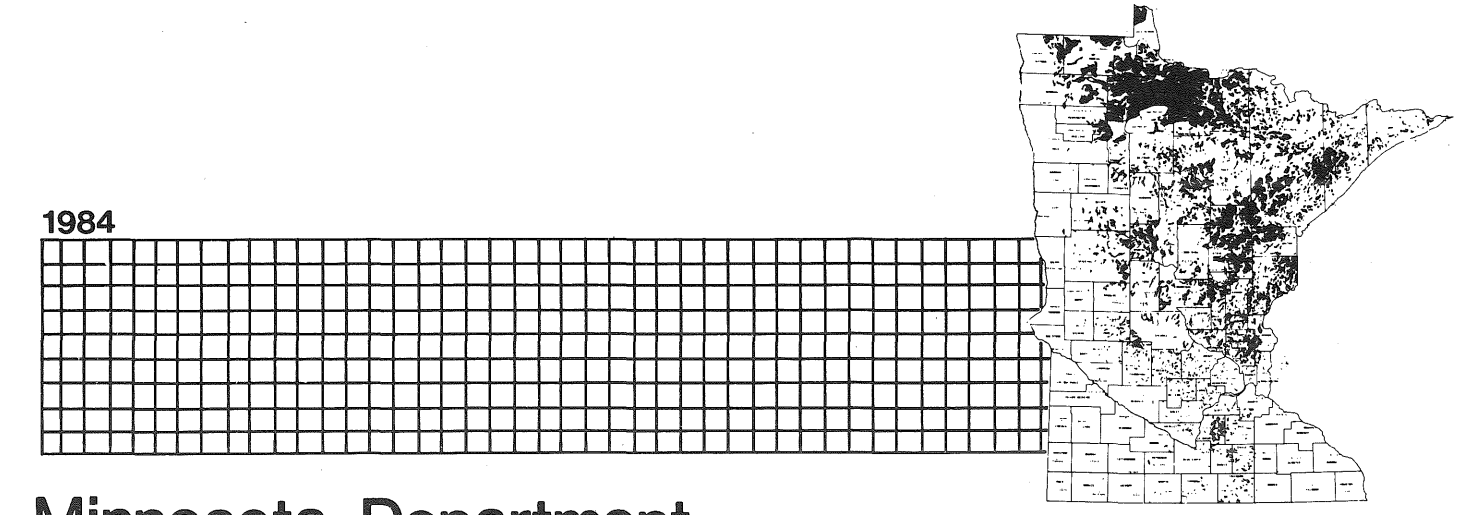
MINNESOTA PEAT PROGRAM

Bird Population Structure and Seasonal Habitat Use as Indicators of Environmental Quality of Peatlands



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Minnesota Department of Natural Resources

Bird Population Structure and Seasonal Habitat Use as Indicators of Environmental Quality of Peatlands

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Field work in these peatlands is among the most difficult of any habitats in the world. We are deeply indebted to the following persons, who worked in the bog: Bruce Avenson, David Blockstein, Mark Bruns, Michael Carter, Susan Doehlert, Myra Doering, Bonita Eliason, Roger Eliason, Bruce Fall, Kerry Fitzharris, Susan Frye, Cindy Hagley, Sarma Jatnieks, Jean Pates, Carol Propotnik, Margaret Torreano, Donald Wanshura, and Marie Ward. Special recognition is due to Roger Eliason and Bonita Eliason as they conducted most, if not all, of the releves. We would also like to thank Bruce Fall for his advice and assistance during the course of this study.

ABSTRACT

The objective of this study was to quantitatively describe the degree of utilization of peatland vegetation types by birds. The major study area was in the east-central watershed of the Red Lake Peatland, Beltrami County, Minnesota. Twelve peatland and two upland habitats were selected for intensive study. The vegetation of each study site was described by means of plant releves, tree and shrub stem counts, and estimates of foliage volume.

Bird censuses were conducted during June through mid-July in 1978 and 1979 to determine the avian distribution and relative abundance during the breeding season. Line transects, usually 2286 m in length, were established in each habitat. Avian populations were determined by using one of two variations of the line transect population estimating technique. Censuses were conducted between 5 and 10 times each year. Within the peatland habitats, 75 bird species were observed in average densities of greater than 0.5 males per 40 ha. An additional 15 species were detected in lower densities, and 7 species were observed only in the upland habitats sampled. The number of species ranged from 4 in muskeg in 1978 to 31 in swamp thicket in 1979. Densities ranged from 40 birds per 40 ha in muskeg in 1978 to 391 birds per 40 ha in uplands in 1979.

By comparing the degree of similarity in bird species composition and abundance between habitats, five clusters of habitats were selected. These clusters can be thought of as units of vegetation that are more or less distinct in terms of bird species composition and abundance. The clusters, or units of vegetation, can be characterized as (1) minerotrophic fens, (2) ombrotrophic bogs with a low, sparse tree cover,

(3) deciduous shrublands over peat, (4) forested peatlands, and (5) forested uplands. The forested uplands showed the least amount of similarity to the other clusters, which emphasizes the locally distinct nature of the avian populations in the peatland.

Species that may be found at their highest densities in peatlands or that are of particular interest state-wide include sandhill crane, yellow rail, great gray owl, black-backed 3-toed woodpecker, yellow-bellied flycatcher, boreal chickadee, golden-crowned kinglet, palm warbler, Connecticut warbler, and Lincoln's sparrow.

In order to document utilization of peatlands by birds during migration, mist-nets were erected in four habitats in spring and summer 1978, three habitats in fall 1978, and two habitats in spring 1979. Marked differences in habitat use between migrant species were observed during spring migration. Some species utilized habitats similar to their breeding habitats while other species showed an opposite pattern. Mist-netting late in the breeding season in one habitat demonstrated extensive wandering by recently fledged young to areas outside their home territories. During the initial stages of fall migration large flocks of birds were observed in habitats that were not heavily utilized in the spring migration. Results of mist-netting suggest that the utilization of the peatlands by birds, both migrants and residents, is very dynamic and has not been adequately described. Habitats that support only a limited breeding population may provide refuge for large numbers of birds during migration.

INTRODUCTION

Objectives

This study was designed to obtain quantitative data on the populations of bird species that utilize resources of the several vegetation types growing on major peat deposits in Minnesota. The primary objective is to establish a firm base for predicting levels of impact on the bird species resulting from any degree of peatland development.

Study Area

The Red Lake Peatland comprises 300 square miles of continuous peatland north of Upper Red Lake in Beltrami, Lake of the Woods, and Koochiching counties. Our study base was in Waskish, Minnesota, on the east shore of Upper Red Lake at the mouth of the Tamarac River.

VEGETATION

Information presented in this report regarding the avian fauna of the peatlands will virtually always be in context of a particular vegetation association or habitat. Considerable effort has therefore been spent describing the habitats we sampled. Several different approaches have been used in this descriptive process. Some were conducted in order to investigate possible relationships between vegetation parameters and the avian species composition of a habitat. Other approaches are purely descriptive and serve only to familiarize the reader with a particular aspect of the habitats. Among the various habitat descriptions presented, it is hoped that the reader will be able to locate descriptions of a nature suitable for his or her purposes.

Habitats

The peatland habitats identified in this study are generally based on the classification schemes developed in northern Minnesota (Heinselman 1970, Gorham and Wright 1979) and Ontario (Jeglum et al. 1974). These classification schemes are primarily based on plant species composition or dominance and properties of the surface water. However, because bird populations are often influenced to a greater extent by physignomic rather than floristic differences, certain plant communities previously recognized have been further subdivided or grouped together into habitats having similar vegetation structure. Twelve peatland and two adjacent non-peatland habitats were identified for this study. Plant releves describing the vegetation of these habitats are provided in Appendix A.

Bog Habitats. Six of the 12 peatland habitats can be defined as

bogs, being characterized by highly acid and extremely nutrient-poor surface water and having a very low species diversity (Jeglum et al. 1974). The habitats are very similar floristically and are typically dominated by sphagnum mosses (Sphagnum spp.) and ericaceous shrubs such as leatherleaf (Chamaedaphne calyculata), bog laurel (Kalmia polifolia) and Labrador tea (Ledum groenlandicum).

In the Red Lake Peatland, Gorham and Wright (1979) found that the vascular flora of the bog communities was characterized by the presence of less than 14 species and the almost total exclusion of minerotrophic species. In our study, however, some of the sites differed slightly from these typical bog types as evidenced by the occasional occurrence of minerotrophic species such as bog birch (Betula pumila) and buckbean (Menyanthes trifoliata). The presence of these species may indicate that some of these bog sites may be characterized as transitional bog types or poor fen (sensa Gorham and Wright 1979).

Although only two distinct bog types were identified by Gorham and Wright, there is a considerable diversity in the size and density of the tree cover within these two types. Consequently, additional bog habitats were identified that make up the continuum from treeless bog through various heights and densities of tree cover. Table 1 shows the major characteristics of the six bog habitats and the plant community thought to correspond to each type.

It should be noted that the black spruce bog/swamp habitat includes black spruce swamps. Black spruce swamps occur in peatlands that are more minerotrophic than black spruce bogs and can be distinguished from the bogs by their much greater diversity of plant species. Because of their similarly uniform and denser tree canopy and open understory,

however, black spruce bog and black spruce swamp are treated as one habitat for this study.

TABLE 1
Bog Habitats

Habitat	Dominant Tree Species	% Forest cover	Corresponding Plant community*
1. open bog	black spruce	5%	Carex oligosperma association (G&W) open bog (J)
2. muskeg	black spruce	5-25%	Carex oligosperma association (G&W)
3. stunted black spruce	black spruce	25-50%	Carex oligosperma association (G&W) treed bog (J)
4. stunted tamarack	tamarack	25-50%	transition type? (G&W) treed bog (J)
5. black spruce bog/swamp	black spruce	50%	Carex trisperma/Vaccinium vitis-idaea association (G&W) treed bog and black spruce swamp (J)
6. spruce island	black spruce	>50%	treed bog and black spruce swamp (J)

* G&W = Gorham & Wright (1979)
J = Jeglum et al. (1974)

One feature of the Red Lake Peatland is ovoid-shaped islands, the larger ones often composed primarily of black spruce. The spruce island selected for this study is approximately 40 ha and is densely stocked with short black spruce. This island was burned in the early 1930s as were many of the islands. The spruce island sampled is also the site of an intensive study of the palm warbler by Bruce Fall, a doctoral candidate at the University of Minnesota.

Fen and Swamp Habitats. Fen and swamp habitats are distinguished from bog habitats by their higher pH and the richer nutrient status of surface water and have a much more diverse flora (Jeglum et al. 1974). Swamps are characterized by forest or tall shrub cover whereas fens are dominated by sedges or low shrubs.

7. tamarack swamp. Very wet with a relatively dense understory of shrubs including bog birch, buckthorn (Rhamnus alnifolia), dogwood (Cornus stolonifera), and willow (Salix spp.). Tree cover is over 25%, most of which is tamarack.

8. cedar-spruce swamp. Comprised mostly of white cedar (Thuja occidentalis), forming a dense canopy, with frequently occurring small balsam fir trees (Abies balsamea). Herb layer is sparse where most densely shaded.

9. spruce swamp clearcut. This is a recently clearcut area, formerly a spruce feathermoss stand that graded into tamarack. There is virtually no tree cover except for black spruce seedlings and quaking aspen (Populus tremuloides) seedlings and saplings. There is a dense shrub layer composed primarily of alder (Alnus rugosa).

10. swamp thicket (Jeglum et al. 1974). Less than 50% tree cover, but densely covered with tall deciduous shrubs, such as bog birch, willows, and alder. A rich herbaceous layer was also present. Swamp thicket is most abundant along the perimeter of the peatlands or in places where mineral soil is close to the surface.

11. open fen. This is the typical fen type dominated by sedges, particularly Carex lasiocarpa (Gorham and Wright 1979). Tree and shrub cover, if present, is minimal, usually less than 5% (Jeglum et al. 1974). These areas usually mark areas of surface water movement

across the peatland and usually have the water at or above the ground surface.

12. shrub fen. The shrub fen habitat is similar to the open fen but is dominated by low shrubs interspersed with sedges. Shrub fen, which is much drier than the open fen, may be the result of decreased water flow caused by adjacent ditches upstream that are diverting surface water flow.

Non-Peatland Habitats.

13. riparian hardwood. This habitat is dominated primarily by box elder (Acer negundo), basswood (Tilia americana), American elm (Ulmus americana), and black ash (Fraxinus nigra). There is a vigorous shrub and herb understory but no peat accumulation. This habitat is located along the meandering Rapid River, which is lower than the surrounding peatlands.

14. mixed conifer-deciduous upland. This habitat is dominated by quaking aspen and balsam fir and has a vigorous shrub layer of hazel (Corylus spp.), bush honeysuckle (Diervilla lonicera), and alder (Alnus spp.). This habitat is typical of the more elevated upland sites found to the south of Waskish.

Sampling Methods

Representative stands of each habitat were selected in the field with the aid of aerial photos and USGS orthophoto maps and the assistance of the DNR district forestry office in Waskish. Line transects were established through each stand and served as a base line for most sampling activities. We attempted to establish 2286 m (7500 ft) of transect through each habitat, although logistics prevented accomplishment of this goal in a few situations. The total length of transect

through a given habitat was not always continuous but often consisted of segments located in separate stands. Data were collected from each stand but combined with other stands to represent the habitat under consideration.

Legal descriptions of the location of each transect are presented in table 2. All transects are located in Beltrami County with the exception of two transects through riparian hardwood stands in Lake of the Woods County (see fig. 1).

Releves. The releve method was used to describe the habitats in a semiquantitative manner. This method is based on dividing the habitat into height strata and estimating the total cover of various life-form types in each height stratum. The symbols used for this section are those of Kuchler (1967). Within each of these categories, individual species are listed, and the cover and sociability of each species are estimated. The symbols used for this portion are from the Braun-Blanquet Floristic System (1932). Finally, flowering and fruiting are indicated by appropriate symbols. The completed releves allow one to visualize the structure and species composition of the community described.

One of the prerequisites for use of the releve method is that the area described be relatively homogeneous. Although each habitat was a definable entity, some were considered heterogeneous by the standards of the releve method. Therefore, for the purpose of the releve descriptions, some of the habitats were divided into subunits. The number of feet of transect represented by the releves and the total number of feet of transect in that habitat are indicated on each releve.

Standard procedure was to locate a 20 x 20 m releve plot in an area

TABLE 2
Description of Line Transects

Transect Number	Vegetation Type*	Legal Description+	Transect Length (m)	(ft)	Releve No.
MP1	Shrub Fen	Sec. 13, T156N, R31W	1219	4000	1-1
MP2	Shrub Fen	Sec. 13, T156N, R31W	1067	3500	1-1
MP3	Open Fen	Sec. 18, T156N, R30W	1219	4000	3-1
MP4	Open Fen	Sec. 18, T156N, R30W	1067	3500	3-1
MP5	Muskeg	Sec. 1,2, T155N, R31W	1219	4000	5-1,5-2,5-3
MP6	Muskeg	Sec. 1, T155N, R31W	1067	3500	5-1
MP7	Open Bog	Sec. 11,12, T155N, R31W	1219	4000	7-1
MP8	Open Bog	Sec. 11,12, T155N, R31W	1067	3500	7-1
MP9	Stunted Black Spruce	Sec. 6, T155N, R30W	762	2500	9-1
MP10	Stunted Black Spruce	Sec. 6, T155N, R30W	762	2500	9-1
MP11	Stunted Black Spruce	Sec. 6, T155N, R30W	762	2500	9-1
MP12	Stunted Tamarack	Sec. 18,7, T155N, R30W	914	3000	12-1
MP13	Stunted Tamarack	Sec. 7, T155N, R30W	1219	4000	12-1,13-1,13-2
MP14	Swamp Thicket	Sec. 19, T155N, R30W	1828	6000	14-1,14-2,14-3
MP15	Swamp Thicket	Sec. 24, T155N, R31W	914	3000	15-1
MP16	Tamarack Swamp	Sec. 16,19, T154N, R30W	914	3000	16-1
MP17	Black Spruce Bog/Swamp	Sec. 9,10, T154N, R30W	1676	5500	18-1,17-1,17-2,17-3,18-3
MP18	Black Spruce Bog/Swamp	Sec. 20, T154N, R30W	762	2500	18-1,18-2,18-3
MP19	Cedar-Spruce Swamp	Sec. 32, T154N, R30W	762	2500	19-1,19-2
MP20	Cedar-Spruce Swamp	Sec. 32,29, T154N, R30W	762	2500	20-1
MP21	Cedar-Spruce Swamp	Sec. 29, T154N, R30W	762	2500	21-1,21-2
MP22	Mix. Con-Decid. Upland	Sec. 33, T154N, R30W	1067	3500	22-1,22-2
MP23	Mix. Con-Decid. Upland	Sec. 33, T154N, R30W	1219	4000	23-1,23-2
MP24	Tamarack Swamp	Sec. 27,34, T153N, R30W	1372	4500	24-1,24-2
MP25	Spruce Swamp Clearcut	Sec. 9, T154N, R30W	610	2000	25-1
MP26	Riparian Hardwood	Sec. 9,16, T157N, R32W	610	2000	
MP27	Riparian Hardwood	Sec. 16,17, R157N, R32W	610	2000	
MP28	Spruce Island	Sec. 19, T156N, R30W	1067	3500	

* Names adapted from Fox, et al. 1977; Heinselman, 1970; Jeglum, et al. 1974.
+ All transects are in Beltrami County with the exception of the two riparian hardwood transects which are in Lake of the Woods County.

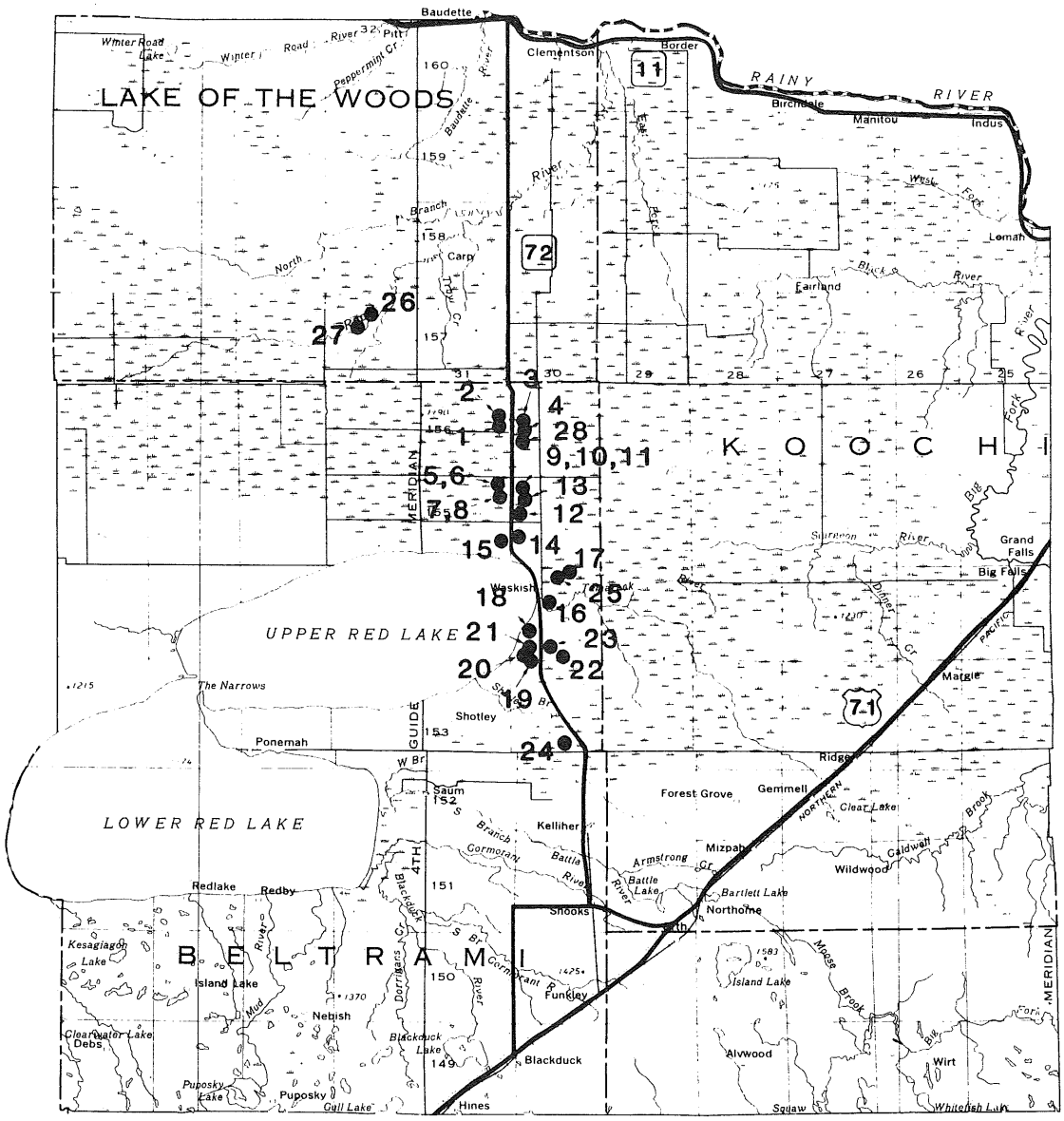

Figure 1. Map of transects (see Table 2).

representative of the habitat to be described. Some habitats posed special problems. Some transects contained small areas where the trees were of much higher or lower density than the majority of the transect. In this case an area of intermediate density considered to be representative of the average density for the whole transect was selected for the location of the releve plot. In two areas (swamp thicket and spruce swamp clearcut) a 20 x 20 m plot was not feasible because of tall and very dense vegetation. The plot size in these areas was 5 x 80 m.

Identification was done to species whenever possible. At times the absence of key structures (flowers, fruits) allowed identification to genus only. It was not possible for us to identify most graminoids and bryophytes. Estimates of total cover are presented in these strata. Grass species in flower were identified and listed, but many were not in flower. Lists in these areas are far from exhaustive.

The releves are presented in Appendix A with additional material explaining the format and symbols used. No attempts have been made to arrange the releves for purposes of examining possible plant communities.

Tree and Shrub Counts. In addition to foliage volume profiles and releves, the vegetation along our transects was described and quantified from tenth-acre plot samples by using techniques similar to those outlined by James and Shugart (1970). These techniques were offered as a means to standardize vegetation descriptions for bird censuses so that both the avifauna and habitat of different areas can be readily compared. In carrying out "tree counts" we not only counted all tree species of designated size classes (diameter at breast height) within each tenth-acre plot, but also counted shrub stems and saplings and

estimated canopy cover.

Sampling points were systematically chosen along each transect. At the midpoint of each 150 m interval along each transect, a distance of 15 m perpendicular to the transect line on each side was measured. Each of these points then became the center of a circle encompassing 404 m^2 (.1 acre). All tree species within a circle were tallied according to species and size. Size categories used were seedlings (< 1 m in height, diameter at breast height (DBH) < 7.7 cm (3")), saplings (> 1 m in height, DBH < 7.7 cm (3")), poles (no height criteria, DBH 7.7-15.4 cm (3-6")), and trees (> 15.4 cm DBH). Dead trees were also enumerated as either < 7.7 cm or > 7.7 cm DBH. Shrub stem counts were conducted within two rectangles in each circle. One side of each rectangle was a randomly determined radius while the width was either 1.5 m (used in 1978) or 1.2 m (used in 1979). An estimate of the number of shrub stems per 404 m^2 (.1 acre) was then determined. An estimate of canopy cover above 3 m was made by recording "hits" or "misses" of canopy foliage against the cross-hairs of a vertically held tube. Twenty sightings were systematically taken in each sampling circle. The fraction of total sightings that recorded a hit was taken as an estimate of percent canopy coverage.

Tree and shrub densities are presented in Appendix B. These densities are intended to aid in the selection of similar habitat for purposes of future research or applied use of the data contained within this report.

Foliage Volume. Foliage volume was estimated for all habitats. From these data we are able to construct a diagram of the vegetational or structural profile of each habitat. Probably more than any other

technique this more readily familiarizes the reader with this aspect of the habitat and paints a picture of the area under consideration. Foliage volume and other related vegetation parameters have previously been considered as predictors of avian parameters such as bird species diversity (see Balda 1975 for review) in an attempt to further the understanding of community structure and organization. Only a cursory examination of these relationships is considered in this report since they contribute little to an understanding of the distribution of individual species, which is of primary interest here.

Foliage volume measurements were made using the technique described by MacArthur and MacArthur (1961). This involves moving a rectangular board (10" by 18") away from the origin of a sampling line at a constant horizontal level until an observer standing at the origin point considers the board to be 50% obscured by foliage silhouette. This distance (D) was recorded with the board held at each of the following heights in feet above the ground: .5, 2, 5, 10, 15, 20 and every 10 ft thereafter if vegetation was present. (Measurements were made in English units to facilitate comparison with other published materials using identical techniques.) Foliage volume (k) was then computed where

$$k = \frac{\log_e 2}{D}.$$

By measuring distances and averaging the results for each horizontal layer, k values were determined for all the habitats. Sampling lines were laid out along a random compass bearing. The origin of the line was determined according to a systematic pattern with respect to each transect so that no habitat was sampled with less than 24 sampling lines.

Foliage Height Diversity. From the foliage volume information we computed the foliage height diversity (FHD) for each habitat. The Shannon formula (Shannon and Weaver 1949) was used where

$$FHD = - \sum_{n=1}^{s} p_i \ln p_i .$$

In this case p_i represents the proportion of the total foliage volume at height i within a given habitat, and s is the number of horizontal zones, as previously defined, where vegetation was present.

Foliage profiles (fig. 2) show the wide range of vegetation structuring present among the peatland habitats. At the extremes are open bog, with vegetation at only one level, and black spruce bog/swamp with vegetation up to 60 ft. Foliage volume parameters are summarized in table 3.

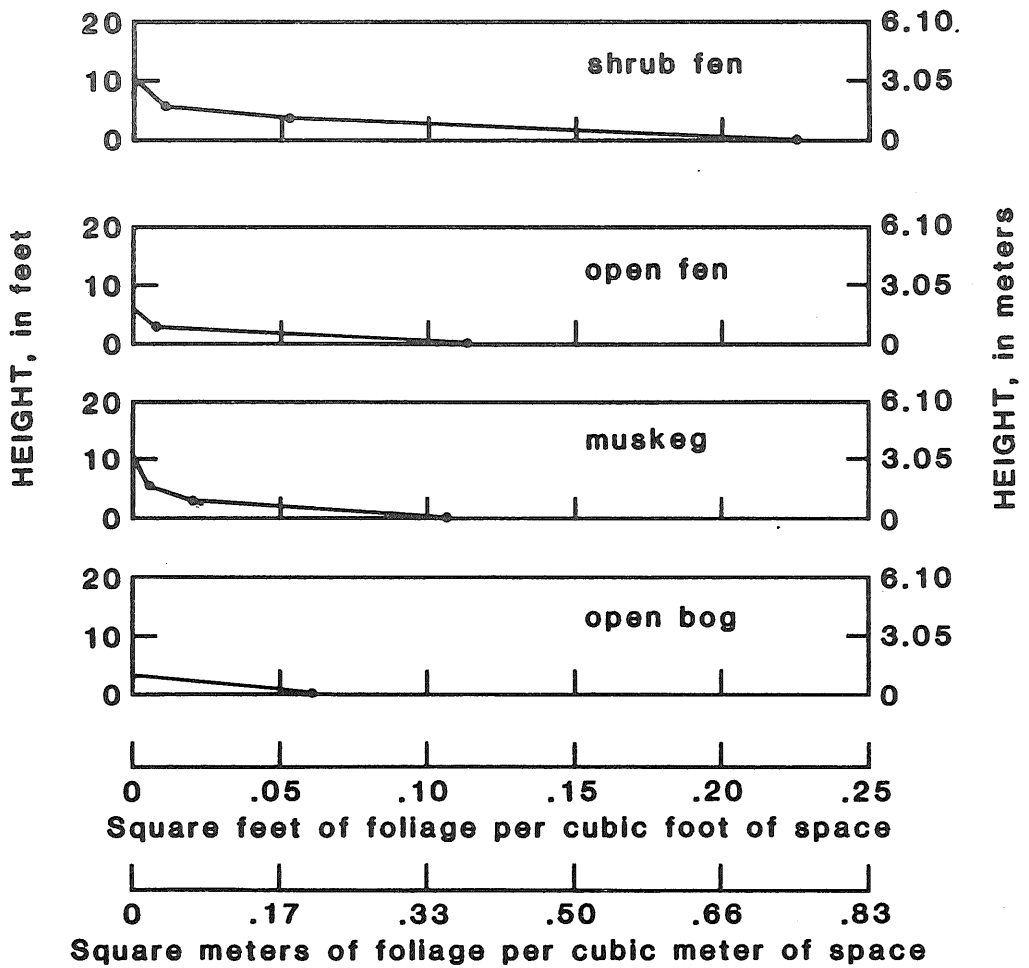

Figure 2. Foliage volume profiles of 14 habitats.

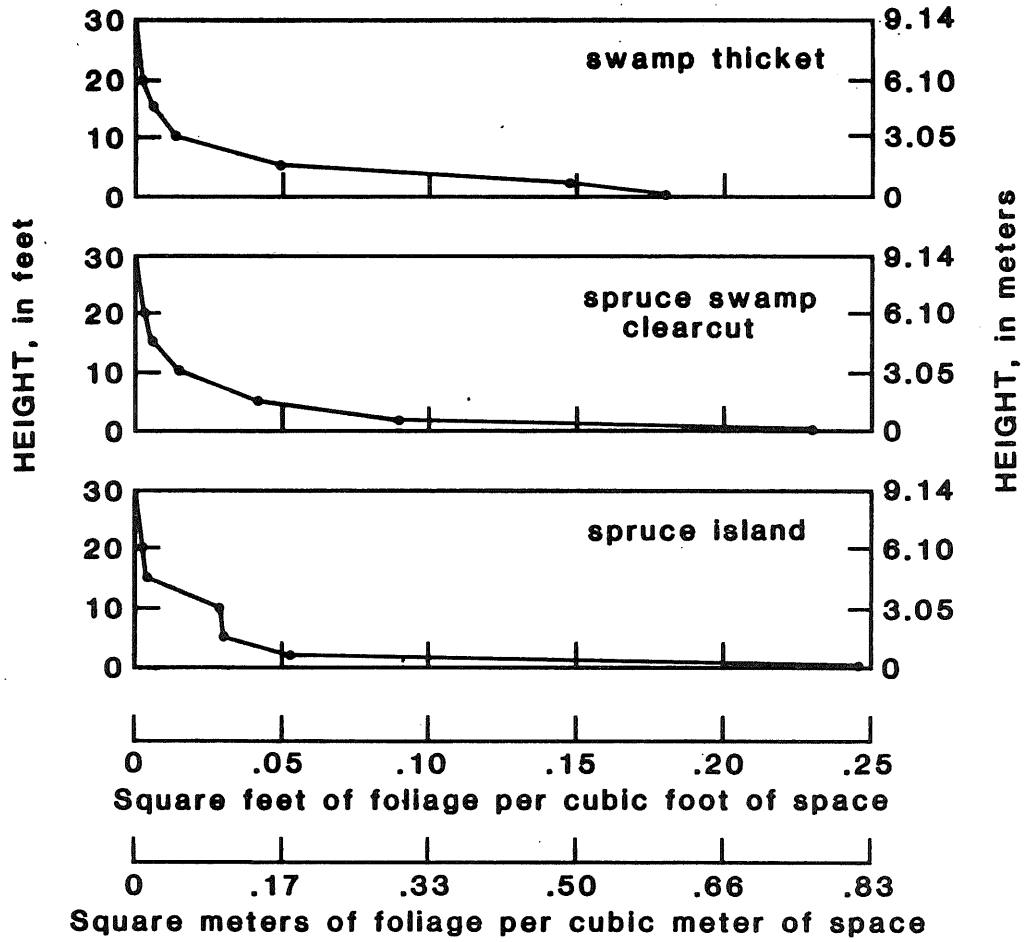

Figure 2 (cont.). Foliage volume profiles of 14 habitats.

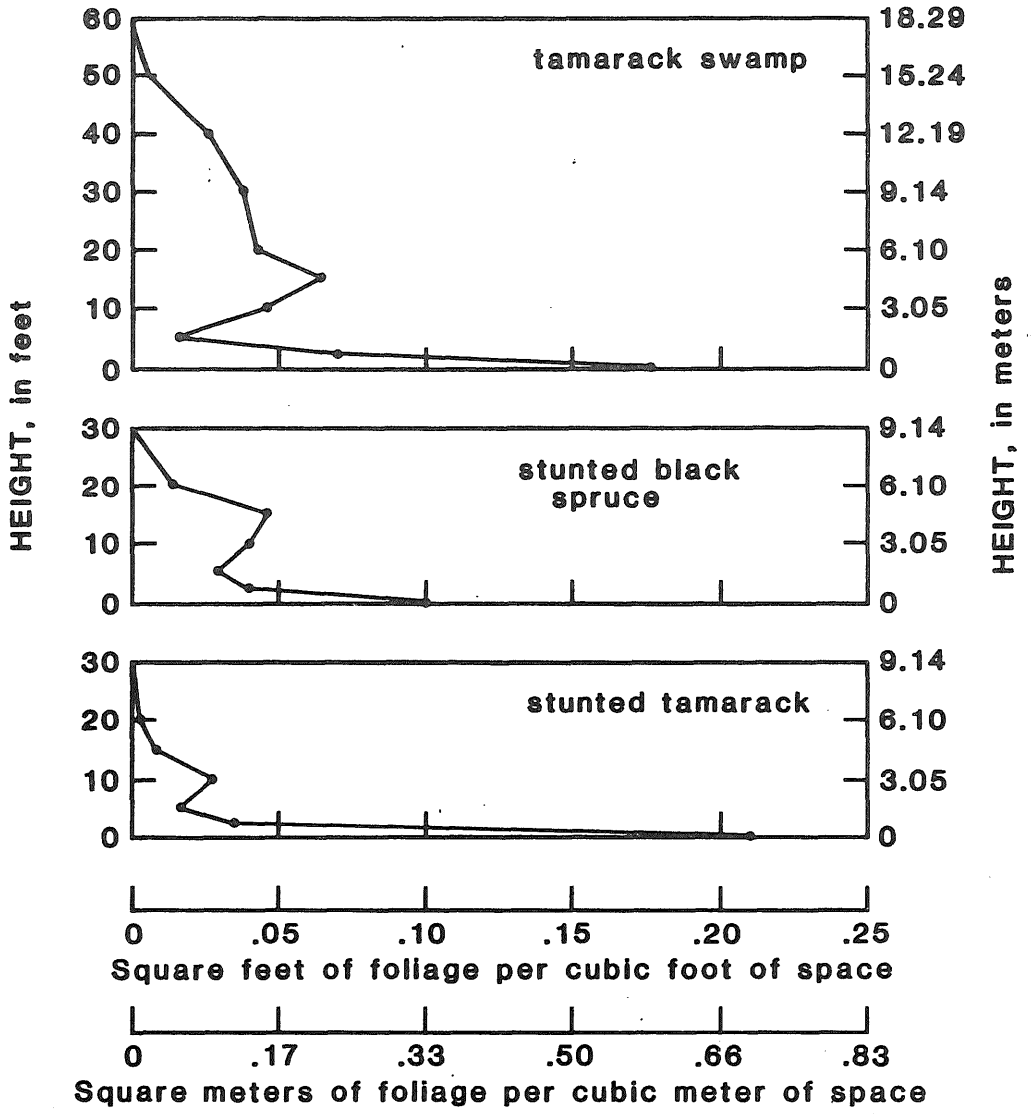

Figure 2 (cont.). Foliage volume profiles of 14 habitats.

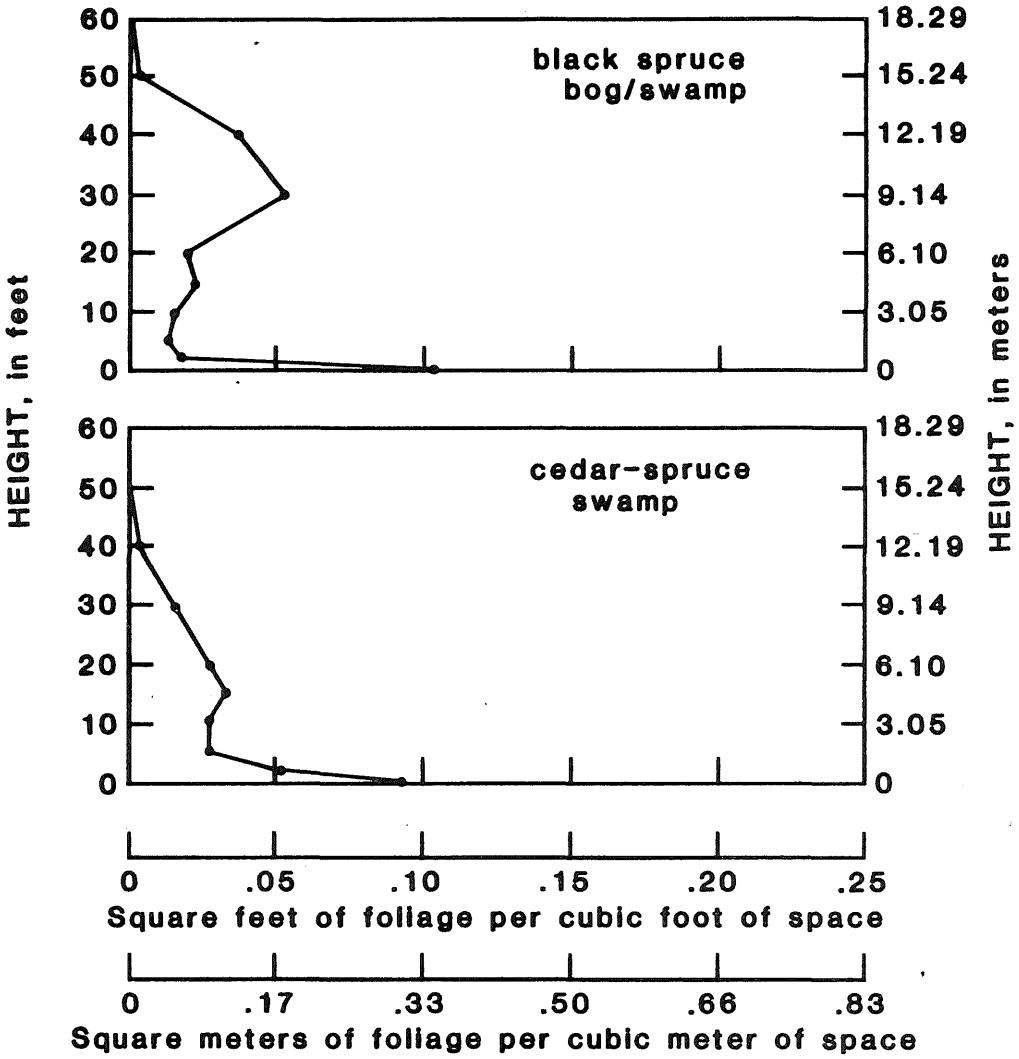

Figure 2 (cont.) Foliage volume profiles of 14 habitats.

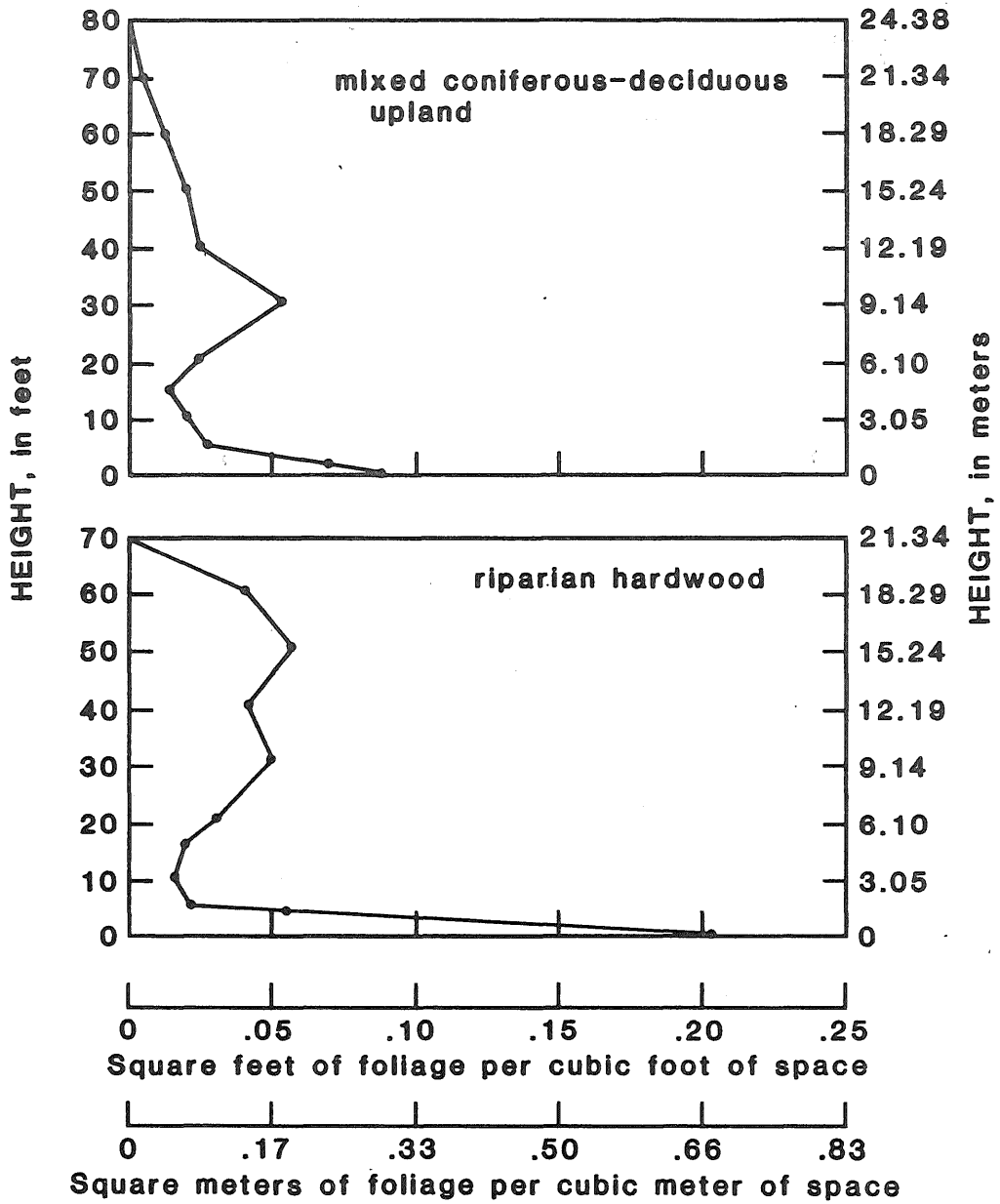

Figure 2 (cont.). Foliage volume profiles of 14 habitats.

TABLE 3
Foliage Volumes for 14 Habitats
(ft^2 of foliage/ft^3 of space)*

Habitat	Height 6"	2'	5'	10'	15'	20'	30'	40'	50'	60'	70'	Total Volume	Foliage Height Diversity	No. of Sampling Points
open bog	.060 (.005)#											.060	-	30
muskeg	.107 (.006)	.020 (.006)	.006 (.003)									.133	.60	30
stunted black spruce	.100 (.006)	.040 (.008)	.029 (.007)	.041 (.009)	.046 (.014)	.013 (.002)						.269	1.63	30
stunted tamarack	.211 (.020)+	.034 (.006)	.016 (.004)	.028 (.005)	.008 (.003)	.003 (.002)						.300	1.01	28
black spruce bog/swamp	.104 (.016)	.017 (.006)	.013 (.004)	.016 (.005)	.022 (.004)	.020 (.004)	.054 (.022)	.036 (.013)	.002 (.001)			.284	1.84	32
spruce island	.249 (.024)	.055 (.008)	.030 (.003)	.029 (.010)	.003 (.001)	.001 (<.001)						.367	1.45	42
tamarack swamp	.176 (.018)	.067 (.023)	.016 (.003)	.043 (.013)	.065 (.025)	.041 (.014)	.038 (.012)	.024 (.013)	.004 (.001)			.474	1.85	30
cedar-spruce swamp	.093 (.012)	.052 (.008)	.029 (.006)	.029 (.004)	.035 (.005)	.027 (.005)	.016 (.008)	.001 (.001)				.282	1.81	30
spruce swamp clearcut	.230 (.034)	.091 (.010)	.043 (.007)	.016 (.005)	.005 (.002)	.002 (.002)						.387	1.11	24
swamp thicket	.180 (.016)	.148 (.020)	.053 (.008)	.016 (.002)	.003 (.001)	.001 (.001)						.401	1.18	36
open fen	.115 (.021)	.007 (.002)										.122	.10	30
shrub fen	.224 (.028)	.052 (.010)	.010 (.005)									.286	.62	30
riparian hardwood	.202 (.036)	.057 (.009)	.023 (.004)	.018 (.004)	.020 (.004)	.032 (.010)	.049 (.014)	.042 (.008)	.057 (.015)	.041 (.017)	.001 (.001)	.542	2.00	24
upland	.083 (.022)	.069 (.023)	.028 (.006)	.020 (.004)	.014 (.003)	.024 (.005)	.054 (.023)	.025 (.004)	.021 (.004)	.011 (.003)	.003 (.002)	.357	2.12	30

*English units are used to facilitate comparison with other published studies.
#Numbers in parentheses represent 1 standard error.
+24 sampling points

AVIAN DISTRIBUTION AND RELATIVE ABUNDANCE

Census Methods

Bird censuses were conducted from the fourth week of May through the end of June in both 1978 and 1979. Thirteen of the 14 habitats were censused in both years; censuses on the spruce island study site were conducted only in 1979. All censuses were conducted from the line transects established through each habitat.

The census procedure required an observer to walk slowly along a line transect while detecting birds from visual or audio cues. Observers conducting censuses were rotated among the line transects to minimize potential observer bias. Each detected bird was identified to species and recorded in a manner to indicate sex (when possible) and method of identification--song, call, or actual observation. Singing males were designated as such on the census form. Each detection was also estimated to be within one of four distance intervals that indicated the right angle distance of the detected bird from the line transect. The intervals used were 0-15 m, 15-30 m, 30-60 m, and 60-120 m.

Censuses were initiated up to three-quarters of an hour before sunrise and lasted until up to two hours after sunrise to encompass the daily period of highest bird activity especially concerning vocalization rates. Censuses were generally conducted under climatic conditions deemed favorable--low winds and no precipitation--for both bird activity and detection of birds. Censuses in 1978, however, were conducted under a greater variety of conditions than during 1979. The number of censuses conducted on each line transect varied somewhat between transects and between years. The number of censuses per transect is indicated at

the end of table 4.

There are a wide variety of techniques available for estimating bird populations (see Robbins 1978 for review), each with its own advantages and disadvantages and assumptions. Trying to design one technique to estimate population levels for all the summer birds in the peatland study area would be difficult at best. We feel that the majority of the summer resident species in our study area can be treated with one of two techniques for estimating population levels, while the status of the remaining species may have to be determined by qualitative rather than quantitative techniques.

For those species where the males occupied territories and sang regularly for at least part of the census period, all singing males were assumed to be detected laterally from the transect to a distance of 60 m for most species but 30 m for some species with a softer song. This results in a belt 120 m (or 60 m) wide and as long as the length of the line transect through each habitat within which a complete count of singing males is assumed. This number can then be extrapolated for the number of singing males per 40 ha. This procedure is nearly identical to that proposed by Emlen (1977), who goes one step farther and applies a correction factor dependent upon the song frequency of each species.

Several species encountered did not fit the pattern necessary to apply the belt transect technique. Some, such as gray jay and black-capped chickadee, have early breeding seasons so that during our census activities the rate of male singing was reduced. In other cases males were relatively silent or else male vocalizations or songs could not be distinguished from other calls of that species. For this group of species, population estimates were based on the numerical pattern of

detections occurring in the lateral distance intervals (Balph et al. 1977). Detections of all individuals of each species, not just singing males, were utilized. The generalized equation for what we will call the Balph technique (Balph et al. 1977) is:

$$D = \frac{n}{1 \times d \times 2} \quad \text{where}$$

n = number of birds observed between transect line and outside edge of last interval used in density estimate,

D = density of birds,

l = length of transect,

d = width from transect to outside edge of last interval used in density estimate, and where the last interval used is the one which maximizes the density estimate.

The density figure can then be extrapolated to number of birds per 40 ha.

Population estimates were calculated for all detected species after each census. With the Balph technique all census results were then averaged to yield a final population estimate. This was not always the case for belt transect estimates. Some species (e.g., olive-sided flycatcher) appeared to sing intensively, or even regularly, for a shorter period of time than the approximately five-week census period. Certain species arrived early in the census period while others arrived later. Only those censuses conducted during the period of high song activity were averaged together for species that exhibited one of these patterns. In 1978 the lowest census estimate was normally omitted even for those species that appeared to sing regularly throughout the census period. This was done to reduce the effects of censusing a bird species under unfavorable climatic conditions. No censuses were omitted in 1979

since censuses were only conducted in what were thought to be ideal conditions--calm, no precipitation, and little cloud cover. It should be noted that while different species may have received different treatments with respect to estimating population levels, any data regarding a given species were treated identically between all habitats to make the population estimates between habitats comparable.

Any bird species detected within a given habitat during the census period should be considered as a potential, if not actual, breeding species. As time permitted we sought to confirm breeding status by searching for active nests, adults feeding young in or out of the nest, or recently fledged young. These are conservative criteria, although proper, for confirming breeding status, but the list should not be considered as complete. The list is intended, as much as for any other reason, to help fill some gaps concerning state-wide records of breeding bird distribution.

Results and Discussion

Distribution and Abundance by Habitats. Population and distribution data are presented in table 4 in a format intended to emphasize the distribution of each species across the range of habitats and for comparison between the two field seasons. There is little population change for the majority of species from 1978 levels to those of 1979. Those species that do show strong changes are discussed below. It will be left to the reader to survey the distributional patterns for most of the species in table 4. Additional comments are presented below, however, on the population levels and distribution patterns of selected species that are of special interest or for which the data presented in table 4 are lacking in detail.

TABLE 4
Relative Abundance of Bird Species by Habitats, 1978 and 1979

KEY

Units of abundance are number of singing males per 40 ha (100 acres) unless the species name in the left hand column is marked with *; units then are number of birds per 40 ha (100 acres).

Where a bird was detected in a habitat, there are two or three numbers. The first represents abundance, the second represents standard error, and the third, if present, represents the number of censuses used in computing the population estimate. The third is given only if it differs from the total number of censuses presented at the end of the table. Two examples are given below:

Examples from table		Explanation
	swamp thicket 1978	habitat
black-billed cuckoo	1 (.3) (8)	abundance: 1 singing male/40 ha standard error: .3 number of censuses used: 8
tree swallow* (blank)	2 (.7)	abundance: 2 birds/40 ha standard error: .7 number of censuses used is found at end of table * indicates use of Balph technique on this species

Other notation:

\+ species was detected but in abundance less than .5/40 ha; not included in summary statistics.

Δ species not detected on census, but netting data or other observations indicate that this species is a summer resident; not included in summary statistics.

Numbers in "confirmed breeding status" column refer to the habitats numbered across the top of the table.

Table 4.

	1 open bog		2 muskeg		3 stunted black spruce		4 stunted tamarack		5 black spruce bog/swamp		6 spruce island		7 tamarack swamp		8 cedar-spruce swamp		9 spruce swamp clearcut		10 swamp thicket		11 open fen		12 shrub fen		13 riparian hardwood		14 mixed conifer-deciduous upland		confirmed breeding status in
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1978	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	
American bittern																			+		1 (1.1) (2)	1 (.6) (2)							
mallard*			1 (1.0)						1 (1.0)								3 (2.7)			1 (1.1)	2 (1.2)	2 (1.2)							1,7 6
blue-winged teal*																					2 (1.6)								
broad-winged hawk*																											1 (.6)		
marsh hawk*																					+	+							
spruce grouse*					2 (.6) (10)	1 (1.2)							2 (1.4)		1 (1.2)														3,7
ruffed grouse*													1 (.4)		1 (.6)	1 (.6)	3 (2.7)		+	1 (.2)							1 (1.3)	6 (5.7)	
sharp-tailed grouse*	2 (2.4)				1 (.6)		1 (.5)				Δ																		6
sora																				+	2 (1.7) (3)	1 (.4)							
yellow rail																					2 (1.5) (2)	1 (.7)							
American woodcock																													
common snipe*		+	1 (1.0)				4 (2.5)												+	2 (1.1)	2 (1.6)	2 (1.1)	1 (.3)						11,2 4
Wilson's phalarope																							+						
black tern																					+								
mourning dove			1 (.5)				+	+							+	1 (.5)			1 (.4) (8)	1 (.5)							+		
black-billed cuckoo													+			+	1 (.8) (7)	2 (1.1)	1 (.3) (8)	4 (2.0)					4 (1.4)		+		10,6

Table 4 (cont.)

	1 open bog		2 muskeg		3 stunted black spruce		4 stunted tamarack		5 black spruce bog/swamp		6 spruce island		7 tamarack swamp		8 cedar-spruce swamp		9 spruce swamp clearcut		10 swamp thicket		11 open fen		12 shrub fen		13 riparian hardwood		14 mixed conifer-deciduous upland		confirmed breeding status in
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1978	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	
common flicker*							+										1 + (.5)		3 (1.3)								1 (1.0)	+	10
pileated woodpecker													+		+										+		+	+	
yellow-bellied sapsucker*																									1 (1.1)	3 (2.7)		1 (.6)	13
hairy woodpecker*													+		+										3 (2.0)		5 (1.6)	2 (2.3)	
downy woodpecker*																									2 (2.2)				
black-backed 3-toed woodpecker*													1 (.6)		2 (1.2) (4)	1 (.6)													8
eastern kingbird				+			+						+							+		+							
great crested flycatcher					+		+		+	+			+	+	1 (.2) 9	1 (.6)	1 (.8) 7	2 (1.0)	+	1 (.2)					1 (.5)	7 (1.4)	+	1 (.4)	
eastern phoebe															+										1 (.5)				
yellow-bellied flycatcher					7 (.5) (10)	3 (0)	2 (.4) (9)		4 (.4) (7)	3 (.7)	Δ		3 (.5) (8)	4 (.7)	8 (1.1) (9)	9 (1.3)															
alder flycatcher				+											+		25 (1.8) (3)	29 (6.0) (4)	13 (1.4) (5)	14 (2.2) (3)									9
least flycatcher													+					1 (.5)	2 (.9)	1 (.3) (8)					25 (4.8)	23 (4.1)	22 (3.4) (8)	13 (.7)	14
eastern wood pewee																				+					2 (.3)	8 (3.4)	3 (.4) (8)	7 (1.2)	
olive-sided flycatcher					1 (.3) (6)		1 (.2) (9)	+	1 (.3) (4)	+					+	1 (.2)	3 (1.3) (4)			+							1 (.4) (4)		
tree swallow*	+	1 (.3)	2 (.6)	1 (.4)	+		+		+						+		+	1 (.5)	2 (.7)	2 (.9)	3 (.6)	3 (.8)							11

Table 4 (cont.)

	1 open bog		2 muskeg		3 stunted black spruce		4 stunted tamarack		5 black spruce bog/swamp		6 spruce island		7 tamarack swamp		8 cedar-spruce swamp		9 spruce swamp clearcut		10 swamp thicket		11 open fen		12 shrub fen		13 riparian hardwood		14 mixed conifer-deciduous upland		confirmed breeding status in
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1978	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	
barn swallow*	+																				+								
gray jay*					3 (1.8)	12 (5.3)	1 (.4)	1 (.6)	3 (1.6)	8 (5.1)	Δ		11 (6.3)		4 (3.5)	3 (1.3)	1 (1.1)								6 (5.4)		1 (.6)		
blue jay*					+	1 (1.2)	1 (.3)	1 (.3)	3 (1.5)	5 (3.0)	3 (3.1)		1 (.6)	5 (1.2)	1 (.6)	2 (1.3)	1 (1.4)	4 (2.0)	6 (2.4)	2 (1.1)							2 (2.0)	1 (.4)	
black-capped chickadee*										1 (.5)			1 (1.3)	1 (.6)	1 (1.2)	2 (.9)			1 (.54)	Δ					1 (1.1)	1 (.7)	5 (2.6)	4 (1.9)	10,7
boreal chickadee*									3 (1.3)	2 (1.0)					+	1 (.7)													
white-breasted nuthatch*									+																1 (1.1)		+		
red-breasted nuthatch*									1 (.7)	+			+		1 (.4)	1 (.6)										1 (1.4)	2 (1.3)		
brown creeper*														1 (.6)	2 (1.2)	1 (1.2)									5 (2.3)				
house wren										+									2 (.4) (8)	3 (1.3)									10
winter wren										+			1 (.2) (8)	3 (.5)	1 (.2) (9)	3 (.8)													8
short-billed marshwren																	2 (1.6) (7)	12 (2.7)	+	13 (.9)	1 (.4) (9)	19 (4.5)	15 (2.9)	43 (6.6)					12
gray catbird																			2 (.6) (8)	2 (1.2)									
American robin										+					+	+			1 (.4) (5)	1 (.6)					+		+		8
wood thrush																									+	1 (1.4)			
hermit thrush				+	2 (.4) (10)	4 (1.2)	2 (.5) (10)	3 (.6)	2 (.3) (7)	2 (.4)	Δ		2 (.4) (8)	1 (.2)	1 (.3) (9)	2 (.5)				+								1 (.3) (8)	+	6

Table 4 (cont.).

	1 open bog		2 muskeg		3 stunted black spruce		4 stunted tamarack		5 black spruce bog/swamp		6 spruce island		7 tamarack swamp		8 cedar-spruce swamp		9 spruce swamp clearcut		10 swamp thicket		11 open fen		12 shrub fen		13 riparian hardwood		14 mixed conifer-deciduous upland		confirmed breeding status in
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1978	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	
Swainson's thrush									+	+			1 (.4) (8)	+	2 (.4) (9)	3 (.4)											1 (.4) (8)	1 (.6)	
veery										+			1 (.2) (8)	1 (.2)		+			13 (2.9) (8)	9 (1.9)					5 (1.3)	1 (1.4)		1 (.3)	
golden-crowned kinglet									5 (1.4) (7)	17 (4.8)						1 (.6)													5
ruby-crowned kinglet									1 (.3) (7)	4 (.9)	Δ				1 (.3) (9)														6
cedar waxwing*							+			2 (2.2)					3 (2.3)		14 (7.1)	4 (4.4)		4 (2.3)						27 (27)		2 (1.7)	
yellow-throated vireo															+													+	
solitary vireo					+					+					2 (.4) (8)	1 (.6)													
red-eyed vireo									1 (.3) (7)				3 (.7) (8)	3 (.8)	1 (.3) (9)	1 (.3)			1 (.3) (8)	4 (1.4)					47 (4.5)	63 (2.8)	14 (1.3) (8)	16 (2.1)	8
warbling vireo																			+						+				
black and white warbler									+	3 (1.5)			1 (.9) (8)	1 (.3)	3 (.5) (9)	6 (2.7)	+	4 (2.0)	6 (.6) (8)	14 (1.4)							+	+	
golden-winged warbler																	5 (1.7) (7)	2 (1.1)	1 (.3) (8)	1 (.7)									
Tennessee warbler																1 (.6)				4 (.8) (3)									
Nashville warbler				+	9 (1.4) (9)	8 (3.1)	13 (1.8) (10)	15 (1.6)	13 (1.1) (7)	17 (4.5)	21 (3.2)		20 (3.5) (8)	21 (3.3)	19 (1.5) (9)	24 (1.8)	22 (6.8) (7)	34 (6.8)	23 (2.9) (8)	25 (6.8)					1 (.5)	1 (.7)	5 (.8) (8)	8 (1.7)	10,7 8,6
northern parula													+		2 (.3) (9)	4 (1.1)													

Table 4 (cont.)

	1 open bog		2 muskeg		3 stunted black spruce		4 stunted tamarack		5 black spruce bog/swamp		6 spruce island		7 tamarack swamp		8 cedar-spruce swamp		9 spruce swamp clearcut		10 swamp thicket		11 open fen		12 shrub fen		13 riparian hardwood		14 mixed conifer-deciduous upland		confirmed breeding status in
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	
yellow warbler																			1 (.2) (8)	8 (2.2)						5 (0)			
magnolia warbler										1 (.8)						1 (.9)		1 (1.1)		+									8
yellow-rumped warbler				1 (.7)		2 (.6) (10)		4 (2.0)		2 (.2) (8)		1 (.4)		10 (2.4) (7)		17 (3.8)		5 (1.6) (2)		2 (.5) (8)		2 (1.3) (3)		3 (.2) (8)		3 (.8)		4 (2.4) (4)	+	3,7, 5
black-throated green warbler										2 + (1.1)						3 X (2.1)										1 + (1.4)		2 (.4) (8)	1 (.6)	
black-burnian warbler						+				5 (.8) (7)		5 (2.3)		1 (.3) (8)		2 (1.7)		1 (.2) (9)		1 (.3)								4 (1.0) (8)	5 (1.8)	
chestnut-sided warbler																+				7 (1.4) (8)		4 (1.1)				4 (.7)		+		
pine warbler																														1 (.6)	
palm warbler				5 (.8) (9)		7 (1.2)		4 (.7) (8)		6 (1.5)		8 (.7) (10)		8 (2.2)				17 (2.5)												2,3, 4,6
ovenbird						+				+				2 + (1.2)		+				+						19 (2.2)		32 (3.6) (8)	29 (4.3) (4)	
Connecticut warbler						3 (.9) (7)		6 (1.3)		5 (.8) (9)		11 (3.8)		4 (.8) (7)		5 (1.0)				14 (2.1) (8)		17 (1.1)		1 (.6) (9)		5 (1.6)				7
mourning warbler								+						1 (.3)												9 (1.0)		1 (.4) (8)	1 (.6)	
common yellowthroat				+						+				3 (.3) (8)		4 (1.1) (4)		3 (.6) (9)		2 (.4)		45 (8.9) (7)		33 (3.8) (4)		30 (3.8) (8)		35 (2.7)		1 (.4) (9)		1 (.3)		23 (4.4) (8)		2 (1.0)		1 (1.4)		+	10
Wilson's warbler																				4 (0) (2)										
American redstart																				+		+				1 (.5)				

Table 4 (cont.)

	1 open bog 1978	1979	2 muskeg 1978	1979	3 stunted black spruce 1978	1979	4 stunted tamarack 1978	1979	5 black spruce bog/swamp 1978	1978	6 spruce island 1978	1979	7 tamarack swamp 1978	1979	8 cedar-spruce swamp 1978	1979	9 spruce swamp clearcut 1978	1979	10 swamp thicket 1978	1979	11 open fen 1978	1979	12 shrub fen 1978	1979	13 riparian hardwood 1978	1979	14 mixed conifer-deciduous upland 1978	1979	confirmed breeding status in
bobolink	2 (.6) (10)	7 (2.1)																			14 (2.6) (8)	17 (2.6)	25 (2.5)	15 (2.2)					12,11
red-winged blackbird																			+	+	2 (.8)	25 (2.6)							
northern oriole																				+					1 (.7)		+		
Brewer's blackbird	2 (2.0) (10)	3 (1.1)																			+								1
common grackle																			Δ										
brown-headed cowbird*					1 (.29)		2 (.6)	3 (1.4)									4 (2.9)	4 (4.4)	11 (.8)	21 (6.2)					4 (4.4)	3 (0)	1 (.7)	1 (.4)	10,6
scarlet tanager													+												1 (.7)	1 (.7)	2 (.8) (8)	1 (.4)	
rose-breasted grosbeak																	1 (.5)		5 (.7) (8)	6 (1.2)					1 (1.4)				10
indigo bunting																									1 (.5)	1 (1.4)		+	
purple finch							+		+						1 (.2) (9)												1 (.3) (8)		
pine siskin*																	1 (.7)		1 (1.1)										
American goldfinch*			1 (.3)												1 (.6)														
red crossbill																											1 (.6)		
savannah sparrow	16 (1.7) (10)	35 (6.3)	10 (1.5) (9)	14 (1.5)			7 (1.2) (10)	3 (1.1)													9 (1.9)	2 (.8)							11,1
LeConte's sparrow		16 (2.9)	+					1 (1.0)									1 (.8) (7)				8 (2.3) (9)	6 (1.2)	10 (1.8)	14 (1.5)					12,11
sharp-tailed sparrow																					+	1 (.7)							

Table 4 (cont.).

	1 open bog		2 muskeg		3 stunted black spruce		4 stunted tamarack		5 black spruce bog/swamp		6 spruce island		7 tamarack swamp		8 cedar-spruce swamp		9 spruce swamp clearcut		10 swamp thicket		11 open fen		12 shrub fen		13 riparian hardwood		14 mixed conifer-deciduous upland		confirmed breeding status in
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1978	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	
dark-eyed junco			1 (.9)		7 (.7) (10)	5 (1.6)	1 (.3) (10)	2 (.7)	1 (.6) (7)	5 (.9)	1 (.6)		+	+	1 (.2) (9)	1 (.6)											+		5
chipping sparrow			1 (.4)		6 (1.6) (10)	8 (1.3)	6 (.8) (10)	7 (1.1)	2 (.5) (7)	+	+						8 (5.1)										1 (.4) (8)	+	3,4
clay-colored sparrow																	2 (1.0)				+	+	13 (2.9)	13 (2.3)					12
white-throated sparrow			+						+	1 (.2)	Δ		3 (.5) (8)	3 (.6) (4)	3 (.3) (9)	2 (.6)	14 (1.6) (7)	16 (3.9)	6 (.8) (8)	8 (.6)									8,9
Lincoln's sparrow			4 (1.1) (9)	6 (2.3) (3)		+	2 (.6) (10)	4 (1.9)			6 (1.3) (4)						+	5 (2.3)		1 (.3)		+		+					
swamp sparrow																	2 (1.0) (7)	•	13 (1.1) (8)	11 (2.1)	1 (.4) (9)		4 (.8)	4 (.6)					10
song sparrow													+				5 (1.9) (7)	2 (1.3)	1 (.4) (8)	+									
maximum no. of censuses	11	5	10	6	11	5	11	5	8	5	5		9	5	10	5	8	5	9	4	10	5	9	5	5	2	9	5	

mallard. While no quantitative estimates are available on the breeding density, we found nests in several habitats--open bog (3 nests), spruce island (1 nest), and tamarack swamp (1 nest). Broods were observed in swamp thicket and several ditches throughout the study area.

green-winged teal. While no green-wings were observed in the peatlands, small numbers of birds, including broods, were observed in wild rice fields. If wild rice cultivation is to be considered as a development of peatlands, further effort should be expended to document the effects on wildlife.

ring-necked duck. The ring-necked duck is commonly referred to as a duck of boggy, marshy areas (Marshall and Miquelle 1978). It is likely that our study sites contained too little open water to be attractive to ringnecks for we observed only one probable nesting pair over the two-year study. This pair occupied a flooded gravel pit. It should be noted, however, that neither our techniques nor the extensiveness of our areal coverage allow us to ascertain ring-necked duck populations over the vast Red Lake Peatland.

turkey vulture. Vultures were observed throughout the spring and summer period in small numbers. No definite statements can be made concerning use of peatlands in comparison to other upland sites.

gyrfalcon. Several observations made between December 1978 and March 1979 suggest that a gyrfalcon utilized the peatlands north of Waskish for foraging. It was seen on one occasion pursuing sharp-tailed grouse.

marsh hawk. One pair was regularly observed foraging over open fen areas. Observations of the birds regularly carrying food off in

the same direction, as towards a nest, indicate that it was a probable nesting pair.

spruce grouse. Spruce grouse habitat utilization in forested peatlands has been well documented by Haas (1974) and Anderson (1973). Most of the habitats they sampled can be cross-referenced with the ones sampled in this study. We found one spruce grouse nest in both stunted black spruce and tamarack swamp. Broods were observed in tamarack swamp and cedar-spruce swamp. Spruce grouse were not observed in any other habitats during the census period.

sharp-tailed grouse. That peatland habitats can be of value to populations of sharp-tailed grouse has been established by several researchers. Hanson (1953) considered muskeg to constitute a primary habitat for the northern race of sharp-tailed grouse, while the original range of sharp-tails in Wisconsin may have centered on the edges of open bogs as well as marshes and burns (Hamerstrom et al. 1952). While bogs and muskeg are recognizied as winter habitat in the northern lake states, it is generally thought that sharp-tails rely heavily on uplands during the remainder of the year (Marshall and Miquelle 1978).

In our study area sharp-tails are indeed present in the winter, but there is also a year-round population. Surveys of a 46.6 km^2 (18 mi^2) area during March-April 1979 revealed seven established dancing grounds. The survey area was centered along State Highway 72. Aerial surveys also indicated the presence of additional dancing grounds as far as 6.4 km from Route 72. Dancing grounds were located in open bog, muskeg, stunted tamarack, and shrub fen.

The value of the peatland to wintering sharp-tails is not well

understood. No density estimates were obtained nor is the composition of the population during this season understood. Grouse from upland areas may migrate to the peatlands to obtain winter food and cover. Since sharp-tailed grouse habitat elsewhere in Minnesota is threatened by the pressures of agricultural development, peatlands may become important refuges for the maintenance of sharp-tails.

sandhill crane. Sandhill cranes are of special interest in Minnesota and have been assigned by the DNR to the priority nongame bird list. Our studies were not extensive enough to adequately survey the crane population of the Red Lake Peatland. However, Doug Murphy, a graduate student at St. Cloud State University, Minnesota, has surveyed spring and summer crane populations in this region during the past two years. All of his sightings, including 12 pairs known or suspected to be territorial, occurred in fen habitats, not bogs. Cranes do nest in bog (i.e., sphagnum-dominated ground cover) habitats in northern Michigan, but the presence of open water is thought to be an important component of that habitat (Walkinshaw 1949) and may be a limiting factor in our study site.

yellow rail. Also assigned to the priority nongame bird list by the DNR, one yellow rail was heard calling from open fen habitat in both 1978 and 1979 in the same location. The approximate area was dragged with ropes in 1978 in an unsuccessful attempt to flush the bird or locate a nest. A yellow rail was flushed in 1979 and positive identification made. In both years the calling was sporadic and only heard during a two-week interval.

American woodcock. Use of the peatlands by woodcock is very limited and

appears to be confined to the vegetation zones associated with the spoil banks of road ditches and drainage ditches. During a 6.25 km (10 mi.) road survey conducted in mid-April 1978 along a section of highway that crosses several peatland habitats, nine displaying woodcock were detected. All birds appeared to be right along the roadside.

common snipe. Displaying snipe were most commonly observed over fen habitats and swamp thicket. Census results (table 4) indicate that shrub fen, open fen, muskeg, stunted tamarack, and swamp thicket are all utilized by snipe. One nest was located in open fen, and broods were observed in muskeg and stunted tamarack. The limited data we have on habitat use are in close agreement with the summary from previous studies presented by Marshall and Miquelle (1978).

Wilson's phalarope. Assigned to priority status by the DNR, the Wilson's phalarope is at the eastern limit of its Minnesota distribution when it is found in our study area. Densities are very low with only one possible breeding pair observed in open fen during the 1979 season. Limited observations suggest that the phalaropes may use the rice paddies to a greater extent than the peatlands, especially during migration.

barred owl. No density estimates are available, but barred owls were heard calling from stands of tamarack swamp.

great gray owl. No density estimates are available from our studies of the great gray owl, a priority status bird in Minnesota. Sporadic observations of one bird in the same locality through the spring and summer of 1978 suggest the possibility of a breeding pair. The bird was observed on the edge of a tamarack swamp stand, a habitat

reported to be nesting habitat (see Marshall and Miquelle 1978).

short-eared owl. As a priority nongame bird, the short-eared owl in the peatlands is noted only for its apparent absence. Only a few sightings occurred during spring migration and no sightings during the breeding season.

black-backed 3-toed woodpecker. Also assigned priority status, the black-backed 3-toed woodpecker was detected in tamarack swamp and cedar-spruce swamp in low densities. One nest was found in the cedar-spruce study site. Limited winter observations also indicate use of black spruce bog/swamp habitat.

yellow-bellied flycatcher. This is one of the species for which peatland habitats constitute a primary breeding habitat. The highest breeding densities were found in cedar-spruce swamp, and this species was also detected in stunted black spruce, black spruce bog/swamp, stunted tamarack, and tamarack swamp. These are all forested peatland habitats. We found no yellow-bellied flycatchers in stands dominated by alder or willows as some authors suggested as reviewed by Marshall and Miquelle (1978).

common raven and common crow. The raven and crow are not censused adequately by our techniques. No density estimates have been prepared. Both are year-round residents of the region, but their dependency upon peatland habitats was not determined.

boreal chickadee. The boreal chickadee demonstrated a narrow range of habitat use, occupying only black spruce bog/swamp and cedar-spruce swamp. The boreal chickadee reportedly prefers lowland conifer swamps for nesting habitat over upland, more xeric, sites.

short-billed marsh wren. This is the only species that showed a

dramatic population change from 1978 to 1979. The population increased in all occupied habitats in 1979. Patterns of abundance remained similar, however, with the highest density in shrub fen and the lowest in swamp thicket or spruce swamp clearcut.

golden-crowned kinglet. Dependent upon lowland conifer swamps for breeding habitat, the golden-crowned kinglet was detected in substantial numbers only in black spruce bog/swamp, where nesting was confirmed through the discovery of an active nest.

Tennessee warbler. The Tennessee warbler also showed population changes; no birds were detected during the 1978 census period while in 1979 birds were detected in two habitats in low densities. Swamp thicket had the highest population, a finding that agrees with previous summaries of habitat use (Marshall and Miquelle 1978).

Nashville warbler. The Nashville warbler has one of the widest distributions among the 14 habitats. It is also one of the most abundant birds. The highest densities occurred, however, in the forested peatland and deciduous shrub-dominated habitats excluding shrub fen.

palm warbler. The peatland contains what constitutes prime habitat for the palm warbler. The spruce island had the highest density while muskeg, stunted black spruce, and stunted tamarack were also occupied. All populated areas were forested, but tree height was generally not greater than 6 m. Prime habitat was densely stocked with black spruce. Marginal habitat also contained stunted tamarack.

Connecticut warbler. The Connecticut warbler is another species for

which peatlands comprise a primary habitat. Tamarack had the highest density while five other habitats were occupied, although it is questionable if spruce swamp clearcut actually constitutes a breeding habitat. The Connecticut warbler is generally considered a sought-after species by birdwatchers because of its narrow range of habitat occupation.

Wilson's warbler. Although not confirmed as a breeding bird in Minnesota, Wilson's warbler sightings occur nearly each summer (Green 1979). In 1978 a singing male was first observed on 28 June in swamp thicket, but no signs of nesting activity were subsequently found. Similarly, in 1979 three singing males were first detected on 24 June, also in swamp thicket. Subsequent visits produced no evidence of breeding activity.

Lincoln's sparrow. Another species for which peatlands contain primary nesting habitat, the Lincoln's sparrow reached its highest peatland density in muskeg and the spruce island. It also occupied habitats with sedge and grass cover such as stunted tamarack and spruce swamp clearcut.

Additional species should be expected to occur as residents or visitors during the winter season. Common and hoary redpoll, red crossbill, white-winged crossbill, pine grosbeak, and snow buntings were observed during limited periods of winter observations. Several of the birds discussed as summer residents are also present during the winter. These are gray jay, black-capped and boreal chickadee, black-backed 3-toed woodpecker, spruce grouse, and sharp-tailed grouse.

Table 5 presents several summary statistics for the 14 habitats

TABLE 5
Relative Avian Abundance Summary Statistics

HABITAT	no. of species 1978	1979	singing males per 40 ha[1] 1978	1979	birds per 40 ha[2] 1978	1979	estimated total birds per 40 ha[3] 1978	1979	bird species diversity 1978	1979	% of max. BSD value[4] 1978	1979
shrub fen	6	7	90	106	0	1	180	213	1.67	1.61	93	83
open fen	14	13	41	74	9	7	91	155	2.10	1.80	80	70
muskeg	4	11	19	31	2	4	40	66	1.16	1.68	84	70
open bog	4	5	20	61	2	1	42	122	.60	1.11	43	69
stunted black spruce	12	11	41	44	6	14	88	102	2.01	2.01	81	84
stunted tamarack	15	15	49	55	5	10	103	120	2.21	2.23	82	82
swamp thicket	23	31	126	176	21	35	273	387	2.39	2.85	76	83
tamarack swamp	17	20	57	67	2	19	116	153	2.10	2.35	74	78
black spruce bog/swamp	16	19	49	84	7	17	105	185	2.22	2.42	80	82
cedar-spruce swamp	26	32	54	76	15	14	123	166	2.62	2.78	80	80
spruce swamp clearcut	18	23	126	155	26	15	278	325	2.10	2.34	73	75
spruce island		6		50		3		103		1.39		77
upland	24	21	94	85	19	18	207	198	2.30	2.20	72	72
riparian hardwood	22	23	120	175	17	41	257	391	2.00	2.07	65	66

[1]sum of all species populations computed using belt transects
[2]sum of all species populations computed with Balph technique
[3]equals singing males/40 ha x 2, plus birds/40 ha
[4]BSD/(max. BSD); maximum BSD = ln (# of species)

under investigation. The estimated total number of birds per 40 ha is based on the assumption that each singing male obtains one and only one mate. Bird species diversity (BSD) was calculated using the Shannon formula (Shannon and Weaver 1949), where p_i represents the proportion that a given species' population represents out of the total population for a given habitat. This index is difficult to evaluate by itself and may possibly yield no more information than just the number of species (Tramer 1969). If the management goal is to maintain natural communities, then emphasis on high BSD values can be misleading (Balda 1975). In conjunction with other indices, however, BSD values can be instructive.

Cedar-spruce swamp was highest in number of bird species both years while swamp thicket, spruce swamp clearcut, upland, and riparian hardwood finished out the top five. The habitats lowest in bird species were muskeg and open bog in 1978 and open bog and spruce island in 1979.

Swamp thicket, spruce swamp clearcut, and riparian hardwood had the three highest estimates of total birds/40 ha in both years while shrub fen and upland also had consistently high densities. Lowest densities were found in muskeg and open bog in 1978 and muskeg in 1979.

BSD values seemed to be fairly equitable between the habitats (table 5). In 1978, 10 out of 13 values were 2.00 or above while in 1979, 9 out of 14 BSD values exceeded 2.00. The maximum limit to BSD values is set by the number of species detected. When viewing BSD values as a percent of the maximum possible within each habitat (table 5), most of the values are 75% or above. When the figure is much lower than this, it is possible to pick out a few species that numerically dominate a given habitat.

Degree of Similarity Between Habitats. Avian composition between habitats was compared through the use of a technique that quantitatively measures the species composition and abundance overlap for each pair of habitats (Horn 1966). The formula is:

$$R_o = \frac{\Sigma(x_i + y_i)\log(x_i + y_i) - \Sigma x_i \log x_i - \Sigma y_i \log y_i}{(X + Y)\log(X + Y) - X\log X - Y\log Y}$$

where in this case

R_o = overlap, ranging from 1 for habitats with identical species composition and abundance to 0 for completely distinct habitats,

x_i = the density of species i in habitat x,

y_i = the density of species i in habitat y,

X = the total population in habitat x,

Y = the total population in habitat y, and

i ranges from 1 to the total number of species present in habitats x and y.

After comparing all possible pairs of habitats, a matrix of overlap values was prepared for each year (tables 6 and 7), and dendrograms were constructed from the matrices that visually demonstrate degrees of similarity between the habitats (figs. 3 and 4). The dendrograms were constructed according to Cody (1974), where

$$C,AB = \frac{CA + CB}{2}.$$

This simply states that the overlap of C with A and B is equal to the average of the overlap of C with A and C with B.

From figure 4, then, we can see that in 1979 tamarack swamp and cedar-spruce swamp overlap at a level of .76 or are 76% similar regarding bird species composition and abundance. They, in turn, are most closely related to black spruce bog/swamp at a level of 0.65. This

TABLE 6
Matrix of Overlap Values Between Habitats Based on 1978 Bird Species Composition and Abundance.

	open bog	muskeg	stunted black spruce	stunted tamarack	black spruce bog/swamp	tamarack swamp	cedar-spruce swamp	spruce swamp clearcut	swamp thicket	open fen	shrub fen	riparian	upland
open bog	X	.58	.03	.31	0	0	0	0	0	.50	.13	0	0
muskeg		X	.15	.23	0	0	0	0	.04	.38	0	0	0
stunted black spruce			X	.79	.68	.52	.57	.22	.21	0	0	.06	.21
stunted tamarack				X	.42	.55	.49	.26	.27	.15	0	.07	.23
black spruce bog/swamp					X	.65	.63	.23	.26	0	0	.07	.37
tamarack swamp						X	.73	.40	.47	.03	.09	.23	.35
cedar-spruce swamp							X	.45	.43	.04	.10	.16	.31
spruce swamp clearcut								X	.69	.13	.36	.10	.12
swamp thicket									X	.10	.29	.23	.15
open fen										X	.53	.02	0
shrub fen											X	.05	0
riparian												X	.70
upland													X

TABLE 7
Matrix of Overlap Values Between Habitat Types Based on 1979 Bird Species Composition and Abundance

	open bog	muskeg	stunted black spruce	stunted tamarack	black spruce bog/swamp	spruce island	tamarack swamp	cedar-spruce swamp	spruce swamp clearcut	swamp thicket	open fen	shrub fen	riparian	upland
open bog	X	.48	0	.16	0	0	0	0	.01	.01	.38	.31	0	0
muskeg		X	.28	.52	.10	.45	.03	.07	.11	.09	.17	.02	0	0
stunted black spruce			X	.73	.62	.54	.64	.55	.31	.14	0	0	.10	.15
stunted tamarack				X	.44	.66	.52	.45	.42	.29	.09	.05	.07	.18
black spruce bog/swamp					X	.46	.63	.67	.33	.25	.02	0	.12	.25
spruce island						X	.42	.44	.40	.29	0	0	.03	.19
tamarack swamp							X	.76	.45	.38	.02	.08	.24	.39
cedar-spruce swamp								X	.43	.39	.02	.05	.13	.31
spruce swamp clearcut									X	.75	.17	.36	.16	.19
swamp thicket										X	.20	.36	.25	.26
open fen											X	.61	.01	0
shrub fen												X	.02	0
riparian													X	.77
upland														X

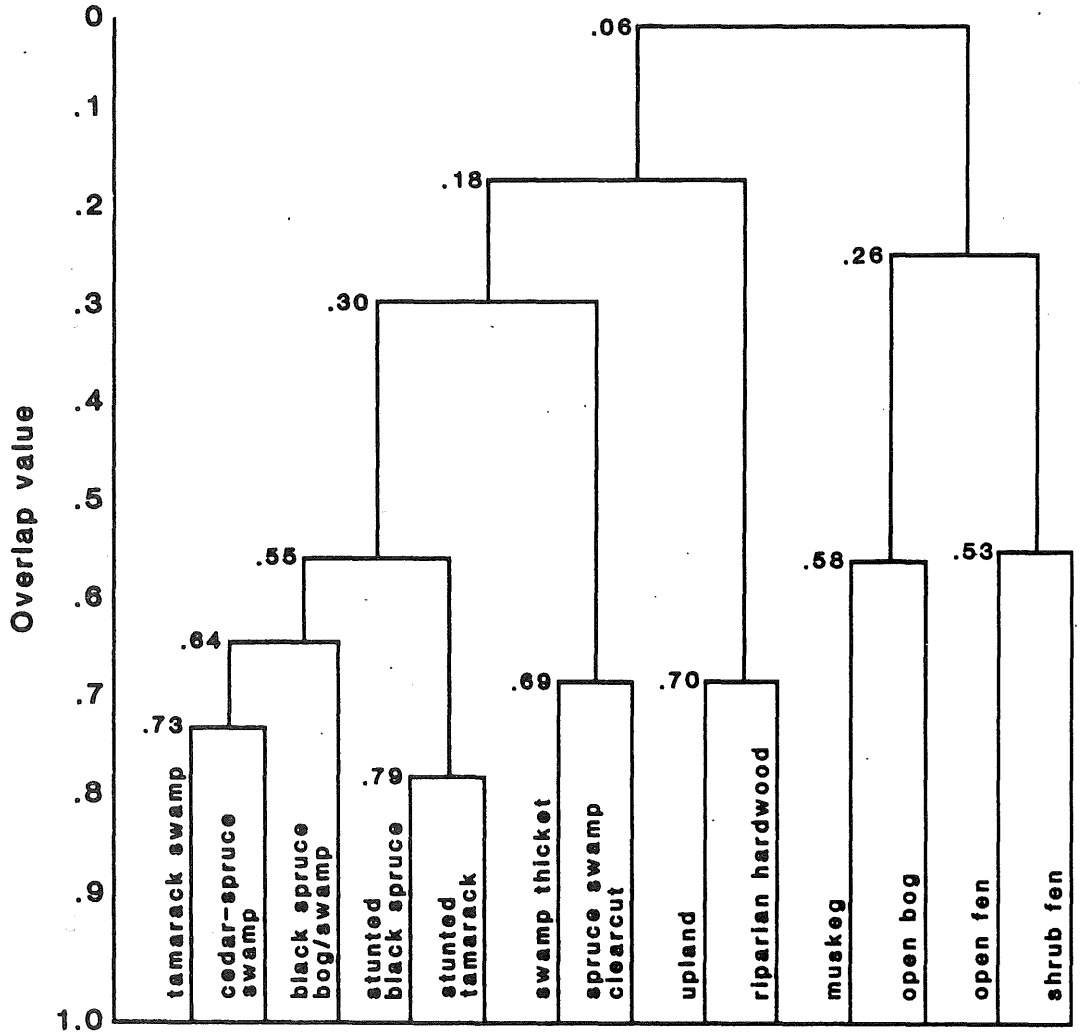

Figure 3. Dendogram of overlap between habitats based on 1978 bird species composition and abundance. Overlap ranges from 0 (completely distinct) to 1 (identical composition).

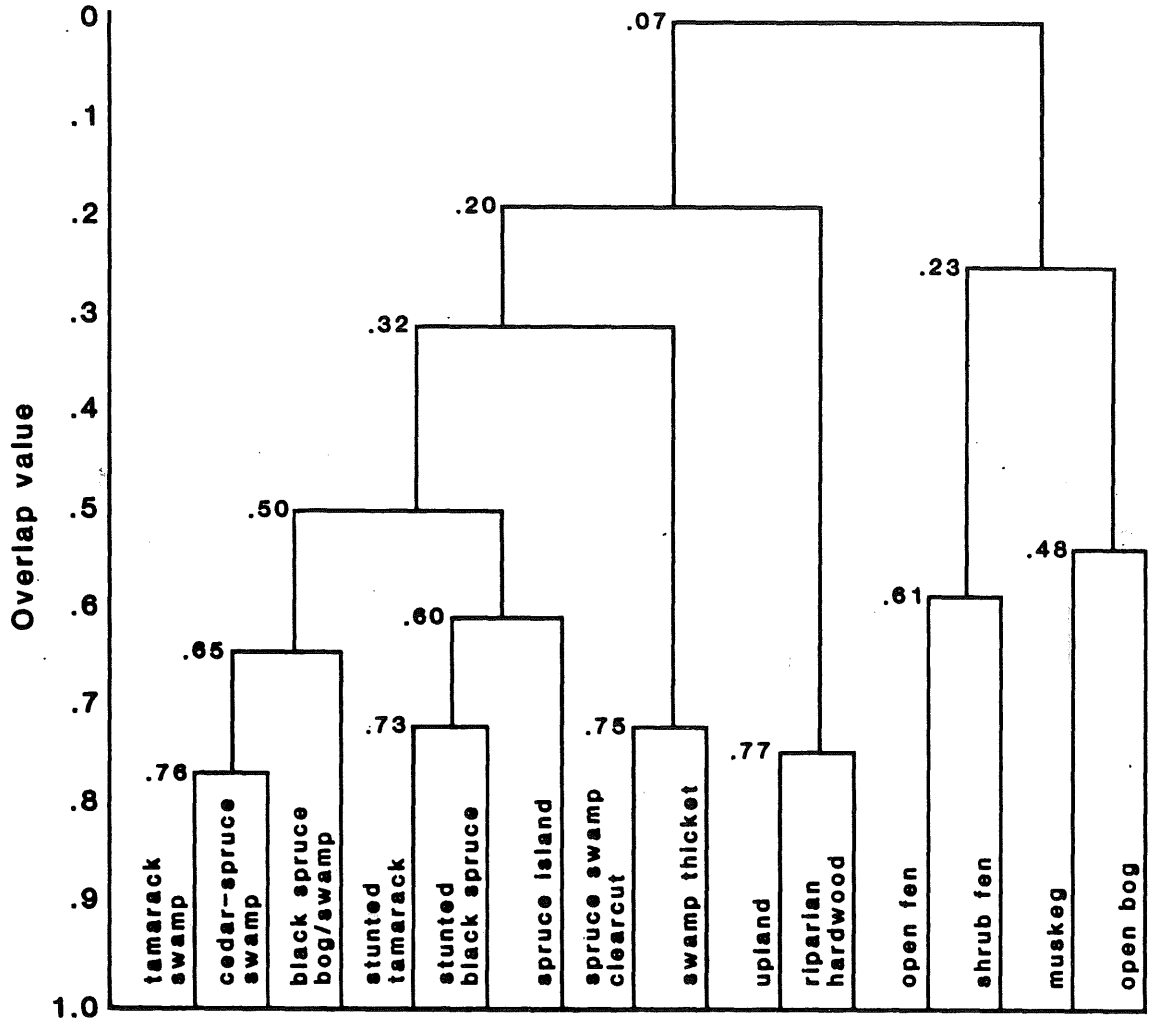

Figure 4. Dendogram of overlap between habitats based on 1979 bird species compostion and abundance. Overlap ranges from 0 (completely distinct) to 1 (identical composition).

group of three habitats then overlaps with another cluster of three habitats at a level of .50. The pattern of decreasing overlap continues until the final two clusters overlap at .07. The dendrograms based on the 1978 and 1979 data (figs. 3 and 4) are similar both in general pattern and actual numerical overlap figures. It is not difficult to separate the habitats into five clusters with the habitats in each cluster related to each other at .50 or higher. The five clusters are:

1. open fen
   shrub fen
2. muskeg
   open bog
3. upland
   riparian hardwood
4. spruce swamp clearcut
   swamp thicket
5. tamarack swamp
   cedar-spruce swamp
   black spruce bog/swamp
   stunted tamarack
   stunted black spruce
   spruce island

In terms of vegetational characteristics, these five clusters can be summarized as follows:

1. minerotrophic fens dominated by sedges and with a variable density of shrubs.
2. ombrotrophic, relatively treeless sites with a dense ericaceous shrub layer and a predominant ground cover of sphagnum mosses.
3. forested stands with mineral soil at the surface.
4. stands dominated by deciduous shrubs but with a peat soil surface.
5. forested peatland sites with varying degrees of minerotrophic influence.

By using these five clusters as starting points the avian composition of the habitats can be summarized. In so doing we point out dominant species in each cluster and the species, if any, that appear to separate

one habitat from another.

1. shrub fen-open fen. The high densities of bobolinks, short-billed marsh wrens, and LeConte's sparrows separate this grouping from most of the other habitats. Major differences between the two fen types include the presence of Savannah sparrow, red-winged blackbird, sora, yellow rail, American bittern, and mallard in open fen while clay-colored sparrow and swamp sparrow inhabit shrub fen. The common yellowthroat is present in both, although much more abundant in shrub fen.

2. open bog-muskeg. Open bog is a relatively simple community as reflected by several of the summary statistics. The low value of percent of maximum BSD value is largely attributable to the numerical dominance of this habitat by Savannah sparrows. This is one of the few species shared with muskeg, where it is also numerically dominant. Open bog is also characterized by Brewer's blackbird, which was not recorded in any other habitat. Muskeg contains palm warbler and Lincoln's sparrow, which, although not found in open bog, do occur in other habitats.

3. upland-riparian hardwood. While not always registering the highest values, these two habitats are consistently high in the various indices used in comparing the habitats (table 5) suggesting a higher productivity associated with these habitats. They were initially established to examine the differences in bird composition between relatively xeric, minerotrophic sites and peatland sites. Figures 3 and 4 show that the upland and riparian hardwood habitats are related to peatland habitats at a level of .20 or less. While the upland-riparian hardwood habitats may be more

productive, one should realize that there is a low overlap with the peatland sites, and the higher productivity figures of the uplands are often referring to different avian species associations.

The birds characterizing these minerotrophic habitats include least flycatcher, hairy woodpecker, eastern wood pewee, red-eyed vireo, ovenbird, mourning warbler, scarlet tanager, and brown-headed cowbird. The coniferous element in the upland contributes to the presence of yellow-rumped warbler, pine warbler, and black-burnian warbler.

4. swamp thicket-spruce swamp clearcut. These two habitats are among the most productive of the peatland habitats. Among the birds that separate this cluster from other transects are alder flycatcher, black-billed cuckoo, golden-winged warbler, and song sparrow. Shared with other forested habitats are black-and-white warbler, Nashville warbler, common yellowthroat, brown-headed cowbird, and white-throated sparrow. Swamp thicket was the only habitat harboring populations of house wren, gray catbird, yellow warbler, rose-breasted grosbeak, chestnut-sided warbler, and Wilson's warbler.

5. tamarack swamp, cedar-spruce swamp, black spruce bog/swamp, stunted tamarack, stunted black spruce, spruce island. These six forested peatland types are tied together by the common occurrence of gray jay, hermit thrush, Nashville warbler, yellow-rumped warbler, Connecticut warbler (not on spruce island), yellow-bellied flycatcher, and dark-eyed junco.

As habitats with slightly more minerotrophic influence than the other habitats in this cluster, tamarack swamp and cedar-spruce

swamp harbor populations of black-and-white warbler, common yellow-throat, and white-throated sparrow as do swamp thicket and spruce swamp clearcut. Tamarack swamp and cedar-spruce also overlap with populations of winter wren, black-backed 3-toed woodpecker and Swainson's thrush. Solitary vireo and northern parula populations were found only in cedar-spruce swamp. Golden-crowned kinglets are most numerous in black spruce bog/swamp while boreal chickadees occur both there and in cedar-spruce swamp. Stunted tamarack, stunted black spruce, and spruce island all have populations of palm warblers, while chipping sparrows are found most regularly in stunted tamarack and stunted black spruce.

Accuracy of Population Estimates

It is nearly impossible for us to state the accuracy of most of our bird species' population estimates. It is generally agreed that the spot-mapping method of estimating populations (International Bird Census Committee 1970) produces the most accurate results of the various census methods (Robbins 1978), and it is often used to compare the accuracy of other census methods (Emlen 1971). The spot-mapping method, however, is not without its own potential sources of error (Best 1975, Svensson 1974) and limitations (Nilsson 1977). Without banding and color-marking territorial birds, it is questionable whether the effort necessary to produce comparative spot-mapping population estimates is worthwhile when dealing with the large number of species involved in this study.

The estimation techniques selected for this study were among those reported to be reasonably accurate in comparison to spot-map results from a recent field study (Hickey and Mikol 1979). In only one instance are we able to test the accuracy of our belt census technique. Palm

warbler densities in the spruce island habitat were independently determined by Bruce Fall, a doctoral candidate at the University of Minnesota, through the use of mist-netting and color-banding. Our estimated density of 17 palm warbler males per 40 ha is nearly identical to the true population of 17 males occupying the 41 ha island. We realize, however, that our estimates are not always this accurate and that the accuracy level varies between species. Of the species listed in table 4 we feel that our estimates of white-throated sparrow and yellow-rumped warbler populations are conservative throughout all the habitats where they are detected. It is indeed likely that many of our estimates are on the conservative side, but this bias should be relatively constant for a particular species across all our habitats.

Additional difficulties arise when attempting to compare the results of this study with surveys of other peatland areas such as the work of Erskine, as summarized by Marshall and Miquelle (1978), in that the habitats are not always directly comparable. Erskine's open bog habitat is described as "open, fairly wet bog dominated by sedges and various willows" (Marshall and Miquelle 1978, p. 8), whereas our open bog had 100% ground cover by sphagnum and only a few black spruce seedlings present. The description of Erskine's tamarack habitat, however, suggests a close similarity to our tamarack habitat. A comparison of the common species between these habitats (table 8) shows generally close agreement.

Relationships Between Vegetation and Avian Population Parameters

Undoubtedly there is a large set of physical and vegetational conditions represented by our 14 habitats. Theoretically one could explain the distribution of a given bird species by its relation to a

TABLE 8
Comparison of Population Levels of Common Species
Between Tamarack Habitats

	NUMBER OF SINGING MALES PER 100 ACRES		
	Tamarack Habitat (summarized by Erskine in Marshall and Miquelle 1978)	Tamarack Habitat (this study)	
SPECIES		1978	1979
gray jay	1	0	11*
red-breasted nuthatch	2.5	2.5*	0
brown creeper	2.5	0	1*
winter wren	1	1	3
hermit thrush	2.5	2	1
Swainson's thrush	2.5	1	2.5
red-eyed vireo	8	3	5
Nashville warbler	25	20	21
black-and-white warbler	4	1	1
Connecticut warbler	2	14	17
yellow-rumped warbler	6	2	2
common yellowthroat	8	3	4
dark-eyed junco	2	2.5	2.5
white-throated sparrow	14	3	3

* number of birds per 100 acres

particular subset of physical and vegetational conditions. As an example of an initial attempt in this direction we computed a dendrogram illustrating the overlap (Horn 1966) between habitats (fig. 5) based on the foliage volume estimated at the various height levels (table 3). If the distribution and abundance of bird species were entirely dependent upon foliage volume patterns, then one would expect identical overlap patterns between habitats when based on bird species composition and abundance (figs. 3 and 4) and foliage volume (fig. 5). In fact, several contradictions to this pattern emerge. While shrub fen and muskeg are essentially identical with respect to foliage volume (fig. 5), they overlap less than .30 with respect to bird species composition and abundance (figs. 3 and 4). Upland and riparian hardwood have a high overlap with other forested peatland habitats based on foliage volume patterns but a low overlap based on bird species composition and abundance. It is clear in these cases that there are additional factors that would be necessary to explain the observed distribution patterns of bird species. Some habitat factors of possible predictive value might be plant species composition, height of water table, nature of ground cover, and nutrient status of runoff waters.

Vegetation parameters, such as foliage height diversity (FHD), may be of value in predicting avian population parameters such as bird species diversity (BSD), but BSD is an impersonal criterion with which to judge habitats. For example, if after some type of disturbance to a habitat, eastern bluebirds were replaced by starlings, BSD values might stay the same for that habitat and would not reflect the fact that a species of importance to management decision making was extirpated. At the species level, vegetation parameters such as FHD could be used to

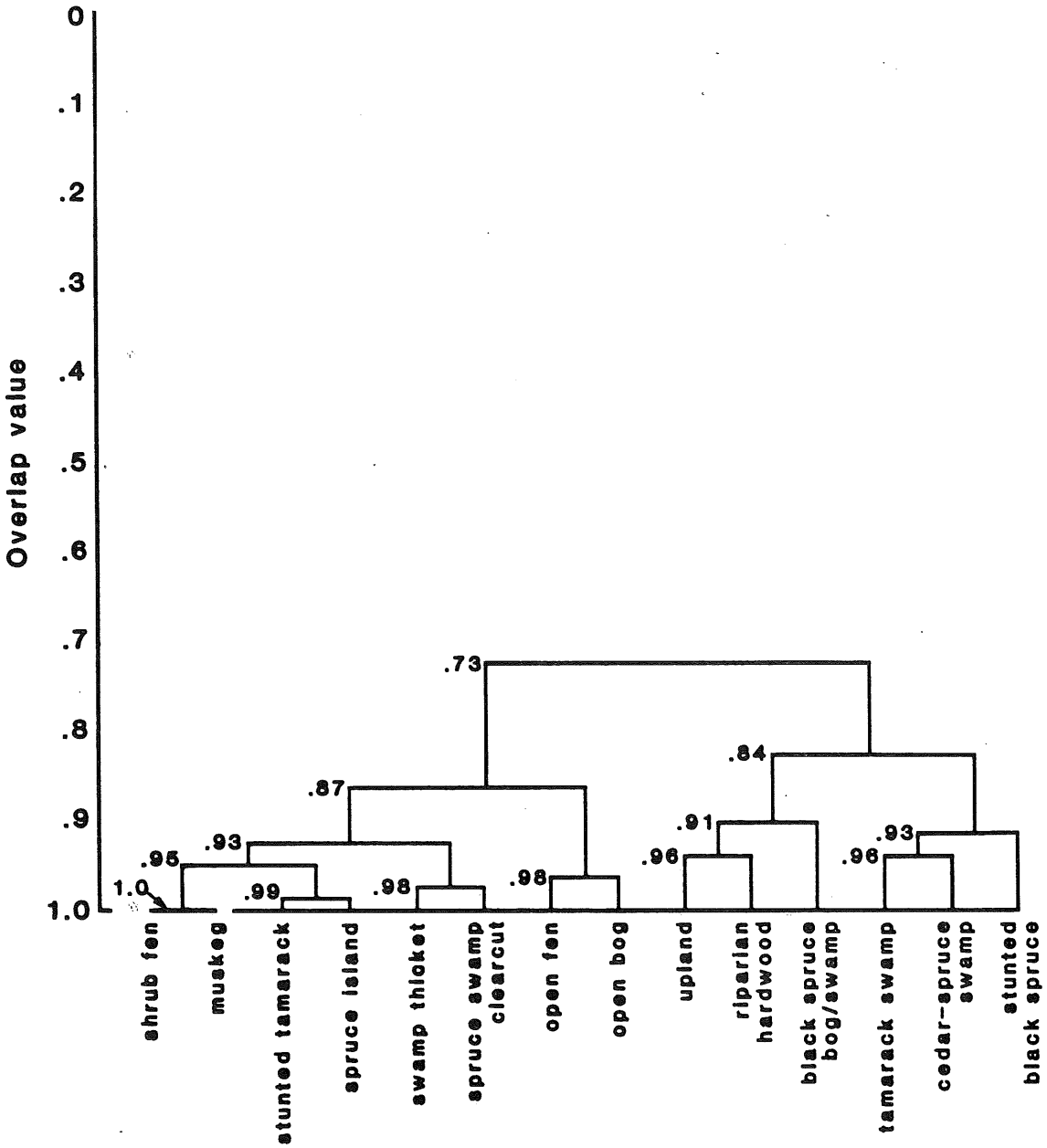

Figure 5. Dendogram of overlap between habitats based on foliage volumes estimated at selected height levels from table 3.

describe the distribution of individual species within the peatlands, but the described relationships would only be of predictive value when applied to other peatland habitats. Peatland development may produce a new set of physical and vegetation conditions for which previously calculated relationships between vegetation parameters and a given bird species may be invalid.

For the reasons noted above we have not developed an exhaustive presentation of quantitative relationships between bird species and vegetation parameters. The quantitative measurements of vegetation parameters presented are intended to aid the reader in identifying habitats to which avian population data apply.

MIST-NETTING AND BANDING

Objectives

Mist-netting and banding activities were originally designed to satisfy two primary objectives. One objective was to test the accuracy of our line transect population estimates by banding and color-marking certain species in selected habitats. Subsequent observations and mapping of marked birds would yield population estimates that could be compared to transect estimates. The second objective was to examine the utilization of selected habitats by avian species during spring and fall migration. The expected pattern of habitat use during migration was that a species would be captured at the highest rate in those habitats that were most similar to that species' breeding habitat (Parnell 1969).

Methods

Four net plots were originally established in spring 1978 in cedar-spruce swamp, spruce island, tamarack swamp, and stunted black spruce habitats. The net plots were located in the same stands where line transects were established for other sampling activities. Each net plot consisted of a grid where the points of intersection of the grid lines were spaced a distance of 50 m. The points of intersecting grid lines served as a reference point from which to select a suitable site to erect a mist net. Each mist net measured 12 m by 2.6 m and had a mesh size of 30 or 36 mm. Forty-five nets were originally erected in cedar-spruce swamp and stunted black spruce, and 35 were put up in spruce island and tamarack swamp. Additional nets were gradually added in spruce island so that 56 nets were present by early summer.

Netting was normally conducted during morning hours or, at times

when cool weather permitted, through the afternoon. After initial opening of the nets, each was checked about every hour, and captured birds were returned to a centrally located banding station for processing. All birds caught were banded with the proper size U.S. Fish and Wildlife Service aluminum band (some were color-marked in addition), and data were recorded regarding age, weight, sex, breeding condition, and molt.

The number of birds captured by mist netting was standardized by converting this figure to birds caught per net hour. Net hours were determined on a daily basis; for example, if 35 nets were open a total of four hours, the total net hours for that day would be 4 x 35 = 140. If during the course of that day 15 birds were captured (excluding recaptures), the standardized birds/net hour figure would be 15/140 = 0.107. To make these values easier to work with, we multiplied by 100 to yield birds/net hr. x 100.

Results

Spring 1978. All four established net plots were sampled by mist netting during spring 1978 (table 9). The largest number of species (30) was caught in spruce island, which also had the highest birds/net-hour (table 10). The lowest number of species was caught in stunted black spruce and tamarack swamp, 11 and 12 species respectively. The lowest rate of capture occurred in stunted black spruce.

It is possible that the between-habitat differences in capture rates and in the species composition of the catch are due in some part to differences in the structure of the vegetation and the foliage volume at this season. Simply put, nets in tamarack swamp may not have been as concealed to migrants as nets in spruce island. While we cannot

TABLE 9
Schedule of Netting Activities During Migration

Season	Inclusive Netting Dates	Habitats Netted	# of Times Netted
spring 1978	3 May-31 May	cedar-spruce swamp	9
		spruce island	8
		tamarack swamp	5
		stunted black spruce	6
fall 1978	20 Aug.-6 Sept.	spruce island	7
		tamarack swamp	6
		cedar-spruce swamp	3
spring 1979	28 April-25 May	spruce island	13*
		swamp thicket	12

* includes 10 days on which netting was also done in swamp thicket

rule out this possibility, the capture figures certainly support the impressions of migrant use gained by field observation. Also, certain species, e.g., palm warbler, exhibit patterns that do not conform to any simple predictions based on habitat differences in structure of foliage volume. If migrating palm warblers were selecting tall vegetation, the greatest number of captures would be expected in tamarack swamp or cedar-spruce swamp. If they were selecting for foliage volume, spruce island and cedar-spruce swamp would be selected. Out of 69 palm warblers captured, however, 39 (57%) were captured in spruce island, a

TABLE 10
Capture Results from Mist Netting During Three Seasons[1]

SPECIES	habitat in which bird is summer resident[2]	SPRING 1978								FALL 1978						SPRING 1979			
		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		4 stunted black spruce		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		3 spruce island		5 swamp thicket	
		birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net/hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured
black-billed cuckoo	5																	.06	1
ruby-throated hummingbird	5															.03	1		
yellow-bellied sapsucker																.03	1		
downy woodpecker														.07	1				
eastern phoebe														.07	1			.06	1
yellow-bellied flycatcher	1,2, 3,4	.46	7			.13	2	.08	1	.15	1					.03	1		
alder flycatcher	5					.13	2			.15	1			.26	4				

TABLE 10 (cont.)

SPECIES	habitat in which bird is summer resident[2]	SPRING 1978								FALL 1978						SPRING 1979			
		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		4 stunted black spruce		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		3 spruce island		5 swamp thicket	
		birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net/hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured
least flycatcher	2,5			.12	1	.06	1					.09	1	.20	3	.03	1	.88	14
gray jay	1,2,4	.07	1					.25	3	.15	1	.09	1						
blue jay	1,2,3,4,5	.20	3	.23	2	.13	2			.15	1	.17	2			.03	1	.13	2
black-capped chickadee	1,2,5			.35	3					.31	2	.17	2	.20	3			.56	9
boreal chickadee	1							.17	2										
red-breasted nuthatch	1													.13	2				
brown creeper	1,2													.13	2	.03	1		
house wren	5																	.38	6

TABLE 10 (cont.)

	habitat in which bird is summer resident[2]	SPRING 1978								FALL 1978						SPRING 1979			
		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		4 stunted black spruce		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		3 spruce island		5 swamp thicket	
SPECIES		birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net/hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured
winter wren	1,2	.13	2																
gray catbird	5															.03	1	.25	4
American robin	1,5	.13	2											.13	2				
wood thrush	1	.07	1																
hermit thrush	1,2, 3,4	.07	1	.58	5	.51	8	.50	6	.92	6			.26	4	.29	9	.25	4
Swainson's thrush	1,2	.46	7	.12	1	.13	2	.06	1	1.07	7	.26	3	.59	9	.20	6	.31	5
gray-cheeked thrush														.07	1	.20	6	.38	6
veery	5			.12	1	.06	1			.15	1			.13	2	.03	1	1.69	27
golden-crowned kinglet	1	.20	3							.31	2					.03	1		

TABLE 10 (cont.)

	habitat in which bird is summer resident[2]	SPRING 1978								FALL 1978						SPRING 1979			
		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		4 stunted black spruce		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		3 spruce island		5 swamp thicket	
SPECIES		birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net/hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured
ruby-crowned kinglet	1,3	.20	3			.51	8			.31	2			.07	1	2.06	63	2.01	32
solitary vireo	1	.26	4							.15	1	.26	3	.39	6	.07	2		
red-eyed vireo	1,2,5	.13	2			.06	1			1.07	7	1.46	17	.20	3				
Philadelphia vireo																		.06	1
black and white warbler	1,2,5	.20	3			.13	2					1.97	23	.33	5	.23	7	1.76	28
Tennessee warbler	1,5									.15	1	3.60	42	6.43	98	.03	1	.25	4
orange-crowned warbler						.32	5							.07	1	.72	22	.63	10

TABLE 10 (cont.)

SPECIES	habitat in which bird is summer resident[2]	SPRING 1978								FALL 1978						SPRING 1979			
		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		4 stunted black spruce		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		3 spruce island		5 swamp thicket	
		birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net/hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured
Nashville warbler	1,2,3,4,5	2.36	36	.47	4	1.72	27	.08	1	1.53	10	26.24	306	6.49	99	.72	22	2.32	37
northern parula	1															.03	1		
yellow warbler	5															.03	1	.13	2
magnolia warbler	1	.20	3			.19	3					.17	2	.33	5	.36	11	.44	7
Cape May warbler										.15	1	.26	3	.66	10				
yellow-rumped warbler	1,2,3,4	.46	7	1.17	10	1.02	16	.59	7	.77	5	4.89	57	4.46	68	.59	18	1.32	21
black-throated green warbler	1					.13	2									.07	2	.06	1

TABLE 10 (cont.)

	habitat in which bird is summer resident[2]	SPRING 1978								FALL 1978						SPRING 1979			
		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		4 stunted black spruce		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		3 spruce island		5 swamp thicket	
SPECIES		birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net/hours	total captured	birds/100 net-hours	total captured	birds/100. net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured
black-burnian warbler	1,2					.06	1					.26	3						
chestnut-sided warbler	5					.13	2												
bay-breasted warbler						.19	3					1.03	12	1.64	25	.07	2		
blackpoll warbler						.25	4					.17	2	.39	6	.42	13	.56	9
palm warbler	3,4			2.68	23	2.48	39	.59	7	.15	1	.34	4	8.79	134	2.68	82	1.38	22
ovenbird		.13	2			.25	4			.15	1	.09	1	.58	4	.13	4	.19	3
northern waterthrush						.06	1			.61	4	.17	2	.20	3	.10	3	1.63	26
Connecticut warbler	1,2, 3,4			.47	4	.13	2	.06	1			.26	3	.20	3	.03	1		

TABLE 10 (cont.)

	habitat in which bird is summer resident[2]	SPRING 1978								FALL 1978						SPRING 1979			
		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		4 stunted black spruce		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		3 spruce island		5 swamp thicket	
SPECIES		birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net/hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured
common yellowthroat	1,2,5	.07	1	.12	1	.06	1					.34	4	.07	1	.10	3	3.07	49
Wilson's warbler	5															.42	13	.94	15
Canada warbler												.09	1			.03	1	.13	2
American redstart	5	.07	1			.19	3					.94	11	.59	9	.85	26	2.20	35
brown-headed cowbird	1,2,3,4,5					.06	1											.13	2
rose-breasted grosbeak	5													.13	2	.03	1	1.07	17
savannah sparrow																		.06	1
dark-eyed junco	1,3,4	.26	4					.25	3	.61	4			.20	3	.03	1		

TABLE 10 (cont.)

	habitat in which bird is summer resident[2]	SPRING 1978								FALL 1978						SPRING 1979			
		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		4 stunted black spruce		1 cedar-spruce swamp		2 tamarack swamp		3 spruce island		3 spruce island		5 swamp thicket	
SPECIES		birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net/hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured	birds/100 net-hours	total captured
chipping sparrow	4					.06	1	1.26	15			.17	2	.52	8	.23	7		
clay-colored sparrow														.20	3	.03	1		
white-crowned sparrow		.06	1			.06	1											.06	1
white-throated sparrow	1,2, 3,5	.46	7	.82	7	.57	9			.31	2			.13	2	.07	3	.63	10
Lincoln's sparrow	3					.19	3					.09	1	.13	2	.07	2	.06	1
swamp sparrow	5															.03	1	.63	10
song sparrow	5															.03	1		

TABLE 10 (cont.)

	SPRING 1978				FALL 1978			SPRING 1979	
	1 cedar-spruce swamp	2 tamarack swamp	3 spruce island	4 stunted black spruce	1 cedar-spruce swamp	2 tamarack swamp	3 spruce island	3 spruce island	5 swamp thicket
number of species	22	12	30	11	21	25	36	41	36
total birds per 100 net-hours	6.63	7.23	9.90	3.94	9.34	43.57	35.39	11.27	26.9
total net-hours	1523	857	1570	1194	653	1166	1525	3060	1594

[1]Recapture data are excluded from this table.
[2]Figures in this column refer to the figures at the heads of the habitat columns.
*indicates species that are strictly migrants; all other species breed locally.

thick stand of short trees, while 23 (33%) were captured in tamarack swamp where there was virtually no foliage yet. A habitat seemingly intermediate in structure and foliage volume--cedar-spruce swamp--was not utilized at all by migrants during the sampling period. In summary, then, it is likely that the habitat use patterns during migration, as detected by our netting activities, demonstrate a response by the migrants to some factor(s) other than the degree to which the nets were concealed by vegetation.

The four habitats sampled by netting attracted migrant species other than those known to breed or reside during the summer within each respective habitat (table 10). Of the 30 species netted in spruce island, 17 species were not observed to reside there in the summer but did breed locally. These 17 species account for 22% of the total number of birds netted in spruce island. Two other species were strictly migrants. Only 2 out of 22 species in cedar spruce swamp bred locally but not in cedar-spruce swamp (3% of total individuals netted). In tamarack swamp 2 out of 12 species fit this same pattern (39% of total individuals), while in stunted black spruce 2 out of 11 species (6% of total individuals) bred locally but not in this habitat.

Spring 1979. During spring 1979, netting was conducted only in spruce island and swamp thicket. These two habitats are structurally similar with respect to height of vegetation and volume of foliage (see fig. 2) but have little overlap with respect to plant species composition. At the time of netting, the foliage in swamp thicket was only beginning to leaf out. Pools of water from snow melt were common in both habitats. Netting activities were concentrated on days when weather conditions were suitable for movement of migrants from the

south. The two habitats were netted simultaneously on 10 occasions (table 9), in order to examine the possible preference for one habitat over the other by migrants.

Spruce island had a higher number of species captured (table 10), but this advantage of five species may be related to the greater number of net-hours accumulated on spruce island. Capture rates in swamp thicket, however, were over twice that recorded in spruce island.

Of the 36 species captured during migration in swamp thicket, 18 are known to breed or reside in this habitat during the summer (this study). This leaves 15 other species that utilized this habitat only as migrants but still bred locally (32% of the total individuals caught) and three strictly migrant species (4% of the total). In spruce island, 28 species that were captured as migrants do not reside there in the summer but do breed locally. This amounted to 33% of the total individuals captured in this habitat. An additional two species (8% of the total) that were captured are strictly migrants.

Fall 1978. Netting activities did not continue for the whole of the fall migration period but only encompassed the initial waves of migrants to move south. Netting activities were conducted in the spruce island, tamarack swamp, and cedar-spruce swamp net plots. The largest number of species, 36, was observed in spruce island (table 10). Tamarack swamp and cedar-spruce swamp were similar with 21 and 25 species respectively. Capture rates, however, were highest in tamarack swamp, a marked contrast to the situation that existed in spring 1978 when these three habitats were also netted. While tamarack swamp was all but ignored in spring 1978 by migrants of several species, this habitat was heavily utilized in fall 1978. Species captured in large

numbers included black and white warbler, Tennessee warbler, Nashville warbler, and yellow-rumped warbler. Conversely, the species that was captured in tamarack swamp in the highest numbers in spring 1978, the palm warbler, all but ignored this same habitat in fall 1979. Habitat utilization by migrant birds is obviously not a static situation but rather a dynamic one.

Of the 21 species captured in cedar-spruce swamp, all but six species were summer residents of this habitat (table 10). Migrant individuals of these six species, which bred locally, accounted for 15% of the total catch. In tamarack swamp, 13 of 25 species captured bred locally but not in this habitat. These 13 species accounted for 17% of all the individuals captured. In spruce island, 26 of 36 species bred locally but not in this habitat; 41% of the individuals captured were in this category. An additional two species captured (0.4% of total individual) were strict migrant species and were not known to breed in the area.

The population turnover during the period of fall netting was large as indicated by the small number of recaptures of the most commonly netted species in tamarack swamp and spruce island (table 11). Recaptured birds showed no consistent patterns with respect to weight change between captures. Migration may not have been advanced enough for the birds to be in a physiological stage promoting fat accumulation in preparation for migration. Three out of the four most common species netted on spruce island showed little evidence of fat accumulation (table 12). It is not known how extensive the movements were that resulted in the large population turnovers observed, but it is clear that large numbers of birds do utilize these habitats during this stage

TABLE 11
Number of Birds Recaptured During Netting Activities, Fall 1978,
and
Average Weight of Birds Recaptured

Species	Habitat	No. of Recaptures	Avg. Wt. Change (gm)
Tennessee warbler	spruce island	8	+.33
	tamarack swamp	0	---
palm warbler	spruce island	10	-.23
Nashville warbler	spruce island	2	+.15
	tamarack swamp	6	+.02
yellow-rumped warbler	spruce island	7	-.1
	tamarack swamp	1	not recorded

TABLE 12.
Stages of Fat Accumulation in the Four Most Abundant
Species Netted on the Spruce Island, Fall 1978

	fat category				
	(no fat)				(very fat)
species	0	1	2	3	4
Tennessee warbler	39	33	17	8	0
palm warbler	115	11	1	1	1
Nashville warbler	66	10	3	0	0
yellow-rumped warbler	53	4	0	0	0

of migration.

Summer 1978. During the 1978 breeding season, we continued to net in spruce island, tamarack swamp, and cedar-spruce swamp on an irregular basis. The time devoted to netting, color-marking, and observing marked birds was not sufficient to enable us to compute bird populations for comparison with line transect estimates. However, these activities did enable us to document the presence of a few species that were not detected from line transect censuses. All species captured during netting are summarized in tables 13, 14, and 15.

Netting during this time period also revealed another period of bird movement prior to fall migration. This pattern is most evident on spruce island (fig. 6) and is due largely to post-fledging movements of palm warblers (fig. 7). Since the majority of palm warblers that were fledged on the spruce island study plot were banded before fledging by Bruce Fall, we were able to tell that palm warblers were moving into (and presumably out of) our study site from other breeding sites nearby.

We cannot say with certainty that the increased capture rates observed before fall migration in the other net plots (figs. 8-10) are not due just to the recent fledging of young of the on-site breeding species. We do suspect, however, extensive post-fledging wandering by young of several species.

Conclusions

Mist-netting activities were initiated with two main objectives in mind. One was to capture and mark sufficient numbers of birds through the breeding season in order to derive a second estimate of the breeding bird population. This aspect of the study was largely unsuccessful on the large-scale originally intended but did yield some comparative data

TABLE 13
Bird Species Netted in Spruce Island Net Plot, 1978

SPECIES	MAY								JUNE									JULY							AUGUST									SEPT.
	7	11	13	16	19	21	23	28	2	7	11	14	15	18	21	23	24	3	7	16	20	24	27	31	6	7	10	13	20	22	25	28	30	31	6
palm warbler	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
myrtle warbler	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x	x
hermit thrush	x	x		x	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x	x		x	x	x		x		x	x	x	x		x
ruby-crowned kinglet		x	x	x	x		x	x	x	x	x											x	x	x											x
orange-crowned warbler		x	x	x	x																														x
northern waterthrush		x																														x	x		
black and white warbler		x		x					x		x			x							x	x	x	x		x	x	x	x		x	x			x
blackpoll warbler		x				x	x	x																								x	x	x	
chipping sparrow		x																													x	x	x		x
Nashville warbler			x	x	x	x	x	x	x	x	x				x		x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x
ovenbird			x		x														x												x	x			x
white-throated sparrow			x	x	x	x	x	x				x					x	x	x	x	x		x							x	x	x		x	
black-throated green warbler			x			x																								x	x	x			
Lincoln's sparrow				x			x								x			x	x	x				x	x	x		x	x		x	x			
veery				x											x		x	x	x						x							x			
Swainson's thrush					x														x	x											x	x	x		
Connecticut warbler					x																x				x			x		x		x			
bay-breasted warbler					x	x	x																							x	x	x	x	x	x
least flycatcher						x				x									x			x		x	x	x					x				x
common yellowthroat						x														x						x			x						
magnolia warbler						x	x					x																		x					x
yellow-bellied flycatcher							x	x	x	x	x				x					x		x					x								
chestnut-sided warbler							x							x																	x	x		x
American redstart							x					x																x		x					x
red-eyed vireo							x												x									x		x					x
brown-headed cowbird							x										x	x	x																
white-crowned sparrow							x																												
Traill's flycatcher								x	x								x		x							x		x			x	x			
blackburnian warbler								x																		x									
blue jay												x																							
rose-breasted grosbeak												x																				x			
gray catbird																	x																		
cedar waxwing																	x																		
savanna sparrow																		x					x												
clay-colored sparrow																	x	x			x	x	x	x	x										
black-billed cuckoo																		x																	
American robin																			x				x			x						x			x
American goldfinch																			x																
dark-eyed junco																			x																
song sparrow																					x														
yellow warbler																						x	x												
solitary vireo																											x					x		x	x
scarlet tanager																									x						x				
Tennessee warbler																												x			x	x	x		x
downy woodpecker																															x				
eastern phoebe																															x				
brown creeper																															x				
Cape May warbler																															x	x	x	x	x
red-breasted nuthatch																																x		x	
black-capped chickadee																																	x	x	x
gray-cheeked thrush																																	x		

TABLE 14
Bird Species Netted in Tamarack Swamp Net Plot, 1978

SPECIES	MAY					JUNE					JULY			AUGUST						SEPT.
	13	16	18	22	27	2	5	10	13	17	15	22	29	5	21	23	24	27	29	3
hermit thrush	x	x		x	x		x	x	x		x		x							
Nashville warbler	x			x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
myrtle warbler	x		x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x
palm warbler																	x		x	
least flycatcher		x																		
blue jay		x								x	x					x	x			
black-capped chickadee		x		x			x	x						x		x		x	x	
white-throated sparrow			x	x	x	x	x		x		x	x	x	x						
Swainson's thrush					x		x	x												
veery					x															
Connecticut warbler					x		x			x	x	x		x	x	x	x			
yellowthroat					x										x		x			
yellow-bellied flycatcher							x	x	x											
Traill's flycatcher											x	x								
red-breasted nuthatch											x									
robin												x								
dark-eyed junco												x								
gray jay															x					
red-eyed vireo															x		x	x		x
black and white warbler															x	x	x	x	x	
Tennessee warbler															x		x	x		x
parula warbler															x					
bay-breasted warbler															x		x	x		
ovenbird															x		x			
northern waterthrush															x		x			x
Lincoln's sparrow															x					
magnolia warbler																x		x		
solitary vireo																	x	x		x
Cape May warbler																	x	x		
blackburnian warbler																	x	x		
chipping sparrow																	x			
blackpoll warbler																			x	x

TABLE 15

Bird Species Netted in Cedar-Spruce Swamp Net Plot, 1978

BIRD SPECIES (in order of first appearance)	MAY									JUNE					JULY			AUGUST				
	3	10	12	14	17	19	20	24	31	4	7	11	14	19	14	17	26	2	8	22	26	28
ruby-crowned kinglet	x			x				x						x								
myrtle warbler	x		x	x			x	x			x	x		x		x	x			x	x	x
Nashville warbler	x		x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
gray jay		x						x					x	x				x	x	x		x
blue jay	x	x	x																			
winter wren			x							x												
magnolia warbler			x						x													
solitary vireo			x					x	x		x						x			x		
white-throated sparrow			x	x	x	x	x		x			x		x	x	x	x			x		
dark-eyed junco				x	x			x	x	x	x	x			x			x	x		x	x
black and white warbler					x				x					x	x		x	x	x			
ovenbird					x	x										x	x		x			x
Swainson's thrush				x	x			x		x	x			x	x	x	x				x	x
hermit thrush					x							x		x			x		x			x
American redstart								x														
yellow-bellied flycatcher								x	x	x	x	x	x		x	x	x	x		x		
American robin								x	x			x							x			
red-eyed vireo									x										x	x	x	x
wood thrush									x													
black-backed 3-toed woodpecker												x		x								
purple finch														x								
red-breasted nuthatch															x	x						
black-throated green warbler																x		x				
Canada warbler																x						
brown creeper																x			x			
great-crested flycatcher																x						
yellowthroat																	x					
black-capped chickadee																	x	x	x			x
least flycatcher																	x					
gold-wing warbler																			x			
rose-breasted grosbeak																			x			
Tennessee warbler																				x		
northern waterthrush																				x	x	
gold-crown kinglet																				x		
Traill's flycatcher																				x		
veery																						x
palm warbler																						x
Cape May warbler																						x

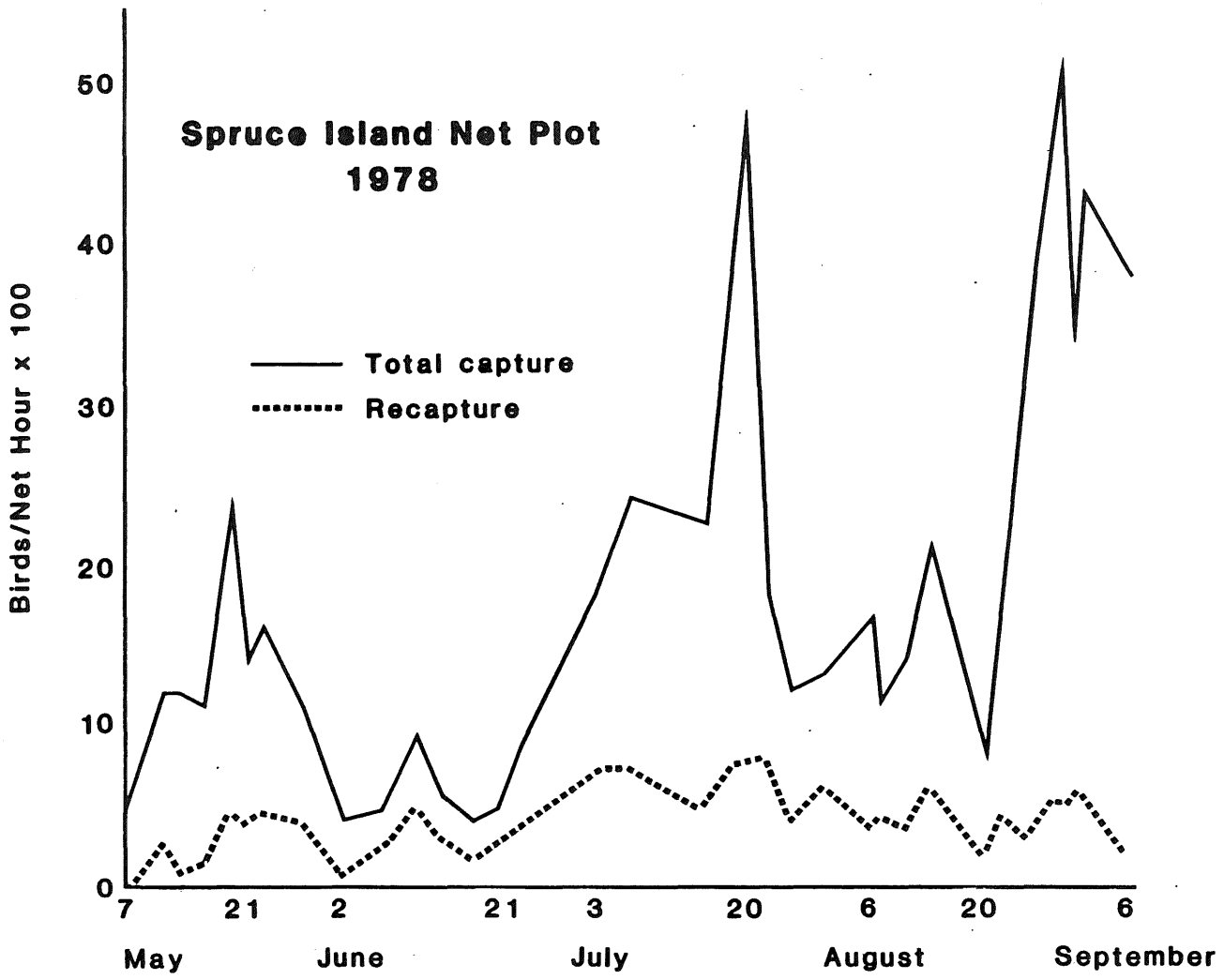

Figure 6. Capture rates of birds in mist nets in spruce island net plot from spring to fall 1979. Three major bird activity peaks are: (1) during spring migration and early territory establishment, (2) after first broods fledged from the nest, and (3) during the fall migration. Recapture levels stayed fairly steady throughout the netting season.

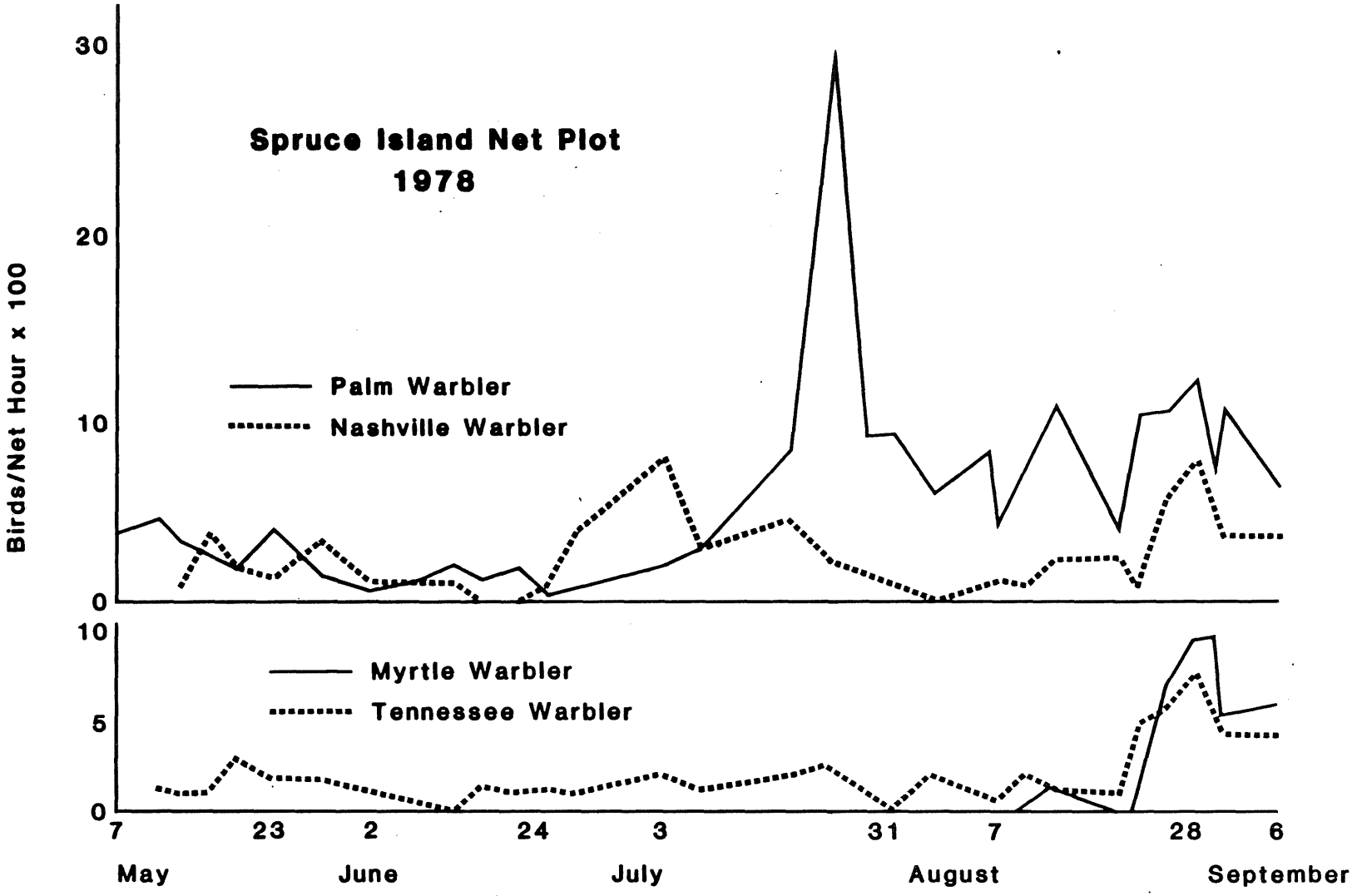

Figure 7. Capture rates of four species of birds in mist nets in spruce island net plot from spring to fall 1978. Although the peak of total captures around July 20 (see fig. 5) was made up primarily of Palm Warblers, the fall peak was made up of close to equal proportions of those species shown here, in addition to lesser numbers of other species.

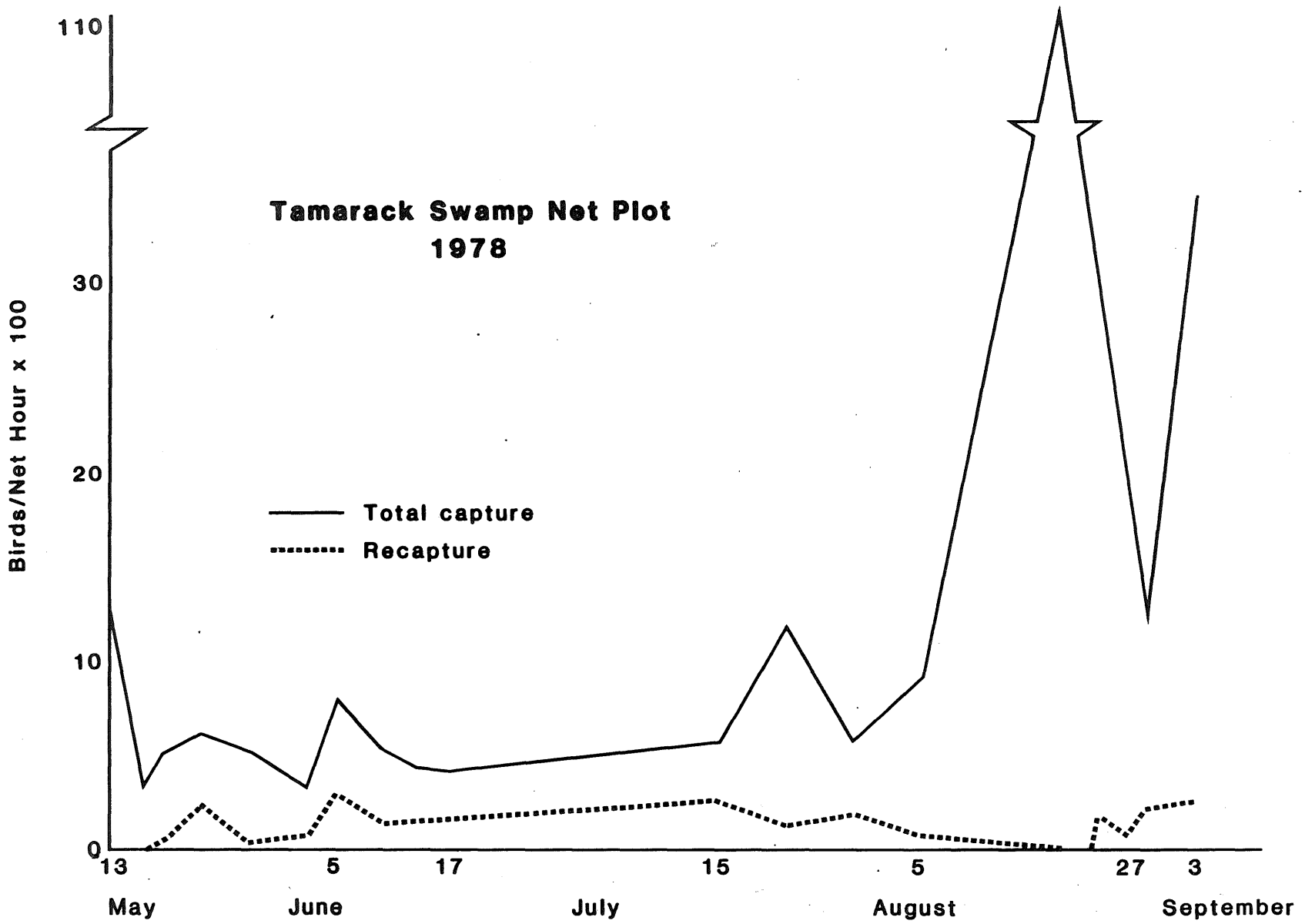

Figure 8. Capture rates of birds in mist nets in tamarack swamp net plot from spring to fall 1978. Although not as distinct as seen in the spruce island, the tamarack swamp netting totals also reflect the same three peaks through the netting season.

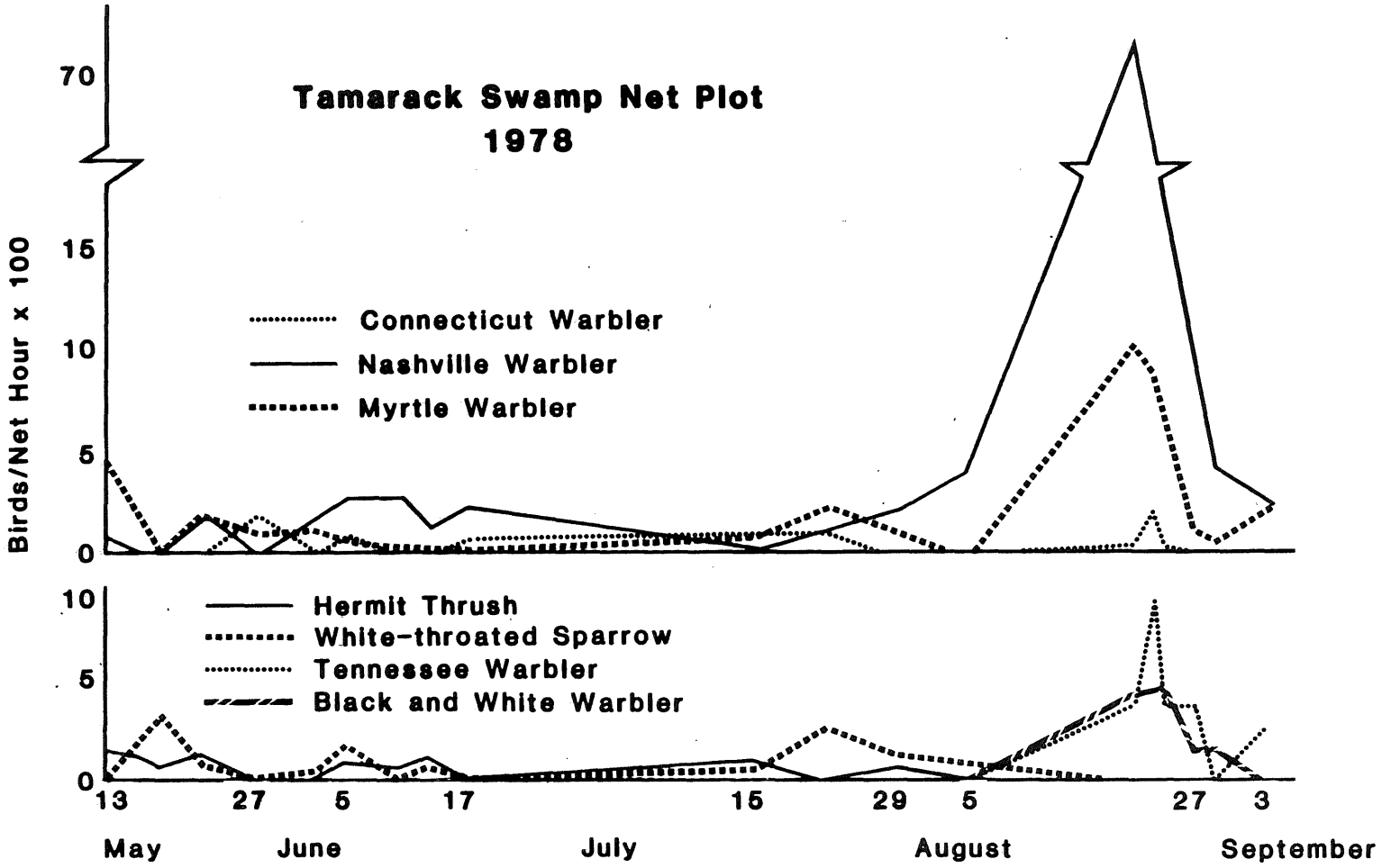

Figure 9. Capture rates of selected species in mist nets in tamarack swamp net plot from spring to fall 1978. While all species maintained fairly low density levels through most of the season in the tamarack swamp net plot, things changed drastically with the fall migration. The bulk of the migrating onrush was made up of Nashville, Myrtle, and Tennessee Warblers, the latter having been present only as a migrating species.

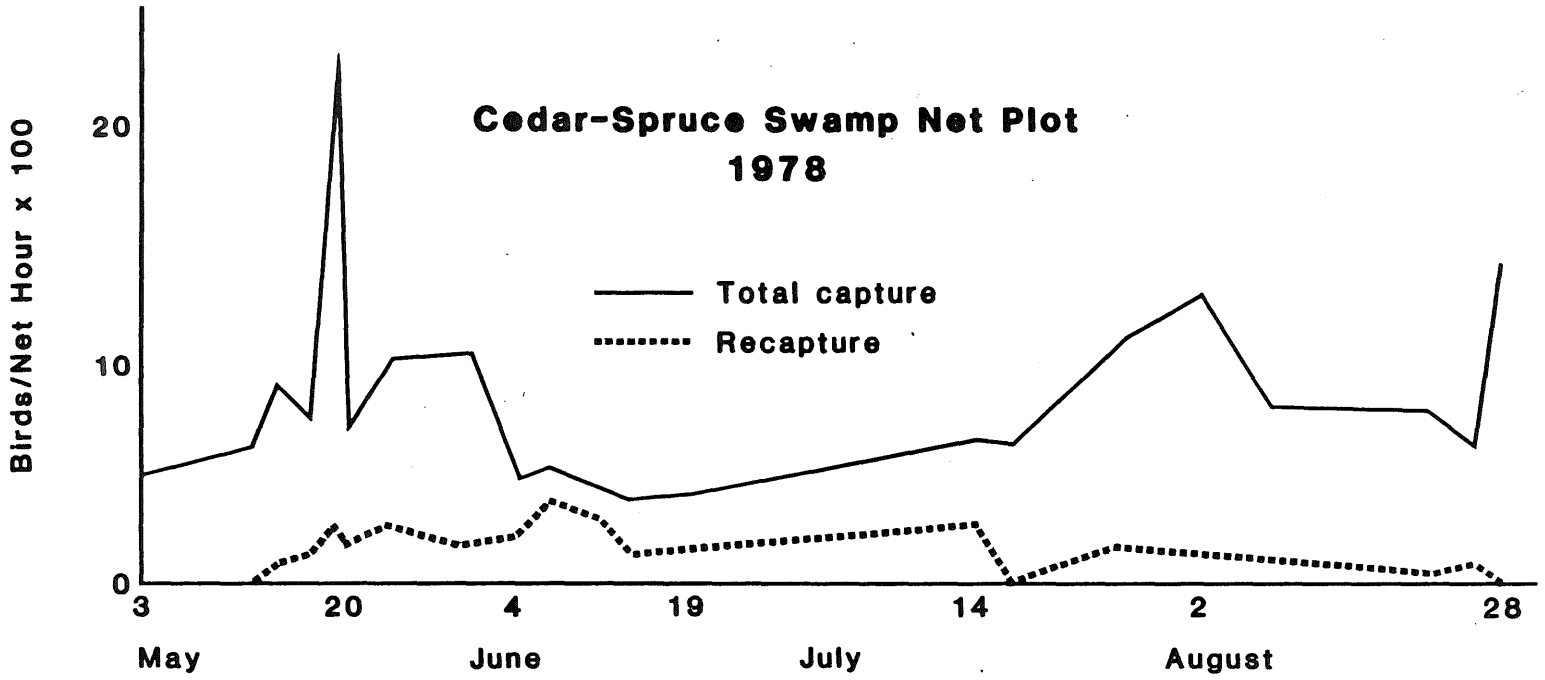

Figure 10. Capture rates of birds in mist nets in the cedar-spruce swamp net plot from spring to fall 1978. Similar peaks occurred in the volume of birds caught through the netting season in the cedar-spruce swamp plot as in the other two plots. Fall migration was not nearly so dramatic here as in the spruce island or tamarack swamp.

for populations in spruce island.

The second objective was to examine habitat utilization by birds during migration. The data gathered from this aspect of the study indicate that patterns of habitat use by birds in the peatlands are very dynamic. A given habitat at any one time may support a complement or community of bird species, and this community may change quite drastically through time even within one growing season. Each habitat netted during migration was utilized to some degree by species not known to breed in similar habitats. During spring 1978, this degree of utilization by non-breeding species ranged from 6% of the birds captured in stunted black spruce to 39% in tamarack swamp. In fall 1979, 15% of the birds captured in cedar-spruce swamp were species that did not breed in that habitat, while in spruce island the percentage was 41%. Mist-netting also revealed large-scale movements by palm warblers late in the breeding season, and similar peaks in activity in other sampled habitats suggest wandering by several species.

The dynamic nature of habitat utilization by birds has very important implications to possible mitigation of impacts in peatland habitats altered by development. It would seem that the value of a given habitat to the avian community cannot be properly evaluated by a survey of its breeding population. A habitat such as that on the spruce island is relatively depauperate in breeding birds but is utilized by migrants of many species. What is important to learn is what are the resources of the spruce island, or any other habitat, that attract the migrants and what would be the impact on the migrants of the loss of this resource.

CONCLUDING REMARKS

While it is often convenient to summarize the results of baseline studies, such as this report, in terms of avian community statistics, it is the patterns of abundance and distribution of individual species that are really important. It is at the species level where natural selection acts and where adaptations to environmental conditions over an evolutionary time scale are expressed. The data on which this report is based have been collected, analyzed, and presented with this theme in mind--that is, an emphasis on species distribution rather than community attributes. We hope that any interpretation of these data acknowledges this idea. As an example, while muskeg does not appear to be of great value in terms of total number of bird species or density of birds, it is an important habitat for the Lincoln's sparrow, which was never found in high numbers in the peatland and not at all outside the peatland during this study.

In addition to the concept described above, there are two other major points to be emphasized. The first is the small degree of similarity between the upland habitats sampled and any of the peatland habitats, even those of similar structure. The impact of the alteration of the peatlands cannot be mitigated with respect to avian species by the acquisition or preservation of surrounding mineral soils with their associated vegetation.

The second point to note is that this report provides baseline data from a given point in time. Without further study it is difficult to predict how the avian species will respond to perturbations in the peatland because we cannot say that our data represent the "normal"

picture. Generalizations are difficult, at best, to make in such a complex ecosystem. Our level of understanding of habitat use during migration is low as is our understanding of the importance of heavily used sites during migration. Do these sites merely provide cover or are they important as a source of food? In order to arrive at intelligent decisions, it will be necessary to answer these questions and others as well as to validate the baseline data presented.

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APPENDIX A
Format for Releve Sheets

Habitat
Code number for releve (first number is transect number)
Date

Location on transect of releve plot (20 x 20 m), portion of transect represented by releve, and number of total feet of that habitat

Symbols

life-form categories (after Kuchler)

E needleleaf evergreen
N needleleaf deciduous
D broadleaf deciduous
B broadleaf evergreen
H forbs
G graminoids
L lichens, mosses

height (stratification)

8 > 35 m
7 20-35 m
6 10-20 m
5 5-10 m
4 2-5 m
3 0.5-2 m
2 0.1-0.5 m
1 < 0.1 m

coverage

c continuous > 75%
i interrupted 50-75%
p parklike 25-50%
r rare 5-25%
b barely present 1-5%
a almost absent, very scarce < 1%

cover-degree/abundance (after Braun-Blanquet)

r single occurrence
+ occasional, cover < 5%
1 plentiful, cover < 5%
2 very numerous, cover 5-25%
3 any number of indiv., cover 25-50%
4 any number of indiv., cover 50-75%
5 any number of indiv., cover 75-100%

sociability

1 growing singly
2 grouped, few individuals
3 large group, many individuals
4 small colonies, extensive patches, broken mat
5 extensive mat

condition and vitality

bl blooming
fr fruiting

Each life-form group in each of Kuchler's height categories is given a cover estimate, e.g., E6i. Individual species are listed under those categories and are assigned cover and sociability symbols, e.g., Picea mariana 3.1 (after Braun-Blanquet).

Shrub fen
Relevé 1-1
3 August 1978

2000' E, MP 1 = SE corner
MP 1, 2; 7500'

N 4a		
Larix laricina	r.1	
N 3a		
Larix laricina	r.1	
D 3p (occasionally i)		
Betula pumila	3.1	
Spiraea latifolia	r.1	bl
N 2a		
Larix laricina	r.1	
D 1-2b		
Salix sp.	1.2	
Betula pumila	1.2	
Potentilla fruticosa	+.1	bl
Rubus sp.	+.2	fr, bl
B 1-2p		
Chamaedaphne calyculata	3.4	fr
Vaccinium oxycoccos	+.2	fr
H 1-2i		
Drosera rotundifolia	2.1	bl
Rubus acaulis	2.1	fr
Dryopteris thelypteris	2.1	
Campanula aparinoides	1.1	bl
Solidago uliginosa	1.1	bl
Lonicera sp.	1.1	
Pedicularis lanceolata	+.2	bl
Parnassia palustris	+.1	bl
Solidago gigantea	+.1	bl
Cirsium muticum	+.1	bl
Lycopus americanus	+.1	bl
Galium sp.	+.1	
Iris versicolor	+.1	fr
Potentilla palustris	+.1	
Aster cf. junciformis	+.1	bl
Utricularia intermedia	+.1	
Rumex orbiculata	+.1	
Viola cf. pallens	+.1	
Aster umbellatus	+.1	bl
Equisetum cf. fluviatile	+.1	
Malaxis unifolia	r.1	bl
Habenaria lacera	r.1	
Pogonia ophioglossoides	r.1	
G 2-3c		
Muhlenbergia racemosa		
Agrostis hyemale		
Bromus ciliatus		
Eriophorum sp.		
Phragmites communis	+.1	
L i		
Sphagnum sp.	4.5	
Other mosses	1.1	

Open fen
Relevé 3-1
5 August 1978

Repr. all MP 3, 4 = 7500' of 7500'

D 2-3b		
Betula pumila	+.1	
Potentilla fruticosa	r.1	
Salix sp.	r.1	
Spiraea sp.	r.1	
B 1-3b		
Vaccinium oxycoccos	r.1	
Ledum groenlandicum	+.1	
Chamaedaphne calyculata	+.1	
Andromeda glaucophylla	r.1	
H 1-2r		
Dryopteris thelypteris	1.1	
Utricularia intermedia	1.1	
Drosera intermedia	1.1	
Pogonia ophioglossoides	1.1	
Rubus acaulis	1.1	
Campanula aparinoides	+.1	
Hypericum virginicum	+.1	
Potentilla palustris	+.1	
Galium sp.	+.1	
Sarracenia purpurea	+.1	
Solidago sp.	+.1	
Equisetum fluviatile	+.1	
Menyanthes trifoliata	+.1	
Viola cf. pallens	+.1	
Lycopus cf. virginianum	+.1	
Iris versicolor	+.1	
Arethusa bulbosa	+.1	
Parnassia glauca	r.1	
Habenaria lacera	r.1	
Eupatorium maculatum	r.1	
Aster junciformis	r.1	
Lobelia kalmii	r.1	
Aster sp.	r.1	
Fragaria virginiana	r.1	
Rumex maculatum	r.1	
G 1-2i		
Phragmites communis		
Eriophorum spp.		
Agrostis hyemale		
Typha sp.		

Muskeg
Relevé 5-1
25 July 1978

1500' E, MP 5 = SE corner
Repr. MP 5 (1600'), MP 6 (3500')
5100' of 7500'

E 4r		
Picea mariana	2.1	
E 3r		
Picea mariana	2.1	
E 2r		
Picea mariana	2.1	
D 2b		
Betula pumila	+.1	
E 1b		
Picea mariana	1.3	
B 2i		
Chamaedaphne calyculata	3.1	fr
Andromeda glaucophylla	2.1	
Kalmia polifolia	1.1	fr
Ledum groenlandicum	+.1	
Vaccinium oxycoccos	+.1	fr
H 1b		
Drosera rotundifolia	+.1	
Sarracenia purpurea	+.1	
G 1-2c		
Eriophorum sp.	5.3	fr
L 1c		
Sphagnum sp.	5.5	
Other moss	1.5	

Muskeg
Relevé 5-2
25 July 1978

300' E, MP 5 = SW corner
Repr. MP 5 (800'); 800' of 7500'

E 5b		
Picea mariana	1.1	fr
E 4r		
Picea mariana	2.1	fr
E 3r		
Picea mariana	2.1	fr
E 2r		
Picea mariana	2.1	
D 2b		
Betula pumila	1.1	
E 1a		
Picea mariana	+.1	
D 1a		
Betula pumila	+.1	
B 2c		
Chamaedaphne calyculata	4.1	fr
Ledum groenlandicum	2.1	fr
Vaccinium oxycoccos	1.2	fr
Andromeda glaucophylla	+.1	fr
Kalmia polifolia	+.1	fr
H 1b		
Smilacina trifolia	+.1	
Drosera rotundifolia	+.1	bl
Sarracenia purpurea	+.1	
G 2r		
Eriophorum spp. (2)	2.1	fr
L 1c		
Sphagnum spp.	5.5	fr
Other moss	1.5	
Lichens	+.5	fr

Muskeg
Relevé 5-3
25 July 1978

2800' E, MP 5 = SE corner
Repr. 1600' (MP 5); 1600' of 7500'

E 4b		
Picea mariana	1.1	fr
E 3r		
Picea mariana	2.1	fr
E 2b		
Picea mariana	1.2	
E 1b		
Picea mariana	+.2	
D 1-2b		
Betula pumila	1.1	
B 1-2p		
Chamaedaphne calyculata	3.2	fr
Kalmia polifolia	1.1	fr
Ledum groenlandicum	1.1	fr
Andromeda glaucophylla	1.1	fr
Vaccinium oxycoccos	+.1	fr
H 1b		
Menyanthes trifoliata	+.1	
Potentilla palustris	+.1	
Smilacina trifolia	+.1	fr
Drosera rotundifolia	+.1	fr
Equisetum fluviatile	+.1	
G 1-2i		
Eriophorum sp.	4.1	
L 1c		
Sphagnum	5.5	
Other moss	1.4	

Open bog
Relevé 7-1
31 July 1978

1200' E, MP 7 = SE corner
Repr. MP 7, 8; 7500' of 7500'

E 3b	
Dead trees	+.1
E 2a	
Picea mariana	+.1
N 2a	
Larix laricina	+.1
D 1-2b	
Betula pumila	1.1
Salix sp.	+.1
B 1-2i	
Chamaedaphne calyculata	3.2
Andromeda glaucophylla	2.2
Kalmia polifolia	1.1
Vaccinium oxycoccos	1.1
Ledum groenlandicum	1.1
H 1b	
Sarracenia purpurea	+.1
Drosera rotundifolia	+.1
Equisetum cf. fluviatile	+.1
G 1-2p	
Eriophorum spp.	3.4
Other sedges	
L 1c	
Sphagnum sp.	5.4
Other moss	2.3

Stunted black spruce
Relevé 9-1
31 July 1978

1500' S, MP 9 = NW corner
Repr. MP 9, 10, 11; 7500' of 7500'

E 5-6p		
Picea mariana	3.1	
E 4r		
Picea mariana	2.1	
E 3r		
Picea mariana	2.1	
D 3b		
Betula pumila	+.1	
E 1-2b		
Picea mariana	1.1	
D 1-2b		
Betula pumila	+.1	
B 1-2r		
Ledum groenlandicum	1.1	fr
Andromeda glaucophylla	1.1	fr
Kalmia polifolia	1.1	fr
Vaccinium oxycoccos	1.2	fr
Chamaedaphne calyculata	1.2	fr
H 1b		
Drosera rotundifolia	+.2	
Sarracenia purpurea	+.1	fr
Smilacina trifolia	r.1	
Menyanthes trifoliata	r.1	
G 1-2i		
Eriophorum	4.1	
Other sedges		
L 1c		
Sphagnum sp.	5.5	
Lichens	1.2	

Stunted tamarack
Relevé 12-1
3 August 1978

2400' S, MP 12 = NW corner
Repr. MP 12, 13 (1100'); 4100' of 7000'

E 5b		
Picea mariana	1.2	
N 5r		
Larix laricina	2.1	
E 4b		
Picea mariana	1.2	
N 4b		
Larix laricina	1.1	
Dead trees	1.1	
E 3r		
Picea mariana	2.2	
N 3b		
Larix laricina	1.1	
D 3b		
Betula pumila	+.2	
E 1-2b		
Picea mariana	+.1	
N 1-2b		
Larix laricina	+.1	
D 1-2r		
Betula pumila	2.2	
B 1-2i		
Chamaedaphne calyculata	3.1	fr
Kalmia polifolia	2.1	fr
Vaccinium oxycoccos	1.2	fr
Andromeda glaucophylla	+.2	fr
Ledum groenlandicum	+.4	fr
H 1p		
Smilacina trifolia	3.2	
G 2-3i		
Eriophorum sp.	4.4	
Other sedges		
L 1c		
Sphagnum sp.	5.4	
Other moss	1.3	

Stunted tamarack
Relevé 13-1
3 August 1978

1400' S, MP 13 = NW corner
Repr. 800' MP 13, 800' of 7000'

E 6r		
Picea mariana	2.1	
E 5r		
Picea mariana	2.1	
E 4r		
Picea mariana	2.1	
N 4b		
Larix laricina	1.2	
Dead trees	+.1	
E 3r		
Picea mariana	2.1	
N 3b		
Larix laricina	+.1	
D 3r		
Betula pumila	2.1	
E 1-2b		
Picea mariana	1.2	
D 1-2b		
Betula pumila	+.1	
B 1-2r		
Ledum groenlandicum	2.1	fr
Kalmia polifolia	1.1	fr
Chamaedaphne calyculata	1.1	fr
Andromeda glaucophylla	+.1	fr
Vaccinium oxycoccos	+.1	fr
H 1-2p		
Smilacina trifolia	3.2	fr
Sarracenia purpurea	+.1	
Drosera rotundifolia	+.1	
Menyanthes trifoliata	r.2	
G 2-3i		
Eriophorum sp.	4.4	
Other sedges		
L 1c		
Sphagnum sp.	5.4	
Other moss	+.4	
Lichens	+.4	

Stunted tamarack
Relevé 13-2
3 August 1978

2500' S, MP 13 = SW corner
Repr. MP 13 (2100'); 2100' of 7000'

E 5b		
Picea mariana	1.1	
E 4b		
Picea mariana	+.1	
N 4p		
Larix laricina	3.1	
E 3b		
Picea mariana	1.1	
N 3a		
Larix laricina	r.1	
D 3r		
Betula pumila	2.1	
E 1-2a		
Picea mariana	+.1	
N 2a		
Larix laricina	+.1	
D 1-2r		
Betula pumila	2.1	
Salix sp.	+.1	
B 1-2p		
Andromeda glaucophylla	2.2	fr
Chamaedaphne calyculata	2.2	fr
Kalmia polifolia	+.1	fr
Ledum groenlandicum	+.2	
Vaccinium oxycoccos	+.2	fr
H 1b		
Potentilla palustris	+.1	fr
Menyanthes trifoliata	r.1	
G 2-3c		
Eriophorum sp.	5.4	
Other sedges		
L 1c		
Sphagnum sp.	5.5	
Other moss	+.3	

Swamp thicket
Relevé 14-1
27 July 1978

Repr. 3000', MP 14; 3000' of 9000'

D 5a		
Salix sp.	+.1	
D 4i		
Salix cf. amygdaloides	4.1	
Salix cf. gracilis		
Betula pumila	2.1	
Alnus rugosa	1.1	fr
D 3i		
Salix cf. amygdaloides	3.1	
Salix cf. gracilis		
Betula pumila	2.1	
Alnus rugosa	2.1	
Rubus sp.	+.1	fr
D 2r		
Salix sp.	2.1	
Rubus sp.	1.2	
Alnus rugosa	+.1	fr
Cornus sp.	+.1	bl
B 2b		
Chamaedaphne calyculata	1.1	fr
D 1b		
Rubus sp.	1.1	
H 1-2p		
Rubus acaulis	2.2	fr
Potentilla palustris	1.1	bl
Dryopteris thelypteris	1.1	
Solidago gigantea	1.1	bl
Lycopus americanus	1.1	bl
Aster cf. junciformis	+.1	bl
Eupatorium maculatum	+.1	bl
Iris versicolor	+.2	fr
Campanula aparinoides	+.1	bl
Viola cf. pallens	+.1	
Lysimachia thyrsiflora	+.1	
Cicuta bulbifera	+.1	bl
Smilacina trifolia	+.1	
Caltha palustris	+.1	fr
Oenothera perennis	+.1	bl
Rumex orbiculatus	+.1	fr
Galium trifidum	+.1	bl, fr
Galium triflorum	+.1	fr
G 1-2p		
Calamagrostis canadensis		
Other grasses and sedges		

Swamp thicket
Relevé 14-2
27 July 1978

Repr. 1000', MP 14; 1000' of 9000'

D 5b		
Dead trees	1.1	
Populus tremuloides	+.1	
D 4p		
Salix spp.	3.1	
Populus tremuloides	+.1	
Dead trees	+.1	
D 3r		
Salix sp.	2.1	
Rubus sp.	1.1	fr
Populus tremuloides	+.1	
D 2b		
Salix sp.	1.1	
Rubus sp.	1.1	fr
Ribes sp.	1.1	
Populus tremuloides	+.1	
H 1-2r		
Solidago gigantea	1.1	bl
Impatiens biflora	1.1	bl
Polygonum sagittatum	1.1	bl
Campanula aparinoides	1.1	bl
Lycopus americanus	1.1	bl
Bidens sp.	+.1	
Dryopteris thelypteris	+.1	
Asclepias incarnata	+.1	bl
Oenothera perennis	+.1	bl
Mentha arvensis	+.1	bl
Potentilla palustris	+.1	bl
Equisetum fluviatile	+.1	
Fragaria virginiana	+.1	
Scutellaria cf. nervosa	+.1	bl
Stellaria longifolia	+.1	fr
Galium trifidum	+.1	fr
Rubus acaulis	+.1	fr
Rumex sp.	+.1	fr
Eupatorium maculatum	+.1	bl
Viola cf. pallens	sp.	
G 1-2c		
Calamagrostis canadensis	5.4	
Sedges	1.4	
L 1b		
Sphagnum sp.		

Swamp thicket
Relevé 14-3
27 July 1978

4800'S, MP 14
Repr. 2000', MP 14; 2000' of 9000'

D 4i		
Betula pumila	3.1	
Salix cf. amygdaloides	2.1	
Alnus rugosa	2.1	fr
D 3p		
Betula pumila	3.1	
Salix sp.	1.1	
Alnus rugosa	+.1	fr
Rubus sp.	+.1	fr
D 2r		
Betula pumila	2.1	
Rubus sp.	1.1	fr
Salix sp.	1.1	
Ribes sp.	+.1	
Alnus rugosa	+.1	
D 1b		
Betula pumila	+.1	
Salix sp.	+.1	
Ribes sp.	+.1	
B 2r		
Chamaedaphne calyculata	2.1	
H 1-2r		
Rubus acaulis	1.1	fr
Dryopteris thelypteris	1.1	
Solidago gigantea	+.1	bl
Campanula aparinoides	+.1	bl
Potentilla palustris	+.1	bl
Oenothera perennis	+.1	bl
Rumex sp.	+.1	fr
Galium triflorum	+.1	fr
Onoclea sensibilis	+.1	
G 2r		
Bromus ciliatus	2.1	
Other grasses and sedges		
L 1i		
Sphagnum sp.	3.5	
Others	1.5	

Swamp thicket
Relevé 15-1
4 August 1978

2700' S, MP 15 = NW corner
Repr. MP 15, 3000' of 9000'

D 4p		
Salix sp.	3.1	
Populus tremuloides	+.1	
D 3b		
Salix sp.	1.1	
Rubus sp.	1.1	
D 2b		
Rubus sp.	1.1	
Ribes sp.	+.1	
H 1-2r		
Dryopteris spinulosa	1.1	
Solidago cf. gigantea	1.1	bl
Campanula aparinoides	+.1	bl
Fragaria virginiana		
Oenothera perennis	+.1	fr
Viola cf. pallens	+.1	
Rumex	+.1	fr
Epilobium angustifolium	+.1	bl
Asclepias incarnata	+.1	bl
Eupatorium maculatum	+.1	bl
Parnassia palustris	+.1	bl
Geum sp.	+.1	fr
Galium triflorum	+.1	fr
Dryopteris thelypteris	+.1	
Polygonum sagittatum	+.1	bl
Lycopus americanus	+.1	bl
Chelone glabra	+.1	bl
G 2-3c		
Poa cf. palustris		
Bromus ciliatus		
Calamagrostis canadensis		
Sedges		
L 1b		
Feathermoss		

Tamarack swamp
Relevé 16-1
4 August 1978

1400'S, MP 16 = NW corner
Repr. MP 16; 3000' of 7500'

N 6i		
Larix laricina	4.1	
N 5a		
Larix laricina	r.1	
D 5p		
Betula papyrifera	3.1	
E 4a		
Abies balsamea	r.1	
Picea glauca	r.1	
D 4b		
Betula papyrifera	1.1	
Betula pumila	+.1	
Cornus stolonifera	+.1	
Alnus rugosa	+.1	
Salix sp.	+.1	
E 3a		
Abies balsamea	r.1	
N 3a		
Larix laricina	+.1	
D 3p		
Cornus stolonifera	3.1	
Rhamnus alnifolia	1.1	
Betula pumila	+.1	
Alnus rugosa	+.1	
Amelanchier sp.	+.1	
Rubus sp.	+.1	
Betula papyrifera	+.1	
Salix sp.	+.1	
Ribes cf. cristata	+.1	
D 1-2r		
Cornus stolonifera	2.1	
Rhamnus alnifolia	1.1	
Ribes cf. cristata	+.1	
Rubus sp.	+.1	
Alnus rugosa	+.1	
Betula pumila	+.1	
Lonicera sp.	+.1	
Quercus sp.	+.1	
H 1-2c		
Lycopus americanus	1.1	bl
Rubus pubescens	1.1	fr

Relevé 16-1 (continued)

H 1-2c (continued)		
Rubus acaulis	1.1	fr
Trientalis borealis	1.1	fr
Scutellaria sp.	1.1	bl
Galium sp.	1.1	bl
Pyrola cf. secunda	1.1	fr
Saxifraga pensylvanica	+.1	
Chelone glabra		fr
Lysimachia thyrsiflora	+.1	
Iris versicolor	+.1	
Dryopteris cristata	+.1	
Fragaria virginiana	+.1	
Vaccinium myrtilloides	+.1	fr
Polygonum sagittatum	+.1	bl
Cornus canadensis	+.1	fr
Equisetum fluviatile	+.1	
Rumex sp.	+.1	fr
Dryopteris thelyptris	+.1	
Circaea alpina	1.1	bl,fr
Mitella nuda	+.1	fr
Smilacina trifolia	+.1	
Coptis groenlandicum	+.1	fr
Solidago sp.	+.1	bl
Corallorhiza trifida	+.1	fr
Cypripedium acaule	+.1	fr
Viola cf. pallens	+.1	
Oenothera perennis	+.1	fr
Eupatorium maculatum	+.1	bl
Rubus sp.	+.1	
Maianthemum canadense	+.1	fr
Galium triflorum	+.1	fr
Impatiens biflora	+.1	
Potentilla palustris	+.1	
Malaxis unifolia	r.1	bl
Habenaria hyperborea	r.1	fr
G 2-3i		
Glyceria striata		
Bromus ciliatus		
Calamagrostis canadensis		
Sedges		
L 1c		
Sphagnum sp.	3.4	
Other moss	2.3	

Black spruce bog/swamp
Relevé 17-1
24 July 1978

3700'S, MP 17 = NW corner
Repr. 1400', MP 17; 1400' of 8000'

E 6r		
Picea mariana	2.1	
Larix laricina	1.1	
E 5p		
Picea mariana	2.1	
Larix laricina	2.1	
E 4p		
Picea mariana	3.1	
Larix laricina	+.1	
E 3r		
Picea mariana	2.1	
E 2a		
Picea mariana	+.1	
Larix laricina	r.1	
E 1a		
Picea mariana	+.1	
B 1-2i		
Ledum groenlandicum	4.1	
Chamaedaphne calyculata	2.1	
Vaccinium oxycoccos	+.1	
Kalmia polifolia		
H 1b		
Smilacina trifolia	+.2	
Monotropa uniflora	r.1	
G 1b		
Sedges	1.2	
L 1c		
Sphagnum sp.	5.5	
Feathermoss	1.4	
Other moss	+.4	

Black spruce bog/swamp
Relevé 17-2
24 July 1978

2300'S, MP 17
Repr. 350', MP 17; 350' of 8000'

E 6i		
Picea mariana	4.1	
E 5b		
Picea mariana	+.1	
E 4a		
Picea mariana	r.1	
E 1a		
Picea mariana	r.1	
B 2b		
Ledum groenlandicum	1.2	
H 1-2 r		
Pyrola secunda	1.1	bl
Habenaria obtusata	1.1	fr
Smilacina trifolia	1.2	
Cornus canadensis	+.1	fr
Malaxis uniflora	+.1	bl
Vaccinium myrtilloides	+.1	fr
Oenothera perennis	+.1	bl
Equisetum cf. fluviatile	+.1	
Pyrola sp.	+.1	
Vaccinium vitis-idaea	+.1	
Rubus cf. acaulis	+.3	
Iris versicolor	+.3	fr
Corallorhiza trifida	+.2	fr
G 1-2c		
Sedges	5.3	
Grass	1.3	

Black spruce bog/swamp
Relevé 17-3
24 July 1978

2400'S, MP 17 = NW corner
Repr. 2600', MP 17; 2600' of 8000'

E 6p		
Picea mariana	3.1	
Larix laricina	2.1	
E 5r		
Picea mariana	2.1	
Larix laricina	+.1	
E 4b		
Picea mariana	1.1	
E 3a		
Picea mariana	+.1	
D 3p		
Alnus rugosa	2.1	
Betula pumila	2.1	
Salix sp.	1.1	
Cornus cf. stolonifera	+.1	
Lonicera sp.	+.1	
Populus tremuloides	r.1	
E 2b		
Picea mariana	+.1	
D 2b		
Betula pumila	1.1	
Ribes sp.	+.1	
Rosa arkansana	+.1	
Cornus cf. stolonifera	+.1	fr
Vaccinium myrtilloides	r.1	fr
B 2p		
Ledum groenlandicum	3.1	fr
Chamaedaphne calyculata	2.1	fr
Kalmia polifolia	+.1	
Vaccinium oxycoccos	+.1	fr
E 2b		
Picea mariana	+.1	
E 1b		
Picea mariana	+.1	
H 1-2p		
Equisetum cf. fluviatile	3.1	
Pyrola secunda	1.1	bl
Potentilla palustris	+.1	
Smilacina trifolia	+.1	
Cornus canadensis	+.1	fr
Malaxis unifolia	+.1	bl
Rubus cf. acaulis	+.1	
G 1-2i		
Sedges	4.2	
Grass	1.2	
L 1c		
Sphagnum sp.	5.5	

Black spruce bog/swamp
Relevé 18-1
16 July 1978

2200'S, MP 18 = SE corner
Repr. 750', MP 17, 2000',
MP 18; 2750' of 8000'

E 6c		
Picea mariana	5.1	
E 5r		
Picea mariana	2.1	
E 4b		
Picea mariana	+.1	
B 1-2r		
Ledum groenlandicum	2.2	fr
Vaccinium vitis-idaea	1.2	fr
Vaccinium oxycoccos	+.2	fr
H 2b		
Vaccinium angustifolium	1.3	fr
Smilacina trifolia	+.2	
Monotropa unifolia	+.2	bl
G 2b		
Carex cf. disperma	1.3	
L 1c		
Sphagnum sp.	4.5	
Feathermoss	2.5	
Bare ground	+.1	
Other moss	+.3	

Black spruce bog/swamp
Relevé 18-2
21 July 1978

500'S, MP 18 = corner
Repr. 250', MP 18; 250' of 8000'

E 6c		
Picea mariana	5.1	
Dead trees	+.1	
E 5a		
Picea mariana	+.1	
Dead trees	+.1	
E 4a		
Picea mariana	r.1	
Dead trees	r.1	
E 1a		
Picea mariana	+.1	
Betula pumila	r.1	
B 2a		
Vaccinium vitis-idaea	1.1	
Ledum groenlandicum	+.2	fr
H 2r		
Smilacina trifolia	1.2	
Vaccinium angustifolium	+.2	fr
Cypripedium acaule	+.2	fr
Vaccinium myrtilloides	+.2	fr
Monotropa uniflora	+.2	bl
Chimaphila umbellata	r.1	
G 2i		
Sedges	4.3	
L 1c		
Sphagnum sp.	2.5	
Feathermoss	3.5	
Lichens	1.3	
Other moss	+.2	

Black spruce bog/swamp
Relevé 18-3
21 July 1978

400'S, MP 18 = SE corner
Repr. 250' MP 18, 400' MP 17,
650' of 8000'

E 6p		
Picea mariana	3.1	
E 5r		
Picea mariana	2.1	
E 4b		
Picea mariana	1.1	
E 3b		
Picea mariana	1.1	
E 2a		
Picea mariana	+.1	
E 1a		
Picea mariana	+.1	
B 2c		
Ledum groenlandicum	5.1	fr
Chamaedaphne calyculata	1.1	fr
Vaccinium oxycoccos	+.2	fr
Vaccinium vitis-idaea	+.2	
Kalmia polifolia	+.2	
H 1r		
Vaccinium myrtilloides	1.1	fr
Smilacina trifolia	1.2	fr
Vaccinium angustifolium	+.1	fr
Monotropa uniflora	+.3	bl
G 1b		
Sedges	1.3	
L 1c		
Sphagnum sp.	5.5	
Feathermoss	2.5	
Lichens	1.5	
Other moss	+.5	
Bare ground	+.1	

Cedar-spruce swamp
Relevé 19-1
19 July 1978

400' E, MP 19 = SW corner
Repr. 1000', MP 19; 1000' of 7500'

E 5p		
Thuja occidentalis	3.1	
Abies balsamea	2.1	
E 4r		
Thuja occidentalis	2.1	
Abies balsamea	2.1	
D 4b		
Betula papyrifera	+.1	
E 3r		
Abies balsamea	2.1	
Thuja occidentalis	1.1	
D 3r		
Cornus stolonifera	2.1	
Rhamnus alnifolia	1.1	
Ribes sp.	+.1	
Salix sp.	+.1	
E 2r		
Abies balsamea	2.1	
Thuja occidentalis	1.1	
E 1b		
Abies balsamea	1.1	
D 1b		
Betula papyrifera	+.1	
B 2i		
Ledum groenlandicum	4.2	
Gaultheria hispidula	2.2	
Linnaea borealis	1.2	fr
Vaccinium oxycoccos	1.2	fr
H 1-2p		
Smilacina trifolia	2.3	fr
Drosera rotundifolia	1.2	
Calopogon pulchellus	+.2	bl
Habenaria hyperborea	+.2	bl
Cypripedium reginae	+.2	bl
Galium trifidum	+.2	fr
Trientalis borealis	+.1	fr
Rubus pubescens	+.2	fr
Cornus canadensis	+.1	
Viola cf. pallens	+.2	
Vaccinium angustifolium	+.2	
Coptis groenlandicum	+.2	fr
Galium triflorum	+.2	fr

Relevé 19-1 (continued)

H 1-2p (continued)		
Mitella nuda	+.2	fr
Habenaria obtusata	+.1	bl
Fragaria vesca	+.1	
Moneses uniflora	+.1	bl
Goodyera cf. pubescens	+.1	bl
Scutellaria sp.	+.2	
Listera cordata	r.1	bl
Habenaria orbiculata	r.1	bl
Cypripedium calceolus	r.1	
G 2r		
L 1i		
Sphagnum	4.4	
Feathermoss	1.4	

Cedar-spruce swamp
Relevé 19-2
20 July 1978

1400' E, MP 19= NE corner
Repr. 1500', MP 19; 1500' of 7500'

E 7b		
Picea mariana	+.1	
E 6r		
Abies balsamea	2.1	
Larix laricina	1.1	
Thuja occidentalis	1.1	
E 5i		
Abies balsamea	4.1	
Thuja occidentalis	4.1	
Dead trees	1.1	
E 4r		
Thuja occidentalis	1.1	
Abies balsamea	1.1	
E 3b		
Thuja occidentalis	+.1	
Abies balsamea	+.1	
E 2r		
Thuja occidentalis	1.2	
Abies balsamea	1.2	
D 2r		
Rhamnus alnifolia	1.1	fr
Cornus cf. stolonifera	+.1	
Acer rubrum	+.1	
Ribes sp.	+.1	
Lonicera sp.	+.1	
Fraxinus nigra	r.1	
E 1b		
Thuja occidentalis	+.1	
Abies balsamea	+.1	
Picea mariana	+.1	
B 2b		
Gaultheria hispidula	2.2	fr
Linnaea borealis	1.2	fr
Ledum groenlandicum	+.2	
Vaccinium vitis-idaea	+.2	
Vaccinium oxycoccos	+.2	
H 1-2p		
Aralia nudicaulis	1.1	fr
Mitella nuda	1.1	fr
Coptis groenlandicum	1.2	fr
Viola cf. pallens	1.1	
Rubus pubescens	+.2	fr
Trientalis borealis	+.1	fr

Relevé 19-2 (Continued)

H 1-2p (continued)		
Cornus canadensis	+.2	
Galium triflorum	+.1	fr
Malaxis unifolia	+.1	bl
Habenaria obtusata	+.1	bl
Goodyera pubescens	+.1	bl
Smilacina trifolia	+.1	fr
Moneses uniflora	+.1	fr
Pyrola secunda	+.1	bl
Corollarhiza trifida	+.1	fr
Maianthemum canadensis	+.1	
Vaccinium myrtilloides	+.1	
Habenaria hyperborea	+.1	bl
Equisetum sp.		
Orchis rotundifolia	+.1	fr
Clintonia borealis	+.1	
Botrychium sp.	+.2	fr
Cypripedium calceolus	r.1	
Habenaria orbiculata	r.1	bl
D 1a		
Quercus sp.	r.1	
G 2r		
Sedges	2.4	
L 1c		
Sphagnum spp.	4.4	
Feathermoss	2.4	
Other	+.4	

Cedar-spruce swamp
Relevé 20-1
20 July 1978

300'S, MP 20 = SW corner
Repr. 2500', MP 20; 2500' of 7500'

E 6r

Larix laricina	1.1	
Picea mariana	1.1	
Thuja occidentalis	+.1	

E 5r

Thuja occidentalis	2.1	
Picea mariana	1.1	
Abies balsamea	r.1	

E 4r

Thuja occidentalis	2.1	
Abies balsamea	1.1	

D 4a

Salix sp.	r.1	

E 3r

Abies balsamea	2.1	
Larix laricina	+.1	
Thuja occidentalis	+.1	
Picea mariana	r.1	

D 3r

Rhamnus alnifolia	2.1	fr
Cornus cf. stolonifera	1.1	
Lonicera sp.	+.1	
Salix sp.	+.1	

E 2r

Larix laricina	1.1	
Abies balsamea	1.1	
Picea mariana	+.1	
Thuja occidentalis	+.1	

D 2b

Rhamnus alnifolia	1.2	
Salix sp.	+.1	
Cornus sp.	+.2	
Betula papyrifera	+.1	
Lonicera sp.	+.1	
Fraxinus cf. nigra	r.1	

E 1b

Larix laricina	1.1	
Thuja occidentalis	+.1	
Picea mariana	+.1	
Abies balsamea	+.1	

D 1a

Betula papyrifera	r.1	

Relevé 20-1 (Continued)

B 2r

Ledum groenlandicum	1.2	fr
Gaultheria hispidula	1.2	fr
Vaccinium vitis-idaea	+.2	fr
Vaccinium oxycoccos	+.2	fr
Linnaea borealis	+.2	

H 1-2c

Smilacina trifolia	2.2	fr
Cornus canadensis	1.1	fr
Galium cf. trifidum	1.2	bl
Rubus pubescens	+.2	fr
Viola pallens	+.1	
Vaccinium myrtilloides	+.1	fr
Pyrola cf. rotundifolia	+.1	fr
Caltha palustris	+.2	fr
Trientalis borealis	+.1	
Scutellaria sp.	+.1	
Galium triflorum	+.2	fr
Mitella nuda	+.1	fr
Goodyera cf. pubescens	+.2	bl
Iris versicolor	+.5	fr
Coptis groenlandicum	+.2	
Pyrola secunda	+.2	fr
Stellaria cf. longifolia	r.1	bl
Cypripedium cf. calceolus	r.1	
Malaxis unifolia	r.1	bl
Habenaria hyperborea	r.1	fr
Equisetum		

G 2-3i

Calamagrostis canadensis		
Sedges		

L 1c

Sphagnum sp.	5.5	
Feathermoss	1.5	
Other moss	+.5	

Cedar-spruce swamp
Relevé 21-1
17 July 1978

2100' W, MP 21 = SW corner
Repr. 1700', MP 21; 1700' of 7500'

E 6p		
Thuja occidentalis	3.1	
Abies balsamea	1.1	
D 6b		
Populus balsamifera	+.1	
Betula papyrifera	+.1	
E 5i		
Thuja occidentalis	4.1	
Abies balsamea	+.1	
D 5b		
Salix sp.	+.2	
E 4b		
Abies balsamea	1.1	
Thuja occidentalis	1.1	
D 4b		
Betula papyrifera	+.1	
Salix sp.	1.1	
E 3b		
Abies balsamea	1.2	
D 3b		
Populus balsamifera	+.1	
Rhamus alnifolia	+.2	
Lonicera sp.	+.3	fr
Fraxinus sp.	r.1	
E 1b		
Abies balsamea	1.1	
Thuja occidentalis	+.2	
Picea mariana	+.1	
B 2b		
Ledum groenlandicum	1.3	
Vaccinium angustifolium	+.2	
Gaultheria hispidula	+.3	
Vaccinium oxycoccos	r.1	
H 1-2r		
Linnaea borealis	2.3	bl,fr
Rubus pubescens	2.2	fr
Trientalis borealis	1.1	
Circaea sp.	1.2	
Habenaria obtusata	1.1	bl
Coptis groenlandicum	1.2	fr
Mitella nuda	1.2	fr

Relevé 21-1 (Continued)

H 1-2r		
Cornus canadensis	1.2	fr
Fragaria virginiana	1.2	
Scutellaria sp.	1.2	bl
Clintonia borealis	+.2	
Galium trifidum	+.2	fr
Corollarhiza trifida	+.2	fr
Maianthemum canadense	+.2	
Smilacina trifolia	+.2	
Goodyera cf. pubescens	+.1	bl
Pyrola secunda	+.2	bl
Solidago sp.	+.2	
Moneses uniflora	+.2	bl, fr
Aralia nudicaulis	+.2	
Actaea alba	+.2	fr
Botrychium sp.	r.1	
Gymnocarpium dryopteris	+.1	
Viola cf. pallens	+.2	
G 2i		
L 1i		
Sphagnum spp.	3.4	
Feathermoss	1.4	
Other moss	1.4	

Cedar-spruce swamp
Relevé 21-2
19 July 1978

1400' W, MP 21 = SW corner of plot
Repr. 800', MP 21; 800' of 7500'

Relevé 21-2 (Continued)

E 6r		
Abies balsamea	r.1	
E 5c		
Thuja occidentalis	5.1	
Abies balsamea	+.1	
E 4p		
Thuja occidentalis	2.1	
Abies balsamea	1.1	
D 4r		
Betula papyrifera	r.1	
E 3r		
Thuja occidentalis	2.1	
Abies balsamea	+.1	
D 3b		
Cornus sp.	1.1	
Salix sp.	+.1	
Rhamnus alnifolia	+.1	
E 2b		
Abies balsamea	1.1	
Thuja occidentalis	+.1	
B 2c		
Ledum groenlandicum	3.2	
Vaccinium vitis-idaea	+.2	
Vaccinium oxycoccos	+.2	
Vaccinium myrtilloides	+.1	fr
H 1-2c		
Rubus pubescens	2.2	
Galium triflorum	1.2	bl, fr
Cornus canadensis	1.1	bl
Smilacina trifolia	1.3	
Scutellaria galericulata	1.1	bl
Rumex sp.	1.1	
Linnaea borealis	1.3	bl, fr
Viola pallens	+.2	
Iris versicolor	+.3	fr
Stellaria longifolia	+.1	bl
Mitella nuda	+.1	fr
Ranunculus lapponicus	+.2	bl
Botrychium sp.	+.1	
Fragaria vesca	+.1	
Solidago sp.	+.1	
Lysimachia thyrsiflora	+.1	
G 1-2c		
L 1c		
Sphagnum spp.	5.5	
Feathermoss	2.4	

Mixed conifer-deciduous upland
Relevé 22-1
24 July 1978

2200' S, MP 22 = NW corner
Repr. 2000', MP 22; 2000' of 7500'

E 6p
Abies balsamea 3.1

D 6i
Populus tremuloides 4.1

E 5r
Abies balsamea 2.1
Picea mariana +.1

D 5b
Populus tremuloides 1.1

E 4b
Abies balsamea 1.1

D 4r
Alnus rugosa 2.1
Populus tremuloides +.1
Corylus cornuta +.1
Amelanchier sp. +.1

E 3r
Abies balsamea 2.1
Picea mariana +.1

D 3b
Corylus cornuta 1.1
Alnus rugosa 1.1
Populus tremuloides +.1
Amelanchier sp. +.1
Salix sp. +.1

E 2b
Abies balsamea 1.1
Picea mariana +.1

D 2b
Corylus cornuta 1.1
Populus tremuloides 1.1
Cornus cf. rugosa +.1
Rosa arkansana +.1
Amelanchier sp. +.1
Salix sp. +.1

E 1b
Abies balsamea +.1

D 1b
Corylus cornuta +.1
Amelanchier sp. +.1
Populus tremuloides +.1
Diervilla lonicera +.1

Relevé 22-1 (Continued)

H 1-2c
Pteridium aquilinum 4.1
Fragaria virginiana 2.1
Maianthemum canadense 2.1
Aralia nudicaulis 1.1
Cornus canadensis 1.1
Gaultheria procumbens +.1
Apocynum androsaemifolium +.1
Diervilla lonicera +.1
Anemone quinquefolia +.1
Melampyrum lineare
Aster macrophyllus +.1
Pyrola sp. +.1
Trientalis borealis +.1
Chimaphila umbellata +.1
Galium triflorum +.1
Botrychium sp. +.1
fr Linnaea borealis +.1

G 1r
Grass 2.2

L 1b
Moss (logs and base of trees) 1.5

Mixed conifer-deciduous upland
Relevé 22-2
24 July 1978

200'S, MP 22 = SE corner
Repr. 1500', MP 22; 1500' of 7500'

D 6i

Populus tremuloides	4.1	
Betula papyrifera	2.1	

E 5b

Abies balsamea	1.1	

D 5i

Acer rubrum	4.1	
Alnus rugosa	2.1	
Populus tremuloides	1.1	
Betula papyrifera	1.1	

D 4r

Alnus rugosa	2.1	
Acer rubrum	2.1	
Amelanchier sp.	1.1	
Corylus cornuta	+.1	
Betula papyrifera	+.1	

D 3p

Corylus cornuta	2.1	
Viburnum rafinesquianum	1.1	
Acer rubrum	1.1	
Ribes sp.	1.1	
Alnus rugosa	1.1	
Amelanchier sp.	1.1	
Rosa arkansana	+.1	
Spiraea sp.	+.1	
Rubus sp.	+.1	
Cornus cf. stolonifera	+.1	
Populus tremuloides	+.1	

D 2r

Rubus sp.	1.1	
Viburnum rafinesquianum	1.1	
Ribes sp.	1.1	
Corylus cornuta	1.1	
Alnus rugosa	1.1	
Acer rubrum	1.1	
Rosa cf. arkansana	+.1	
Lonicera sp.	+.1	
Prunus cf. virginiana	+.1	
Cornus cf. stolonifera	+.1	

D 1b

Acer rubrum	1.1	
Ribes sp.	1.1	
Corylus cornuta	+.1	
Populus tremuloides	+.1	
Rosa cf. arkansana	+.1	

Relevé 22-2 (Continued)

H 1-2c

Vaccinium angustifolium	2.1	fr
Aster macrophyllus	1.1	
Aralia nudicaulis	1.1	
Cornus canadensis	1.1	bl
Fragaria virginiana	1.1	
Rubus pubescens	1.1	
Maianthemum canadense	1.1	fr
Osmunda claytoni	1.1	
Monotropa uniflora	1.1	bl
Pteridium aquilinum	1.1	
Rhus radicans	+.1	
Trientalis borealis	+.1	fr
Vaccinium myrtilloides	+.1	fr
Streptopus roseus	+.1	
Gaultheria procumbens	+.1	
Viola sp.	+.1	
Galium triflorum	+.1	fr
Pyrola sp.	+.1	
Clintonia borealis	+.1	
Equisetum sylvaticum	+.1	
Coptis groenlandicum	+.1	
Lycopodium obscurum	+.1	
Apocynum androsaemifolium	r.1	
Botrychium sp.	r.1	
Actaea sp.	r.1	

G 1r

Sedges	2.1	

L 1b

Moss	+.5	

Mixed conifer-deciduous upland
Relevé 23-1
21 July 1978

2700' N, MP 23 = SE corner of plot
Repr. 2500', MP 23; 2500' of 7500'

E 6i
- Pinus resinosa 4.1
- Pinus banksiana 2.1
- Abies balsamea 1.1

D 6p
- Populus tremuloides 3.1
- Betula papyrifera 1.1

E 5r
- Pinus resinosa 2.1
- Pinus strobus 1.1
- Abies balsamea 1.1
- Pinus banksiana r.1

D 5a
- Betula papyrifera r.1

E 4b
- Abies balsamea 1.1
- Pinus resinosa +.1

D 4r
- Populus tremuloides 2.1
- Corylus cornuta +.1
- Betula papyrifera +.1
- Amelanchier sp. +.1

E 3b
- Abies balsamea +.1
- Pinus strobus +.1

D 3r
- Populus tremuloides 1.1
- Lonicera sp. +.1
- Corylus cornuta +.1
- Amelanchier sp. +.1
- Betula papyrifera +.1
- Salix sp. +.1
- Rosa cf. arkansana +.1

E 2b
- Pinus strobus 1.1
- Abies balsamea 1.1
- Pinus resinosa r.1

D 2r
- Diervilla lonicera 2.1
- Populus tremuloides 1.1
- Rubus sp. +.1
- Prunus sp. +.1
- Salix sp. +.1

Relevé 23-1 (Continued)

D 2r (continued)
- Betula papyrifera +.1
- Corylus sp. +.1

E 1b
- Abies balsamea 1.1
- Pinus strobus +.1
- Picea glauca r.1

D 1b
- Amelanchier sp. +.1
- Diervilla lonicera +.1
- Betula papyrifera +.1
- Populus tremuloides +.1

H 1-2i
- Pteridium aquilinum 3.1
- Maianthemum canadense 2.1
- Linnaea borealis 1.1
- Anemone quinquefolia 1.1
- Gaultheria procumbens +.1
- Vaccinium angustifolium +.1
- Viola sp. +.1
- Chimaphila umbellata +.1
- Lycopodium cf. complanatum +.2
- Galium sp. +.1
- Fragaria virginiana +.1
- Melampyrum lineare +.1
- Pyrola sp. +.1
- Vaccinium myrtilloides +.1
- Aster macrophyllus +.1
- Equisetum sp. +.1
- Spiranthes alba r.1

G 1r
- Sedges 2.1

L 1b
- Moss (on trees and ground) +.5
- Lichens on trees +.2

Mixed conifer-deciduous upland
Relevé 23-2
23 July 1978

850' N, MP 23 = NE corner
Repr. 1500', MP 23; 1500' of 7500'

E 6b

Pinus resinosa	1.1	
Abies balsamea	1.1	

D 6c

Betula papyrifera	4.1	
Populus grandidentata	3.1	
Populus tremuloides	2.1	

E 5p

Abies balsamea	3.1	

D 5r

Acer rubrum	1.1	
Betula papyrifera	1.1	
Populus tremuloides	+.1	

E 4r

Abies balsamea	2.1	

D 4p

Corylus cornuta	3.1	
Cornus cf. rugosa	2.1	
Amelanchier sp.	1.1	
Betula papyrifera	1.1	
Populus tremuloides	1.1	
Prunus cf. virginiana	1.1	
Viburnum rafinesquianum	+.1	
Populus grandidentata	+.1	

E 3r

Abies balsamea	2.1	
Pinus resinosa	+.1	
Pinus strobus	+.1	

D 3p

Corylus cornuta	3.1	
Viburnum rafinesquianum	1.1	
Rosa cf. arkansana	+.1	
Amelanchier sp.	+.1	
Populus tremuloides	+.1	
Cornus cf. rugosa	+.1	

E 2b

Abies balsamea	1.1	
Pinus strobus	+.1	

E 1b

Pinus strobus	+.1	
Abies balsamea	+.1	

Relevé 23-2 (Continued)

D 1b

Corylus cornuta	1.1	fr
Rosa cf. arkansana	+.1	
Amelanchier sp.	+.1	
Prunus virginiana	+.1	
Viburnum rafinesquianum	+.1	
Diervilla lonicera	+.1	

H 1-2r

Maianthemum canadense	1.1	
Vaccinium angustifolium	1.1	fr
Cornus canadensis	1.1	
Gaultheria procumbens	1.1	
Linnaea borealis	+.1	fr
Lycopodium clavatum	+.1	
Viola sp.	+.1	
Fragaria virginiana	+.1	
Anemone quinquefolia	+.1	fr
Chimaphila umbellata	+.1	fr
Aralia nudicaulis	+.1	fr
Pyrola sp.	+.1	

G 1-2b

L 1b

Tamarack swamp
Relevé 24-1
29 July 1978

1900' N, MP 24 = NW corner
Repr. 2900', MP 24; 2900' of 7500'

N 5p		
Larix laricina	3.1	
N 4r		
Larix laricina	2.1	
D 4p		
Salix spp.	3.1	
N 3r		
Larix laricina	2.1	
D 3p		
Betula pumila	2.1	
Salix sp.	1.1	
Cornus stolonifera	+.1	fr
Rhamnus alnifolia	+.1	fr
E 3a		
Picea mariana	+.1	
N 1-2b		
Larix laricina	1.1	
D 1-2r		
Rhamnus alnifolia	1.1	fr
Betula pumila	1.1	
Salix	1.1	
Lonicera sp.	+.1	fr
Rubus sp.	+.1	fr
Cornus stolonifera	+.1	fr
E 1-2a		
Picea mariana	+.1	
B 1-2p		
Ledum groenlandicum	2.1	fr
Vaccinium oxycoccos	1.1	fr
Andromeda glaucophylla	1.1	fr
H 1-2i		
Rubus acaulis	2.2	fr
Smilacina trifolia	1.2	
Potentilla palustris	1.2	fr
Lysimachia thyrsiflora	1.2	
Equisetum cf. fluviatile	+.1	
Polygonum sagittatum	+.1	bl
Campanula aparinoides	+.1	bl
Rumex sp.	+.1	bl
Rubus pubescens	+.1	fr

Relevé 24-1 (continued)

H 1-2i (continued)		
Oenothera perennis	+.1	bl
Sarracenia purpurea	+.1	bl
Galium trifidum	+.1	fl
Viola pallens	+.1	fr
Caltha palustris	+.1	
Stellaria longifolia	+.1	bl
Maianthemum canadense	r.1	
G 1-2r		
L 1c		
Sphagnum	5.5	

Tamarack swamp
Relevé 24-2
29 July 1978

500' N, MP 24 = NE corner
Repr. 1600', MP 24; 1600' of 7500'

N 6r		
Larix laricina	2.1	
N 5p		
Larix laricina	3.1	
E 4a		
Picea mariana	+.1	
Thuja occidentalis	+.1	
D 4r		
Salix sp.	2.1	
Betula pumila	+.1	
N 4a		
Larix laricina	+.1	
E 3b		
Picea mariana	+.1	
Thuja occidentalis	+.1	
D 3p		
Rhamnus alnifolia	2.1	fr
Salix sp.	1.1	
Betula pumila	1.1	
Lonicera sp.	+.1	fr
Rubus sp.	+.1	fr
Ribes triste	+.1	
Cornus stolonifera	+.1	bl
E 2b		
Picea mariana	+.1	
Thuja occidentalis	+.1	
N 2b		
Larix laricina	+.1	
D 1-2r		
Rhamnus alnifolia	2.1	fr
Lonicera sp.	+.1	fr
Betula pumila	+.1	
Rubus sp.	+.1	fr
Ribes sp.	+.1	
Cornus stolonifera	+.1	
B 1-2p		
Ledum groenlandicum	2.1	fr
Vaccinium oxycoccos	1.1	fr
Gaultheria hispidula	+.1	
Andromeda glaucophylla	+.1	fr
H 1-2p		
Polygonum sagittatum	1.1	bl

Relevé 24-2 (continued)

H 1-2p (continued)		
Potentilla palustris	1.1	fr
Viola cf. pallens	1.1	fr
Rubus acaulis	1.1	fr
Menyanthes trifoliata	+.2	
Smilacina trifolia	+.2	
Oenothera perennis	+.1	bl
Equisetum cf. fluviatile	+.1	
Linnaea borealis	+.1	
Galium trifidum	+.1	fl
Corollarhiza trifida	+.1	fl
Lysimachia thyrsiflora	+.1	
Campanula aparinoides	+.1	bl
Rubus pubescens	+.1	
Fragaria virginiana	+.1	
Rumex sp.	+.1	bl
Pyrola cf. secunda	+.1	
Caltha palustris	+.1	fr
Eupatorium maculatum	+.1	
Cicuta bulbifera	+.1	bl
Cypripedium acaule	r.1	
Maianthemum canadense	r.1	
Sarracenia purpurea	r.1	fr
Habenaria hyperborea	r.1	
G 1-2c		
L 1c		
Sphagnum sp.	4.5	fr
Feathermoss	2.5	
Other moss		

Spruce swamp clearcut
Relevé 25-1
2 August 1978

Repr. MP 25; 2000' of 2000'

Relevé 25-1 (Continued)

E 5a		
Picea mariana	+.1	
N 5a		
Larix laricina	+.1	
D 5b		
Populus tremuloides	1.1	
D 4p		
Alnus cf. rugosa	2.1	
Salix sp.	2.1	
Populus tremuloides	1.1	
Betula pumila	1.1	
E 3b		
Picea mariana	1.1	
N 3a		
Larix laricina	+.1	
D 3i		
Salix sp.	2.1	
Rubus sp.	2.1	fr
Betula papyrifera	1.1	
Alnus rugosa	1.1	
Populus	1.1	
Cornus stolonifera	+.1	
Lonicera sp.	+.1	fr
D 1-2r		
Rubus sp.	1.1	fr
Quercus sp.	r.1	
Ribes sp.	1.1	
E 1-2b		
Picea mariana	1.1	
B 1-2r		
Ledum groenlandicum	1.1	fr
Vaccinium oxycoccos	1.1	fr
Chamaedaphne calyculata	+.1	fr
Gaultheria hispidula	+.1	fr
H 1-2p		
Smilacina trifolia	1.1	
Rubus pubescens	1.1	fr
Polygonum sagittatum	1.1	bl
Lycopus americanum	1.1	bl
Eupatorium maculatum	+.1	bl

H 1-2p (continued)		
Aster puniceus	+.1	
Rumex orbiculatus	+.1	fr
Vaccinium angustifolium	+.1	fr
Chelone glabra	+.1	bl
Aster junciformes	+.1	bl
Cornus canadensis	+.1	fr
Dryopteris spinulosa	+.1	
Polygonum natans	+.1	bl
Solidago sp.	+.1	bl
Scutellaria galericulata	+.1	bl
Equisetum fluviatile	+.1	
Epilobium angustifolium	+.1	bl, fr
Viola cf. pallens	+.1	fr
Vaccinium myrtilloides	+.1	fr
Campanula aparinoides	+.1	bl
Trientalis borealis	+.1	bl
Galium triflorum	+.1	fr
Aralia nudicaulis	+.1	
Fragaria virginiana	+.1	
Lactuca sp.	+.1	fr
Gentiana linearis	r.1	bl
Habenaria hyperborea	r.1	bl
Eupatorium perfoliatum	+.1	bl
G 1-2i		
L 1p		
Sphagnum	3.1	
Other moss	1.1	

APPENDIX B
Density of Tree and Shrub Stems for 14 Habitats

KEY

All density figures are average numbers per 404 m^2 (.10 acre). The number in parenthesis is one standard error of the density figure. The number of sampling points appears at the end of the table. Canopy cover is presented as the percent of sky obscured by foliage, as described in the text.

Size categories of trees:

seedling	< 1 m in height and DBH < 7.7 cm (3 in.)
sapling	> 1 m in height and DBH < 7.7 cm (3 in.)
pole	no height criterion; DBH 7.7 cm-15.4 cm (3 in.-6 in.)
tree	DBH > 15.4 cm (6 in.)

Other notation:

\+ present but in density < .1 stem per 404 m^2 (.10 acre)

* indicates presence of a particular shrub, but the stem density of this species is included only as part of a total that includes other shrubs marked with this symbol.

TABLE B-1
Density of Tree Stems for 14 Habitats

		1 open bog	2 muskeg	3 stunted black spruce	4 stunted tamarack	5 black spruce bog/swamp	6 spruce island	7 tamarack swamp	8 cedar-spruce swamp	9 spruce swamp clearcut	10 swamp thicket	11 open fen	12 shrub fen	13 riparian hardwood	14 mixed conifer-deciduous upland
Picea mariana	seedling	2 (.9)	122 (15.2)	88 (9.0)	29 (4.0)	16 (4.4)	260	5 (1.0)	5 (1.9)	95 (36.4)	+				.5 (.3)
	sapling	1 (.3)	67 (8.2)	63 (3.7)	23 (4.7)	56 (9.0)	243	3 (.9)	5 (3.7)	23 (8.2)					.4 (.3)
	pole			39 (2.9)	7 (1.8)	62 (5.4)	20	.3 (.2)	.4 (.3)	.1 (.1)	.1 (.1)				.2 (.2)
	tree			2 (.6)	.5 (.2)	16 (1.8)			.5 (.2)						.2 (.2)
Larix laricina	seedling	.3 (.1)	.3 (.2)	.4 (.2)	17 (4.3)	.1 (.1)	2	11 (2.8)	11 (4.7)	16 (5.8)		.1 (.1)			
	sapling	.7 (.2)	.5 (.3)	8 (1.1)	24 (3.6)	.5 (.21)	.1	13 (2.5)	4.7 (4.7)	28 (10.6)	+				
	pole			1 (.4)	13 (1.6)	2 (.9)	.8	55 (5.4)	.3 (.3)	.3 (.2)	+				
	tree				1 (.1)	.3 (.2)	.3	9 (1.6)	+						
Thuja occidentalis	seedling							1 (.6)	45 (11.7)						
	sapling							1 (.8)	60 (10.3)						
	pole								52 (4.5)						
	tree							.1 (.1)	18 (1.7)						
Populus tremuloides	seedling									38 (24.5)	.5 (.3)			9 (6.5)	10 (3.5)
	sapling									8.8 (34.7)	2 (1.0)			2 (1.1)	11 (3.4)
	pole									1 (1.4)	.5 (.2)			.1 (.1)	7 (.9)
	tree										.3 (.1)			.4 (.2)	7 (1.2)
Betula papyrifera	seedling								+	2 (1.1)	.5 (.3)				.6 (.3)
	sapling							5 (1.7)	.2 (.2)	10 (3.9)	+			.4 (.3)	3 (1.0)
	pole							1 (.4)	.3 (.3)		1			.1 (.1)	2 (.6)
	tree							1 (.1)	.1 (.1)						.8 (.3)

TABLE B-1 (cont.)

		1 open bog	2 muskeg	3 stunted black spruce	4 stunted tamarack	5 black spruce bog/swamp	6 spruce island	7 tamarack swamp	8 cedar-spruce swamp	9 spruce swamp clearcut	10 swamp thicket	11 open fen	12 shrub fen	13 riparian hardwood	14 mixed conifer-deciduous upland
Abies balsamea	seedling							.1 (.1)	36 (4.7)	.1 (.1)					31 (5.0)
	sapling							.1 (.1)	58 (8.9)						9 (1.4)
	pole								10 (1.7)						4 (.8)
	tree								1 (.3)						2 (.4)
Pinus strobus	seedling														1 (.9)
	sapling													.1 (.1)	.1 (.1)
	pole														.1 (.1)
	tree														.1 (.1)
Populus balsamifera	seedling														1 (.9)
	sapling													.1 (.1)	.1 (.1)
	pole														.1 (.1)
	tree														.1 (.1)
	dead trees DBH <7.7 cm	26 (2.1)	12 (1.1)	22 (1.9)	17 (3.2)	9 (1.5)		14 (2.1)	13 (3.5)	.5 (.4)	.3 (.2)	1.5 (.3)		2 (.6)	3 (.7)
	dead trees DBH >7.7 cm			6 (1.2)	3 (0.4)	4 (.9)		4 (.5)	3 (.5)		1 (.5)	.4 (.2)		1 (.2)	3 (.5)

TABLE B-1 (cont.)

	13 riparian hardwood				14 mixed conifer deciduous upland	
seedling	*Tilia americana*	22 (12.4)	*Ulmus americana*	101 (32.9)	*Acer rubrum*	1 (.6)
sapling		2 (1.6)		5 (2.0)		1 (.8)
pole		.2 (.1)		2 (.5)		.1 (.1)
tree		.4 (.3)		2 (.4)		
seedling	*Fraxinus nigra*	252 (57.4)	*Acer negundo*	15 (12.3)	*Pinus banksiana*	1 (.9)
sapling		35 (7.8)		25 (5.0)		4 (1.5)
pole		3 (.7)		.1 (.1)		.6 (.2)
tree		3 (1.3)		1 (.8)		.4 (.2)
seedling	*Acer saccharinum*	4 (3.4)	*Quercus macrocarpa*	57 (15.7)	*Pinus resinosa*	5 (1.9)
sapling		.6 (.4)		3 (1.3)		9 (2.9)
pole		1 (.4)		.8 (.3)		1 (.47)
tree		2 (.6)		.9 (.4)		.7 (.3)
seedling	*Populus deltoides*	8 (5.0)			*Picea alba*	.3 (.2)
sapling		.1 (.1)				.6 (.4)
pole		.1 (.1)				.2 (.1)
tree						.1 (.1)

TABLE B-2
Density of Shrub Stems for 14 Habitats

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	open bog	muskeg	stunted black spruce	stunted tamarack	black spruce bog/swamp	spruce island	tamarack swamp	cedar-spruce swamp	spruce swamp clearcut	swamp thicket	open fen	shrub fen	riparian hardwood	mixed conifer-deciduous upland
Betula pumila			12 (3.9)	26 (9.9)	20 (13.2)		193 (36.1)		143 (131.5)	574 (110.3)	64 (41)	1538 (223)		
Salix spp.					10 (7.4)		148 (25.0)	23 (7.8)	630 (206.5)	671 (106.7)		+		57 (24.1)
Alnus rugosa					25 (14.5)		156 (46.3)	.4 (.4)	247 (187.3)	398 (92.1)				15 (8.0)
Cornus stolinifera							140 (40.4)	11 (4.3)	74 (54.0)					
Other shrubs combined					.2 (.2)		6 (2.3)	102 (36.9)	278 (187.5)				624 (129.3)	521 (72.9)
Prunus spp.							*						*	*
Lonicera							*	*						*
Rhamnus spp.							*	*						
Ribes spp.							*	*					*	*
Amelanchier spp.					*								*	*
Viburnum spp.													*	*
Rosa spp.													*	*
Corylus													*	*
Total average # stems/.1A	0	0	12	26	55		643	136	1372	1643	64	1583	624	593
% canopy cover	0	0.3	20.0	7.5	55.6		44.3	61.2	15.0		0	0	85.6	79.3
# of .1A samples	30	30	30	28	32	14	30	30	8	36	30	30	16	30

APPENDIX C
Scientific Names of Birds
(according to the A.O.U., 1957 and supplement)

Botaurus lentiginosus (Rackett): American bittern
Anas platyrhynchos (Linneaus): mallard
Anas acuta (Linneaus): pintail
Anas discors (Linneaus): blue-winged teal
Aix sponsa (Linneaus): wood duck
Mergus merganser (Linneaus): common merganser
Mergus serrator (Linneaus): red-breasted merganser
Buteo platypterus (Vieillot) broad-winged hawk
Haliaeetus leucocephalus (Linneaus): bald eagle
Circus cyaneus (Linneaus): marsh hawk
Pandion haliaetus (Linneaus): osprey
Falco tinnunculus (Linneaus): kestrel
Canachites canadensis (Linneaus): spruce grouse
Bonasa umbellus (Linneaus): ruffed grouse
Pedioecetes phasianellus (Linneaus): sharp-tailed grouse
Porzana carolina (Linneaus): sora
Coturnicops novaboracensis (Gmelin): yellow rail
Philohela minor (Gmelin): American woodcock
Capella gallinago (Linneaus): common snipe
Steganopus tricolor (Vieillot): Wilson's Phalarope
Chlidonias niger (Linneaus): black tern
Zenaida macroura (Linneaus): mourning dove
Coccyzus erythropthalmus (Wilson): black-billed cuckoo
Archilochus colubris (Linneaus): ruby-throated hummingbird
Megaceryle alcyon (Linneaus): belted kingfisher
Colaptes auratus (Linneaus): common flicker
Dryocopus pileatus (Linneaus): pileated woodpecker
Sphyrapicus varius (Linneaus): yellow-bellied sapsucker
Dendrocopos villosus (Linneaus): hairy woodpecker
Dendrocopos pubescens (Linneaus): downy woodpecker
Picoides arcticus (Swainson): black-backed three-toed woodpecker
Tyrannus tyrannus (Linneaus): eastern kingbird
Myiarchus crinitus (Linneaus): great-crested flycatcher
Sayornis phoebe (Latham): eastern phoebe
Empidonax flaviventris (Baird and Baird): yellow-bellied flycatcher
Empidonax alnorum (Brewster): Traill's flycatcher
Empidonax minimus (Baird and Baird): least flycatcher
Contopus virens (Linneaus): eastern wood pewee
Nuttallornis borealis (Swainson): olive-sided flycatcher
Iridoprocne bicolor (Vieillot): tree swallow
Hirundo rustica (Linneaus): barn swallow
Petrochelidon pyrrhonota (Vieillot): cliff swallow
Progne subis (Linneaus): purple martin
Perisoreus canadensis (Linneaus): gray jay
Cyanocitta cristata (Linneaus): blue jay
Corvus corax (Linnaeus): common raven
Corvus brachyrhynchos (Brehm): common crow
Parus atricapillus (Linnaeus): black-capped chickadee
Parus hudsonicus (Forster): boreal chickadee

Sitta carolinensis (Latham): white-breasted nuthatch
Sitta canadensis (Linnaeus): red-breasted nuthatch
Certhia familiaris (Linnaeus): brown creeper
Troglodytes aedon (Vieillot): house wren
Troglodytes troglodytes (Linnaeus): winter wren
Cistothorus platensis (Latham): short-billed marsh wren
Dumetella carolinensis (Linnaeus): catbird
Turdus migratorius (Linnaeus): robin
Hylocichla mustelina (Gmelin): wood thrush
Hylocichla guttata (Pallas): hermit thrush
Hylocichla ustulata (Nuttall): Swainson's thrush
Hylocichla fuscescens (Stephens): veery
Sialia sialis (Linnaeus): eastern bluebird
Regulus satrapa (Lichtenstein): golden-crowned kinglet
Regulus calendula (Linnaeus): ruby-crowned kinglet
Bombycilla cedrorum (Vieillot): cedar waxwing
Vireo flavifrons (Vieillot): yellow-throated vireo
Vireo solitarius (Wilson): solitary vireo
Vireo olivaceus (Linnaeus): red-eyed vireo
Vireo gilvus (Vieillot): warbling vireo
Mniotilta varia (Linnaeus): black-and-white warbler
Vermivora chrysoptera (Linnaeus): golden-winged warbler
Vermivora peregrina (Wilson): Tennessee warbler
Vermivora celata (Say): orange-crowned warbler
Vermivora ruficapilla (Wilson): Nashville warbler
Parula americana (Linnaeus): northern parula
Dendroica petechia (Linnaeus): yellow warbler
Dendroica magnolia (Wilson): magnolia warbler
Dendroica tigrina (Gmelin): Cape May warbler
Dendroica coronata (Linnaeus): yellow-rumped warbler
Dendroica virens (Gmelin): black-throated green warbler
Dendroica fusca (Muller): Blackburnian warbler
Dendroica pensylvanica (Linnaeus): chestnut-sided warbler
Dendroica castenea (Wilson): bay-breasted warbler
Dendroica striata (Forster): blackpoll warbler
Dendroica pinus (Wilson): pine warbler
Dendroica palmarum (Gmelin): palm warbler
Seirus aurocapillus (Linneaus): ovenbird
Seirus noveboracensis (Gmelin): northern waterthrush
Oporornis agilis (Wilson): Connecticut warbler
Oporornis philadelphia (Wilson): mourning warbler
Geothlypis trichas (Linneaus): yellowthroat
Wilsonia pusilla (Wilson): Wilson's warbler
Wilsonia canadensis (Linneaus): Canada warbler
Septophaga ruticilla (Linneaus): American redstart
Dolichonyx oryzivorus (Linneaus): bobolink
Sturnella magna (Linneaus): eastern meadowlark
Xanthocephalus xanthocephalus (Bonaparte): yellow-headed blackbird
Agelaius phoeniceus (Linneaus): red-winged blackbird
Iceterus galbula (Linneaus): northern oriole
Euphagus carolinus (Muller): rusty blackbird
Euphagus cyanocephalus (Wagler): Brewer's blackbird
Quiscalus quiscula (Linneaus): common grackle
Molothrus ater (Boddaert): brown-headed cowbird

Piranga olivacea (Gmelin): scarlet tanager
Pheucticus ludovicianus (Linneaus): rose-breasted grosbeak
Passerina cyanea (Linneaus): indigo bunting
Carpodacus purpureus (Gmelin): purple finch
Spinus pinus (Wilson): pine siskin
Spinus tristis (Linneaus): American goldfinch
Loxia curvirostra (Linneaus): red crossbill
Passerculus sandwichensis (Gmelin): savannah sparrow
Ammospiza leconteii (Audubon): LeConte's sparrow
Ammospiza caudacuta (Gmelin): sharp-tailed sparrow
Junco hyemalis (Linneaus): dark-eyed junco
Spizella passerina (Bechstein): chipping sparrow
Spizella pallida (Swainson): clay-colored sparrow
Zonotrichia albicollis (Gmelin): white-throated sparrow
Melospiza lincolnii (Audubon): Lincoln's sparrow
Melospiza georgiana (Latham): swamp sparrow
Melospiza melodia (Wilson): song sparrow