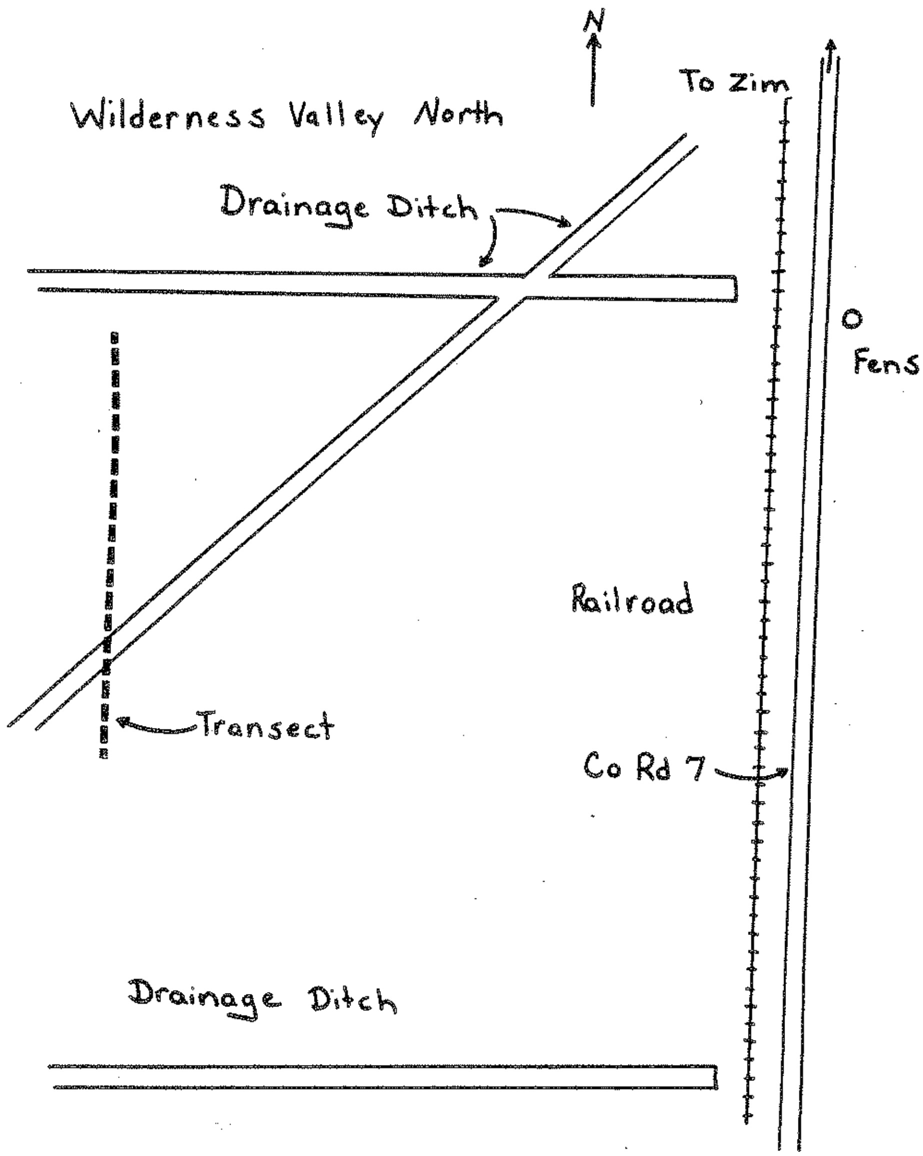
Appendix 1c. Location of study transect at the Floodwood Ponds site.



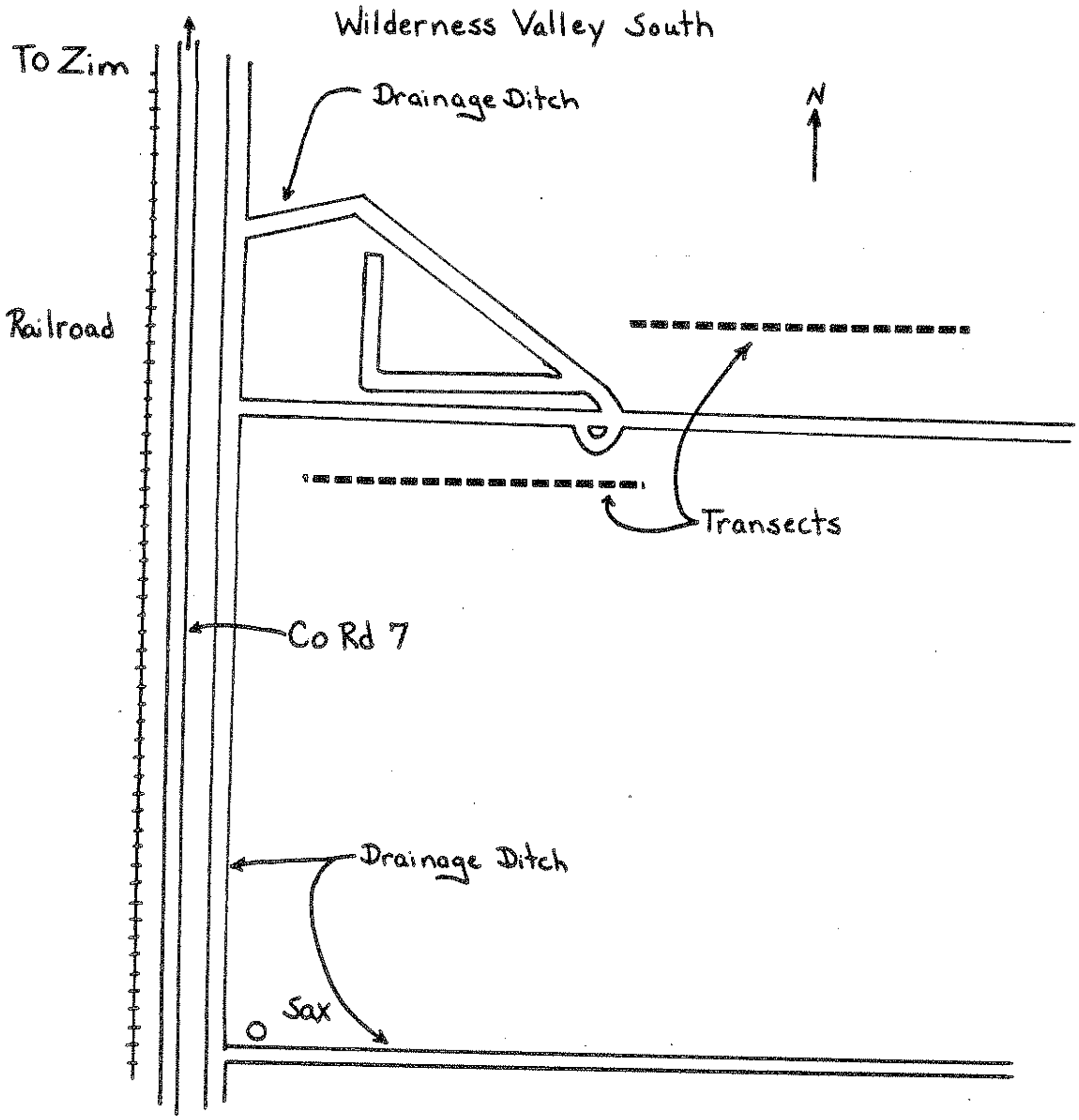
Appendix 1d. Location of study transect at the Floodwood North site.



Appendix 1e. Location of study transect at the Wilderness Valley North site.



Appendix 1f. Location of study transect at the Wilderness Valley South site.



Appendix 2. Formula for estimating the density (pairs/km^2) of bird populations gathered on line transects (Järvinen and Väisänen 1975).

$$D = \frac{1000}{L}\,\underline{ky}\,\underline{SB_i}$$

Where: $$K = (1-\sqrt{1-(MB_i/SB_i)})/25$$

$$Y = 0.0426X + 0.6211$$

$$X = MB/L$$

MB = # of main belt observations on all species

MB_i = main belt observations on the ith species

SB_i = survey belt observations on the ith species

L = length of transect