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WILDERNESS ECOLOGY:

THE UPLAND PLANT COMMUNITIES, WOODY BROWSE PRODUCTION, AND SMALL MAMMALS OF TWO ADJACENT 33-YEAR-OLD WILDFIRE AREAS IN NORTHEASTERN MINNESOTA

NORTH CENTRAL FOREST EXPERIMENT STATION
FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

The trend toward integrated multidisciplinary research is increasing. The research arm of the Forest Service recognizes the desirability of this approach. While not strictly a multidisciplinary effort, this instance of three studies conducted simultaneously on the same sample areas is a start toward integration of research effort. Small mammal populations, amount of woody browse available for large herbivores, and the composition and structure of the plant communities are all highly interrelated. Reporting all three related study results in one publication seems both logical and efficient.

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WILDERNESS ECOLOGY: THE UPLAND PLANT COMMUNITIES, WOODY BROWSE PRODUCTION, AND SMALL MAMMALS OF TWO ADJACENT 33-YEAR-OLD WILDFIRE AREAS OF NORTHEASTERN MINNESOTA

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PART I. THE UPLAND PLANT COMMUNITIES

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ABSTRACT

The present upland vegetation of two adjacent wildfire areas that burned 33 years ago consists of four plant community types: aspen, aspen-birch, jack pine-birch, and jack pine. These types were identified through cluster and canonical analysis of species frequency of occurrence data from 33 sample stands located randomly over the two areas. Present vegetation differences appear to relate better to the type and condition of vegetation present before the fire than to measured environmental parameter differences found between the types.

The virgin forest communities of the Boundary Waters Canoe Area in northeastern Minnesota probably owe a major portion of their variation in composition and structure to the presence of wildfire over the past 400 years (Heinselman 1969, 1970). Ohmann and Ream (1971b) studying mature upland virgin plant communities of the BWCA concluded that (1) the length of time elapsed since last major disturbance (usually fire) and (2) the type of vegetation present at the time of that disturbance were important factors in determining the structure and composition of the present plant communities. Early postfire vegetation response has been described by Ahlgren (1960) and is currently being studied in detail on seven plant communities following a recent (1971) 15,000-acre wildfire in the BWCA.[1/]

Since periodic fires are apparently fundamental to the vegetation of the area, it is important to document the structure and composition of the postfire plant communities intermediate in age between those described by Ohmann and Ream (1971b) and Ahlgren (1960). Thus, the present paper quantitatively describes and classifies intermediate-aged upland virgin vegetation. Because it is intended to complement quantitative ecological baseline data that were previously published for the mature virgin plant communities of the BWCA (Ohmann and Ream 1971b), it includes extensive tabular data for each plant community defined in this study.

OBJECTIVES

One objective of the study was to classify and describe the upland plant communities resulting from wildfire 33 years ago. A second objective was to examine further the hypothesis that time elapsed since disturbance, and the vegetation present at the time of disturbance, are more important than differences in environmental parameters in determining the structure and composition of present plant communities over a small region such as the BWCA (Ohmann and Ream 1971b). If elapsed time since last major disturbance is unimportant, we should expect many of the same plant communities described for the mature forest to be also present on the study area where time since disturbance is a constant. Preburn aerial photographs allow at least superficial examination of preburn vegetation. The relationship of certain environmental factors (other than fire) to the resultant communities can also be examined.

STUDY AREA

BWCA fires were compiled for the period 1936-1966 by Brown[2/] from National Forest Administration Fire Reports. Analysis of his compilation showed that of 155 wildfires occurring during that period, only 41 burned areas were unlogged or partly unlogged and only 14 of these were 5 acres or larger in size. Six of the 14 fires occurred in upland vegetation and of these, two were 5 acres, one 18 acres, one 158 acres, and two were over 3,000 acres. The two large wildfires were assumed to be more typical (in terms of size and thus variability of effects) of past fires in the area and were chosen for study.

No two wildfires are likely to produce the exact same effects; however, the fires that burned the Frost Lake and Cherokee Lake areas seem to have had comparable impact and produced similar effects, making them suitable for a combined study. Similarities include:

1/ Office report on file at North Central Forest Experiment Station, St. Paul, Minn.

2/ Data on file, North Central Forest Experiment Station, St. Paul, Minn.

	FROST LAKE FIRE	CHEROKEE LAKE FIRE
Location of fire origin	T-64N, R-4W, S-36	T-64N, R-4W, S-27
Date of fire start	7-11-36	8-12-36
Duration of fire	10 days	9 days
Major timber types burned:		
NH (Hardwoods)	2,295 acres	1,899 acres
A (Aspen)	363	92
J (Jack pine)	--	611
Sp (Black spruce)	--	568
Yp-J (Red pine-Jack pine)	153	--
Sp-T (Black spruce- Tamarack)	326	--
Wp (White pine)	136	10
Balsam fir	119	12
Br (Brush)	--	7
Total acres burned	3,392	3,199

The timber type symbols above are from the 1936 fire reports. Although the type symbols in the fire reports are different, J and Yp-J probably refer broadly to the same type, and similarly for Sp and Sp-T. Types in parentheses are our interpretations of the major species that the symbols represent.

Thus, two areas were chosen for study that burned under similar fire conditions during the same fire season, that cover the same acreage in essentially the same timber types, and that lie adjacent to each other (fig. 1).

METHODS

Prefield

The major vegetation types on the two burn areas were identified from 1961 aerial photographs and outlined on U.S. Geological Survey topographic maps. From these maps the acreage of each type was estimated by dot-grid overlay.

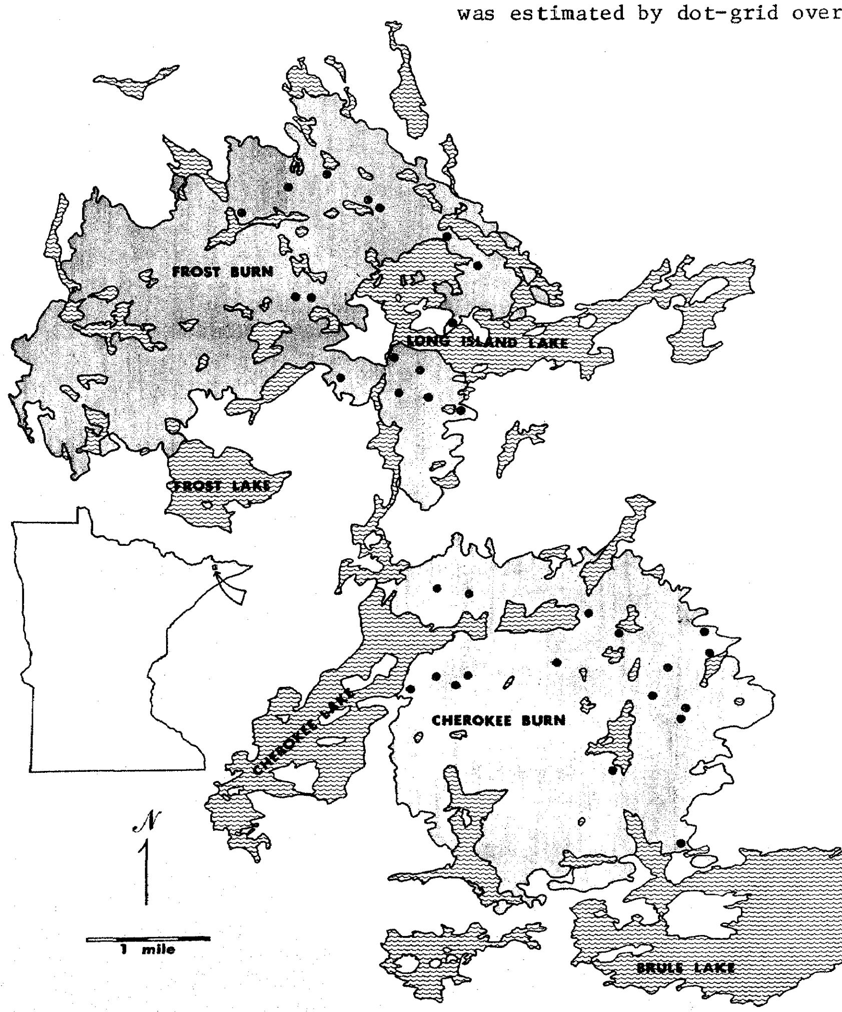

Figure 1.--Frost Lake and Cherokee Lake study area with sample locations indicated by dots.

Potential sample sites were located within the two areas by using a random-numbers table and grid overlay on the quadrangle maps. Randomization was restricted with the criterion that the sample contain both north- and south-facing aspects for each of the major upland vegetation types in each burn area. Seventy-two locations were selected and plotted under the assumption that at least one-half of these would meet the field criteria for acceptance and could be sampled during the 1969 field season. Thirty-three stands were selected for sampling.

Field

Methods have been described in detail by Ohmann and Ream (1971a). Briefly, they consist of the following: only upland plant communities, defined as those in which surface water never accumulates, were sampled. The minimum size of each sampled area was normally about 5 acres, and only sites uniform in topography and vegetation were acceptable. Twenty points were examined within each stand to sample the vegetation. The point-centered quarter method (Cottam and Curtis 1956) was used for trees. Because of the immaturity of these forests, and thus smaller diameter of the trees, the tree size class included all stems more than 1 inch in diameter at breast height (d.b.h.). Circular milacre plots were used for tree seedlings (all stems less than 1 inch d.b.h.) and tall shrubs, and rectangular 1 x 2 foot plots were used for other vegetative components. General environmental information including elevation, slope, aspect, and distance to water were measured and recorded for each stand. A soil pit was dug and samples of the mineral horizon were collected. Surface organic horizons were never deeper than 6 inches and ground-water tables were not near the surface.

Numerical Analysis

The general analytical procedures outlined for other BWCA plant community studies (Ohmann and Ream 1971a, Ream and Ohmann 1971) were used in this study. Specific classification philosophy and procedures are detailed in Ohmann and Ream (1971b). Use of canonical ordination (Goldstein and Grigal 1972) in place of the principal component ordination used in the earlier study (Ohmann and Ream 1971b), however, necessitated a reduction in the number of species used in the classification and ordination portion of this analysis.

It is generally accepted that only a few representatives of the flora of a region will occur and/or be sampled within any one small randomly selected stand. Therefore, the sample data as a matrix of species values within stands is expected to contain many zero values. Analysis of such a matrix creates problems both because of the large core-storage requirement for the computer and because some multivariate techniques (like canonical ordination) may fail when many zeros occur in the input matrix. For these reasons, we decided to reduce the number of species used in the classification process.

An effort was made to reduce species number with some objectivity. Thus, species were selected on the basis of occurrence in at least half of the sampled stands. A few species "groups" were removed from consideration in this process (e.g., grasses, sedges, lichens, other than *Cladonia* species, and mosses other than the feather mosses). Within the occurrence criterion, we selected 30 species which represented all strata of the forest: trees, tree seedlings, tall shrubs, low shrubs, herbs, and moss-lichens. The number of species selected in each stratum reflected that stratum's contribution to the total flora of the study.

Percent frequency of occurrence within each sample stand for the selected species was subjected to a polythetic agglomerative numerical classification based on within-group dispersion using standard distance (Grigal and Goldstein 1971, Goldstein and Grigal 1972). The classification produces a hierarchy of stand relationships (fig. 2).

Thirteen stand groups from different levels of the classification hierarchy were subjected to canonical ordination (Goldstein and Grigal 1972) (fig. 3). The stands which were common to the stand groups comprising the regional nodes that resulted from the ordination were re-ordinated as new stand groups (fig. 4).

Environmental Parameter Analysis

Samples of mineral soil (B horizon) were analyzed for exchangeable calcium, magnesium, potassium, and sodium by shaking 5 grams of soil in 20 ml neutral normal ammonium acetate for one-half hour. This mixture was filtered and leached with an additional 80 ml of ammonium acetate. Calcium and magnesium were analyzed on a Perkin Elmer atomic absorption spectrophotometer Model 303.[3/] Sodium and potassium were analyzed on a Perkin Elmer flame photometer. Exchangeable hydrogen was measured by the $BaCl_2$-Triethanolamine, pH 8.1 method. Extractable phosphorus was analyzed by shaking 5 grams of soil for 5 minutes in 50 ml of Bray's No. 1 solution (0.025 N HCl - 0.03 N NH_4F). Molybdophosphoric blue color was developed and read on a Klett Summerson Colorimeter. Acidity (pH) was determined on a 1:1 soil-water mixture by a Beckman Zeromatic pH meter.

Mineral soil samples were analyzed by a modification of the hydrometer method (Bouyoucos 1951) for percent sand, silt, and clay. Moisture retention capacity was determined by pressure membrane extraction at 15 and pressure plate extraction at 1/3 atmospheres (Richards 1954).

Environmental data were summarized for each of the plant community types generated by the numerical analysis. The mean value and standard error

3/ *Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

of each parameter for each type were calculated and plotted. The presence of differences between means was detected by use of the Student-Newman-Keuls multiple-range test (Steel and Torrie 1960).

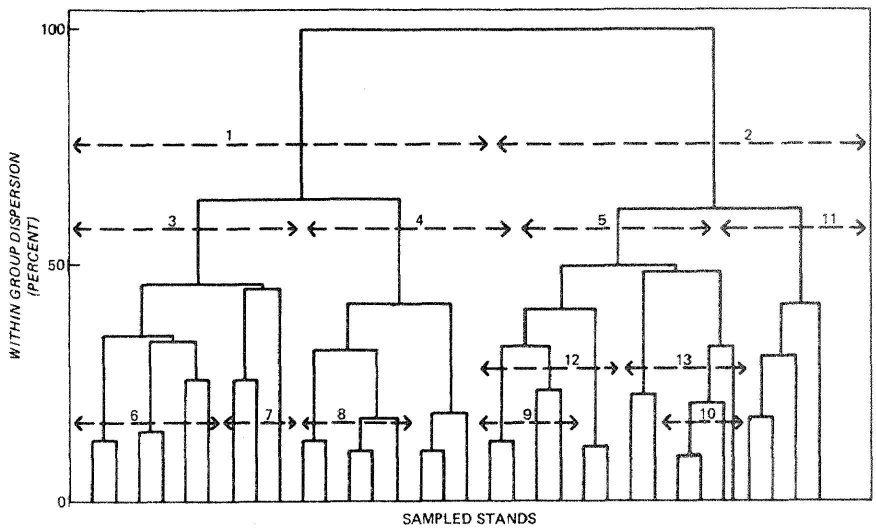

Figure 2.--Dendrogram representing the numerical classification of 33 sampled stands from the Frost Lake and Cherokee Lake wildfire areas. Dashed lines enclose stand groups subjected to canonical ordination.

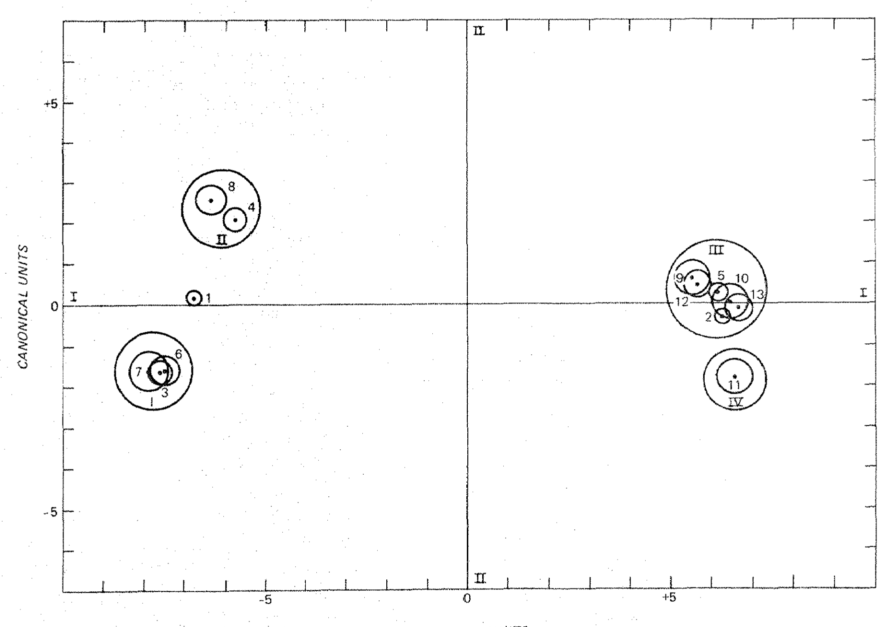

Figure 3.--Position along first two canonical axes of stand groups 1 through 13 from the dendrogram (figure 2). Small circles represent 90 percent confidence intervals around group means. These two axes account for 95 percent of the variation. Large circles surrounding more than one stand group represent regional nodes I, II, III, and IV whose stands held in common were reordinated as new stand groups.

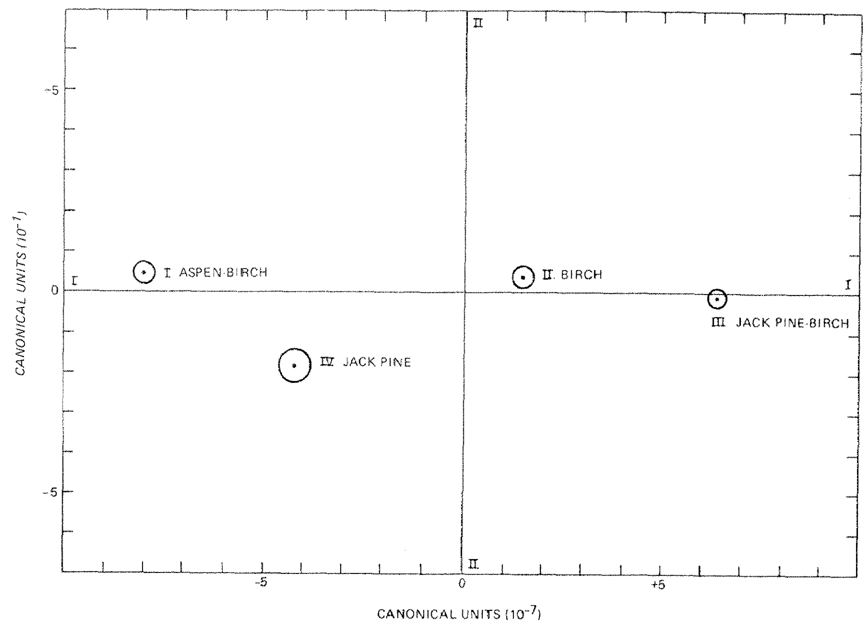

Figure 4.--Position along first two canonical axes of stand groups comprising regional nodes I, II, III, and IV from the Frost Lake and Cherokee Lake wildfire areas. Circles represent 90 percent confidence intervals around group means. Note that axis I scale units are multiplied by (10^{-7}) and axis II units by (10^{-1}). These axes account for nearly 100 percent of the variation.

Preburn Vegetation Analysis

Partial stereo-coverage for the area is available from 1934 aerial photographs. Unfortunately, the photo scale is smaller than that of the 1961 photos and the quality is highly variable, but the preburn cover type and degree of canopy cover were determined where possible.

RESULTS AND DISCUSSION

The Sample

Prior to the sampling procedure four upland vegetation types, aspen-birch, jack pine, upland brush, and rock outcrop, were identified and delimited on 1961 aerial photographs (table 1) through photo interpretation. Based simply on this interpretation process, aspen-birch is clearly the major vegetation type of the Frost Lake area, while aspen-birch and jack pine are of similar areal extent on the Cherokee Lake area. When the selected sites were visited, we found that what we had classified as upland brush and rock outcrop in 1961 consisted of forest or open-grown trees in 1969. We disregarded this change and proceeded to sample as in the original schedule. The original sample assignment included 72 potential sites distributed throughout the four upland types on both north and south slopes, and 33 of these stands were sampled. Sixteen stands were sampled in the Frost Lake area; four from areas originally typed aspen-birch, five jack pine, three upland brush, and four rock outcrop. Seventeen stands were sampled in the Cherokee Lake area; three originally typed aspen-birch, five jack pine, four upland brush, and five rock outcrop.

Table 1.--Vegetation type acreage estimates based on 1961 aerial photographs of the Frost and Cherokee wildfire areas prior to sampling (Acres)

Vegetation type	Frost Lake	Cherokee Lake
Aspen-birch	2,069	1,312
Jack pine	373	1,471
Upland brush	509	160
Rock outcrop	169	64
Lowland brush	204	160
Swamp conifer	68	32
Total	3,392	3,199

Classification and Ordination

The goal of classification is to combine those stands which are most similar floristically. Any two samples of vegetation can be found to differ if sufficient detail is considered, but samples can also be combined at various levels of similarity and useful generalizations made about the composition and structure of the groups. Thirty species were selected for use in the classification and ordination procedure (table 2).

Table 2.--Species selected for use in the classification and ordination procedures defining the plant communities of the Frost and Cherokee Lakes wildfire areas

Stratum	Species	
Tree	*Abies balsamea* *Betula papyrifera*	*Pinus banksiana* *Populus tremuloides*
Tall shrub	*Acer spicatum* *Amelanchier* spp. *Corylus cornuta*	*Prunus pensylvanica* *Salix bebbiana*
Tree seedling	*Abies balsamea* *Betula papyrifera* *Picea glauca*	*Picea mariana* *Populus tremuloides*
Low shrub	*Rubus strigosus*	*Rubus pubescens*
Herbaceous	*Aralia nudicaulis* *Aster macrophyllus* *Clintonia borealis* *Cornus canadensis* *Epilobium angustifolium*	*Galium triflorum* *Linnaea borealis* *Maianthemum canadense* *Streptopus roseus* *Trientalis borealis*
Moss-lichen	*Calliergonella schreberi* *Cladonia rangiferina*	*Dicranum* spp. *Polytrichum* spp.

The percent of selected species in each stratum category--trees, tall shrubs, tree seedlings, low shrubs, herbaceous, and moss-lichen--approaches (by design) the percent of all species represented in these same categories for the entire sample. The classification used was polythetic agglomerative based on within-group dispersion using standard distance (Orloci 1967). The results of the classification can be depicted diagrammatically as a dendrogram (fig. 2) which shows the combining of stands at various levels of within-group dispersion until all are combined at the 100-percent level.

We wished to know which stand combinations best represented identifiable community types. The stands comprising each stand group (1 through 13) of figure 2 were ordinated. Those stand groups which are most similar or contain many of the same stands (e.g., groups 9 and 12) would be expected to fall near each other in the ordination.

The stand groups are located along axes I and II of the ordination (fig. 3). All of the stand groups from the left half of the dendrogram fell along the left half of axis I and all from the right half alined along the right half of axis I. Stand group 1 is comprised of all the stands that also make up dendrogram groups 3, 4, 6, 7, and 8, and on the ordination it falls about midway between those stand groups. Stand groups 4 and 8, which have five stands in common, fall near each other. Stand group 3 and its subgroups (6 and 7) all fall near each other with their confidence intervals overlapping.

Except for group 11 all the stand groups from the right side of the dendrogram (fig. 2) fall near each other in the ordination, and their confidence intervals overlap. We believe this means group 11 is dissimilar from the other, more closely related groups of this portion of the dendrogram.

Circles were drawn around those stand groups that appear to be closely related on the first two axes of the canonical analysis (fig. 3). Only two axes were considered because the first axis represented 92 percent of the variation and the second axis accounted for 3 percent more, while the remaining eight axes combined accounted for only 5 percent. The encircled areas were designated as regional nodes I, II, III, and IV, and stands common to each area were re-ordinated as new stand groups (fig. 4). We interpret the broad separation in these two axes of multidimensional space as a useful level of generalization to distinguish between the groups of stands. Throughout the remainder of this report we describe the upland vegetation of the two burn areas in terms of four plant community types composed of the stand groups I-IV on the final ordination, or in terms of the dendrogram (fig. 2), groups 3, 4, 5, and 11, respectively, at the 55 percent within-group dispersion level.

The Plant Communities

The four community types generated through the classification-ordination process we termed aspen-birch, birch, jack pine-birch, and jack pine based on the most important contributors to the tree stratum. About equal numbers of the 33 sampled stands are classified as aspen-birch and birch, 9 and 8, respectively (table 3). Only four stands make up the jack pine type, and the remaining 12 stands form the jack pine-birch community type. Three of the types are unequally distributed between the two burns. All of the birch stands are on the Frost Lake burn, while the Cherokee Lake burn contains all but one of the aspen-birch stands and all of the jack pine stands.

Table 3.--A comparison of the four plant community types delimited for the Frost Lake and Cherokee Lake wildfire areas

Item	Community type			
	Aspen-birch	Birch	Jack pine-birch	Jack pine
Number of sampled stands	9	8	12	4
Frost Lake area	1	8	7	0
Cherokee Lake area	8	0	5	4
Number of stands presampling typed				
Aspen-birch	3	4	0	0
Jack pine	0	0	7	3
Upland brush	3	1	2	1
Rock outcrop	3	3	3	0
Tree stratum				
Basal area (ft^2/acre)	100	88	149	160
Density (stems/acre)	1,585	3,056	3,198	1,575
Tall shrub stratum				
Basal area (ft^2/acre)	10	3	2	2
Density (stems/acre)	9,567	5,269	2,129	3,163
Tree seedling stratum				
Cover (percent)	8	11	14	2
Density (stems/acre)	7,622	7,981	12,713	2,975
Low shrub stratum				
Cover (percent)	6	3	3	2
Herbaceous stratum				
Cover (percent)	53	46	21	50
Moss-lichen stratum				
Cover (percent)	9	7	16	15

The types resulting from the classification corresponded reasonably well with those from the aerial photo typing. Sample areas typed from the photos as aspen-birch are members of the aspen-birch or birch types and those typed as jack pine are jack pine-birch or jack pine. All but one of the stands typed as upland brush and rock outcrop are members of the aspen-birch, birch, or jack pine-birch types.

Tree basal area is greatest in the communities having a significant amount of jack pine (*Pinus banksiana*)[4/] in the canopy, while tree density is highest where paper birch (*Betula papyrifera*) is significant. The birch, where common, are obviously more numerous but smaller in diameter. However, analysis of age data from sample trees in each stand indicates no significant difference in average age of the birch [30.2 years (n = 30)] compared to jack pine [31.9 years (n = 67)] or quaking aspen (*Populus tremuloides*) [30.8 years (n = 49)].

While tree basal area and density values of mature upland plant communities in the BWCA reported by Ohmann and Ream (1971b) would not be expected to be equivalent to the immature communities of this study, it is useful to compare the range of values. The basal area value of the 1936 aspen-birch community (100 square feet per acre) is about the same as that for the mature aspen-birch community type elsewhere (90 square feet). Density values are very dissimilar, however, with only 483 stems per acre in the mature community, about one-third the value for the 1936 burn area aspen-birch type. The closest equivalent to the 1936 jack pine community is the jack pine (oak) community type of the mature forest (Ohmann and Ream 1971b). Again the basal area values are somewhat similar (160 versus 110 square feet per acre, respectively), but the density values are quite different (1,575 versus 602 stems per acre, respectively). There is no close equivalent of the birch community in the mature forest, but we can compare this type to the fir-birch community under the assumption that the presence of balsam fir (*Abies balsamea*) trees and seedlings in the 1936 birch stands are indicative of a succession to fir-birch. The comparative values are 97 square feet and 707 stems per acre for the fir-birch type versus 88 square feet and 5,269 stems per acre for the 1936 birch type. A loss of a third or more of the present stems can therefore be expected during maturation of the communities in these burns.

The tall shrubs are best represented in the aspen-birch type, both in terms of basal area and density, and both values decrease with an increase in the amount of conifers in the canopy (table 3). This follows the general pattern found in the mature communities where the deciduous plant communities contain by far the greatest number of tall shrub stems per acre.

Part of the difference among the four types in total tree seedlings can be accounted for by the occurrence of balsam fir (table 3). The jack pine-birch type has the greatest number and percent cover of tree seedlings, and also the most balsam fir, whereas the jack pine type has the lowest total seedling numbers and cover and also the fewest balsam fir. However, even when the balsam fir are deducted, there is still a considerable difference among types (aspen-birch 5,755; birch 3,931; jack pine-birch, 7,571; and jack pine 2,950 stems per acre).

There appears to be less difference among the communities in percent cover in the other vegetative classes (table 3). Total cover values for the herbaceous and low shrub categories are somewhat higher in the aspen-birch than in the other types, while total cover for lichens and mosses is higher where jack pine is an important canopy member.

The low occurrence of blueberry and wintergreen in all four of the communities seems inconsistent with their general occurrence in the mature plant communities and in comparison to their presence following a 1971 wildfire in the BWCA (unpublished data). Twenty of the stands were, therefore, revisited and in each, 20 one-by-two-foot plots were established and checked for the presence of *Gaultheria procumbens*, *Vaccinium angustifolium*, and *V. myrtilloides*. A particular effort was made to check the stands of the jack pine and jack pine-birch communities where these species would be expected. These species were less frequent than they are in communities of the mature forest (table 4). We believe this is an indication of the severity of the two 1936 fires which burned in mid-summer of drought year. The 1971 fire referred to above

Table 4.--A comparison of presence in stands and average frequency of occurrence in sample plots of three species in the plant communities of the Frost Lake and Cherokee Lake wildfire areas and in the mature virgin plant communities of the BWCA

(In percent)

Community	*Gaultheria procumbens*		*Vaccinium angustifolium*		*Vaccinium myrtilloides*	
	Presence	Frequency	Presence	Frequency	Presence	Frequency
CHEROKEE LAKE-FROST LAKE COMMUNITIES						
Aspen-birch	0	0	0	0	0	0
Birch	0	0	0	0	20	1
Jack pine-birch	11	1	22	4	33	4
Jack pine	0	0	0	0	25	3
MATURE VIRGIN COMMUNITIES						
Jack pine (oak)	100	45	90	54	27	3
Aspen-birch	0	0	46	8	62	10
Fir-birch	0	0	12	1	50	5

4/ *Scientific names for tree species follow Little (1953); those for shrubs and herbs follow Gleason (1963) with a few exceptions, in which either Lakela (1965) or Fernald (1950) are used. Scientific names for lichens follow Hale and Culbertson (1965), and those for mosses follow Grout (1928-1940).*

was a spring fire in which little of the duff was removed by burning. These species sprouted vigorously the same growing season following the fire. Heavy-fruited species such as wintergreen and blueberry may require a long time to become reestablished in an area following a severe fire that has consumed everything down to the mineral soil.

Aspen-Birch Community

Paper birch and quaking aspen together dominate the tree stratum of this community, each having an average of 40 square feet of basal area per acre (table 5). The birch are of smaller diameter, however, having an average density of 895 stems compared with 512 aspen stems per acre. Birch is also more common; e.g., it is more likely to be found at any point within a stand as is indicated by the commonness index (presence x frequency). Jack pine, occurring in eight of the nine stands in the type, also has a considerable basal area, but is scattered with an average of only 43 stems per acre. Three tree species--white spruce (*Picea glauca*), mountain-ash (*Sorbus americana*), and black spruce (*Picea mariana*)--are more numerous than jack pine, but they are of much lower basal area. White spruce, while not abundant, occurred in eight of the nine stands comprising the type--more frequently than in any other type. Balsam fir and white-cedar (*Thuja occidentalis*) are also present. White-cedar occurred in the tree size class only in this community type.

The most abundant and most common tall shrub species is mountain maple (*Acer spicatum*) with an average of 5,200 stems and 2.1 square feet of basal area, more than in any other type. Beaked hazel (*Corylus cornuta*) is a significant member of the tall shrub stratum, but did not occur in all stands. While considerably less numerous and common than mountain maple, beaked hazel outnumbers mountain maple in two stands within the type. Bebb willow (*Salix bebbiana*) with an average of only 370 stems makes up half the total shrub basal area, but the basal area is high because of several stems in one quadrat which had attained the stature and diameter of the canopy trees. Pincherry (*Prunus pensylvanica*) occurred in eight of the nine stands and frequently in the sample plots, but is low in density, probably because of its single-stem habit of growth. It is a representative of the immediate postfire stages of regeneration, and thus the individual stems are of large average size and contribute significantly to the basal area (0.6 square foot) despite its low density. Other tall shrubs present are fly honeysuckle (*Lonicera canadensis*), juneberry (*Amelanchier* spp.), round-leaved dogwood (*Cornus rugosa*), speckled alder (*Alnus rugosa*), green alder (*A. crispa*), and common elder (*Sambucus canadensis*). The latter species was encountered only in this community type.

Paper birch is the most important tree seedling of the community with an average of 3,944 stems per acre and a ground cover of 1.6 percent (table 5). It is consistently present in high numbers in all but one stand within the type. Balsam fir seedlings occur nearly as frequently as birch as is indicated by their similar indices of commonness, and fir also has a similarly high cover value (2.0 percent) but is much lower in average density (1,867 stems per acre). In only three stands within the type does fir outnumber birch.

White-cedar and black spruce seedlings are also important in terms of cover. While the cedar is about the same average density as balsam fir, it occurred in only five of the nine stands in the type and as a seedling is important only in this community. Black spruce is much lower in average density and occurred in six of the nine stands. Other seedling species present include white spruce (in low numbers but present in all but one stand), quaking aspen, mountain-ash, red maple (*Acer rubrum*), jack pine, and white pine (*Pinus strobus*). The seedling composition indicates a trend toward a community type like that of the fir-birch community of the mature forest (Ohmann and Ream 1971b).

The most important low shrubs of the community are dewberry (*Rubus pubescens*) and bush honeysuckle (*Diervilla Lonicera*), with dewberry by far the most common (table 5). It has a consistently higher cover than in any other type. Red raspberry (*Rubus strigosus*) and wild rose (*Rosa acicularis*) are probably remnants of early postfire stages and are still of some importance, although not occurring in every example of the type.

Species composition of the herbaceous stratum is, in general, the same as that of the mature aspen-birch community, except that fewer species were encountered, probably because of this more restricted sampling region. In fact, the five most important species here were among the six most important of the mature community and have about the same ground cover values. Six species not present in the mature community were recorded in this type, but of these, one occurred in single plots in two stands, and the rest occurred in a single plot. Large-leaf northern aster (*Aster macrophyllus*) has the highest average percent ground cover of the herbs, although it is not consistently high. Other important species are bunchberry (*Cornus canadensis*), wild sarsaparilla (*Aralia nudicaulis*), false lily-of-the-valley (*Maianthemum canadense*), violets (*Viola* spp.), Clinton's lily (*Clintonia borealis*), sweet bedstraw (*Galium triflorum*), and grasses.

The moss-lichen stratum is slightly better developed here than in the mature aspen-birch community (Ohmann and Ream 1971b) and is similarly dominated by mosses, although many lichen species are present (table 5).

Table 5.--Summary of Frost Lake and Cherokee Lake wildfire areas aspen-birch plant community

Species and ground cover	Presence in stands	Average frequency in sample plots within stands	Average density	Average basal area	Average cover	Average relative frequency	Average relative density	Average relative dominance	Average importance value	Commonness index[1/]
	Percent	Percent	Stems per acre	Sq. ft. per acre	Percent	Percent	Percent	Percent	Percent	Presence X frequency
TREES										
Betula papyrifera	100	82	895	40	--	43	50	39	44	8,167
Populus tremuloides	100	69	512	40	--	35	37	39	37	6,889
Picea glauca	89	12	54	3	--	6	3	3	4	1,086
Pinus banksiana	89	12	43	13	--	6	4	14	8	1,086
Picea mariana	44	13	44	3	--	6	4	3	4	593
Abies balsamea	56	6	24	1	--	3	2	1	2	309
Sorbus americana	44	6	72	X	--	8	2	2	4	272
Thuja occidentalis	33	3	13	X	--	2	1	X	1	111
TALL SHRUBS										
Acer spicatum	100	48	5,172	2	--	33	40	25	33	4,778
Corylus cornuta	78	25	2,583	2	--	16	25	20	20	1,944
Prunus pensylvanica	89	18	261	1	--	14	5	13	11	1,580
Salix spp.	44	11	494	1	--	7	5	7	6	469
Salix bebbiana	44	9	372	5	--	8	8	20	12	395
Amelanchier spp.	67	3	89	X	--	3	1	X	1	222
Lonicera canadensis	44	4	233	X	--	3	4	1	3	198
Alnus crispa	44	4	328	1	--	3	4	10	6	173
Cornus rugosa	22	1	17	X	--	1	X	X	1	25
Sambucus canadensis	11	1	6	X	--	X	X	X	X	6
Alnus rugosa	11	1	11	X	--	X	X	X	X	6
TREE SEEDLINGS										
Betula papyrifera	100	37	3,944	--	2	31	54	27	37	3,722
Abies balsamea	100	36	1,867	--	2	26	22	20	22	3,611
Populus tremuloides	89	14	339	--	X	12	5	5	7	1,235
Picea glauca	89	8	83	--	X	6	1	6	4	691
Picea mariana	67	9	156	--	1	8	2	25	12	630
Thuja occidentalis	56	11	1,078	--	2	7	13	14	12	586
Sorbus americana	44	6	72	--	X	4	1	1	2	272
Pinus banksiana	33	3	33	--	X	3	1	1	1	111
Acer rubrum	33	2	44	--	X	2	1	1	1	74
Pinus strobus	11	1	6	--	X	X	X	1	X	6
LOW SHRUBS										
Rubus pubescens	100	31	--	--	2	53	--	40	46	3,111
Diervilla Lonicera	89	9	--	--	3	19	--	36	28	840
Rubus strigosus	67	8	--	--	X	13	--	5	9	556
Rosa acicularis	67	4	--	--	1	7	--	7	7	296
Vaccinium myrtilloides	33	2	--	--	X	4	--	6	5	56
Ribes spp.	11	1	--	--	X	2	--	5	4	12
Ribes triste	11	1	--	--	X	1	--	X	X	12
Ribes glandulosum	11	1	--	--	X	X	--	X	X	6
Vaccinium angustifolium	11	1	--	--	X	1	--	X	X	6
Chimaphila umbellata	11	1	--	--	X	1	--	X	1	6
HERBACEOUS										
Aster macrophyllus	100	71	--	--	23	17	--	43	30	7,111
Cornus canadensis	100	66	--	--	7	16	--	15	15	6,611
Aralia nudicaulis	100	57	--	--	7	13	--	13	13	5,667
Gramineae	100	33	--	--	2	8	--	4	6	3,278
Maianthemum canadense	100	28	--	--	2	7	--	4	5	2,778
Viola spp.	100	27	--	--	1	6	--	2	4	2,722
Galium triflorum	89	16	--	--	X	4	--	1	2	1,432
Clintonia borealis	89	14	--	--	2	3	--	3	3	1,235
Linnaea borealis	78	12	--	--	1	3	--	2	3	907
Epilobium angustifolium	89	10	--	--	1	2	--	1	2	889
Cyperaceae	78	10	--	--	1	2	--	1	2	778
Trientalis borealis	67	12	--	--	1	3	--	2	2	778
Streptopus roseus	78	9	--	--	1	2	--	2	2	691
Lycopodium clavatum	67	7	--	--	1	2	--	2	2	482
Lycopodium obscurum	56	6	--	--	X	1	--	1	1	340
Apocynum androsaemifolium	56	5	--	--	X	1	--	1	1	278
Anaphalis margaritacea	44	3	--	--	X	1	--	1	1	148
Pyrola rotundifolia	33	4	--	--	X	1	--	X	1	130
Melampyrum lineare	44	3	--	--	X	1	--	X	1	124
Waldsteinia fragarioides	33	2	--	--	X	1	--	X	X	74
Equisetum spp.	33	2	--	--	X	X	--	X	X	56
Dryopteris spinulosa	22	2	--	--	X	X	--	X	X	49
Fragaria vesca	22	2	--	--	X	X	--	X	X	37
Pteridium aquilinum	22	2	--	--	X	X	--	1	X	37
Pyrola elliptica	22	1	--	--	X	X	--	X	X	25
Lathyrus ochroleucus	22	1	--	--	X	X	--	X	X	25
Aster ciliolatus	22	1	--	--	X	X	--	X	X	25
Gymnocarpium dryopteris	11	2	--	--	X	X	--	1	X	19
Goodyera tesselata	11	2	--	--	X	X	--	X	X	19
Lycopodium annotinum	11	1	--	--	X	X	--	X	X	12
Goodyera repens	11	1	--	--	X	X	--	X	X	12
Petasites palmatus	11	1	--	--	X	X	--	X	X	6
Dryopteris Phegopteris	11	1	--	--	X	X	--	X	X	6
Pyrola secunda	11	1	--	--	X	X	--	X	X	6
Mitella nuda	11	1	--	--	X	X	--	X	X	6
Solidago hispida	11	1	--	--	X	X	--	X	X	6
Actea rubra	11	1	--	--	X	X	--	X	X	6
Anemone quinquefolia	11	1	--	--	X	X	--	X	X	6

Continued on next page

Table 5 continued

Species and ground cover	Presence in stands	Average frequency in sample plots within stands	Average density	Average basal area	Average cover	Average relative frequency	Average relative density	Average relative dominance	Average importance value	Commonness index 1/
	Percent	Percent	Stems per acre	Sq. ft. per acre	Percent	Percent	Percent	Percent	Percent	Presence X frequency
MOSS-LICHEN										
Dicranum spp.	100	43	--	--	2	11	--	2	7	4,278
Other mosses	89	42	--	--	2	10	--	2	6	3,074
Calliergonella schreberi	100	34	--	--	3	9	--	3	6	3,389
Polytrichum spp.	100	29	--	--	1	8	--	1	5	2,889
Other lichens	78	29	--	--	1	7	--	1	4	2,247
Cladonia rangiferina	67	8	--	--	X	2	--	X	1	556
Hypnum crista-castrensis	33	2	--	--	X	X	--	X	X	56
Cladonia sylvatica	22	2	--	--	X	X	--	X	X	37
Cladonia alpestris	11	2	--	--	X	X	--	X	X	19
Cladonia mitis	11	1	--	--	X	X	--	X	X	6
Hylocomium splendens	11	1	--	--	X	X	--	X	X	6
GROUND CHARACTERISTICS										
Litter	100	100	--	--	85	27	--	84	56	10,000
Dead wood	100	37	--	--	3	10	--	3	6	3,722
Live wood	89	38	--	--	1	11	--	1	6	3,358
Bare rock	78	12	--	--	2	3	--	2	2	907
Bare ground	33	2	--	--	X	X	--	X	X	56

X denotes values of less than one percent.

1/ The commonness index is not always an exact product of presence and frequency here because these two factors were rounded for this table after the commonness index was determined.

Birch Community

The tree stratum of this community is characterized by many small paper birch trees with scattered larger-diameter quaking aspen. Paper birch has an average density of 2,458 stems and basal area of 54 square feet per acre (table 6). Its high index of commonness (9,800) indicates that it is present at nearly every point in every stand. While aspen are fewer in number, they are present in all but one stand within the type and make up nearly a quarter of the total basal area. Jack pine and balsam fir are a distant third in basal area followed by white pine, white spruce, black spruce, and mountain-ash. Balsam fir is present in all but two stands of the type and has a higher average density than in the other types. White spruce is less important than in the aspen-birch type.

The major tall shrub is beaked hazel with an average density of 2,613 stems and 1.6 square feet of basal area (table 6). Each of these values represents at least half of the total for all tall shrubs. It is the only species present in all stands of the type. Mountain maple with an average density of 1,125 stems and 0.4 square foot of basal area is present in all but one stand. Fly honeysuckle, round-leaved dogwood, and chokecherry (*Prunus virginiana*) all attain their greatest abundance in this community, though together they have an average density of only 1,179 stems, 0.2 foot of basal area, and are not present in every stand within the type. Other species represented are pincherry, bebb willow, juneberry, hairy climbing honeysuckle (*Lonicera hirsuta*), and speckled alder.

Balsam fir and paper birch are the most important tree seedlings with an average density of 4,050 and 3,225 stems, and percent ground cover of 5.6 and 3.0, respectively (table 6). In this type they are both consistently of high value with each being the more numerous in half the examples of the type. White spruce and black spruce seedlings are also important because of their relatively large size; each contributes about 1 percent cover while numbering only about 100 stems (table 6). White spruce is present in all but one stand of the type and is of about the same importance as in the aspen-birch type. Black spruce is present in only one-half the stands and is less important then in the aspen-birch type. White-cedar is considerably less important here than in the aspen-birch type. Other seedlings present are quaking aspen, mountain-ash, white-cedar, red maple, white pine, and jack pine. The two deciduous communities thus have similar total average seedling density and species composition, and like the aspen-birch community, this type shows a trend toward the fir-birch community of the mature forest.

Dewberry is the only low shrub of the community that is consistently present, although it is somewhat less important than in the aspen-birch community. The same species group is present here as in the aspen-birch type; however, total average cover is lower.

Large-leaf northern aster is again the most important member of the herbaceous class attaining its greatest cover and abundance in this type. Fewer species are present than in the previous community but the most important species are the same; e.g., wild sarsaparilla, false lily-of-the-valley, twin flower (*Linnaea borealis*), twisted stalk (*Streptopus roseus*), Clinton's lily, and grasses (table 6).

Mosses predominate in the moss-lichen class (table 6).

Table 6.--Summary of Frost Lake and Cherokee Lake wildfire areas birch plant community

Species and ground cover	Presence in stands	Average frequency in sample plots within stands	Average density	Average basal area	Average cover	Average relative frequency	Average relative density	Average relative dominance	Average importance value	Commonness[1] index
	Percent	Percent	Stems per acre	Sq. ft. per acre	Percent	Percent	Percent	Percent	Percent	Presence X frequency
TREES										
Betula papyrifera	100	98	2,458	54	--	62	79	63	68	9,813
Populus tremuloides	88	33	329	21	--	19	11	21	17	2,844
Abies balsamea	75	15	149	5	--	9	5	6	7	1,125
Sorbus americana	88	8	150	X	--	9	3	2	5	711
Picea glauca	63	6	44	1	--	4	1	2	2	352
Pinus banksiana	38	6	35	5	--	3	2	6	4	211
Pinus strobus	25	4	35	2	--	3	1	2	2	109
Picea mariana	13	1	8	X	--	1	X	X	X	16
TALL SHRUBS										
Corylus cornuta	100	29	2,613	2	--	28	49	61	46	2,938
Acer spicatum	88	28	1,125	X	--	22	19	16	19	2,461
Lonicera canadensis	88	11	816	X	--	9	15	7	10	968
Prunus pensylvanica	63	11	163	X	--	9	3	5	6	664
Amelanchier spp.	75	8	106	X	--	6	2	1	3	563
Salix bebbiana	63	8	113	X	--	8	2	4	5	469
Prunus virginiana	50	4	81	X	--	4	1	1	2	188
Cornus rugosa	50	4	200	X	--	3	3	1	2	188
Lonicera hirsuta	12	1	50	X	--	X	1	X	X	8
Alnus rugosa	12	1	133	X	--	X	X	X	X	8
TREE SEEDLINGS										
Abies balsamea	100	77	4,050	--	6	41	45	47	44	7,688
Betula papyrifera	100	66	3,225	--	3	36	46	32	38	6,563
Populus tremuloides	75	14	231	--	X	7	4	2	4	1,031
Picea glauca	88	11	119	--	1	6	2	11	6	930
Sorbus americana	88	8	150	--	X	4	2	1	2	711
Picea mariana	50	8	138	--	1	4	1	7	4	406
Thuja occidentalis	25	1	25	--	X	1	X	1	X	31
Acer rubrum	25	1	19	--	X	1	X	X	X	31
Pinus strobus	13	2	19	--	X	1	X	X	X	23
Pinus banksiana	13	1	6	--	X	X	X	X	X	8
LOW SHRUBS										
Rubus pubescens	100	26	--	--	1	61	--	50	56	2,563
Rubus strigosus	63	6	--	--	1	12	--	15	14	352
Rosa acicularis	75	3	--	--	X	7	--	9	8	234
Diervilla Lonicera	50	3	--	--	1	8	--	14	11	156
Chimaphila umbellata	38	3	--	--	X	6	--	5	6	94
Ribes triste	13	1	--	--	X	1	--	X	1	16
Rubus parviflorus	13	1	--	--	X	1	--	6	4	8
Ribes spp.	13	1	--	--	X	3	--	1	2	8
Vaccinium angustifolium	13	1	--	--	X	1	--	X	1	8

Jack Pine-Birch Community

This community is the most complex of the four. The community summary (table 7) indicates a mixture of deciduous and coniferous canopy species. However, when the tree component of the 12 stands comprising the type is examined, three conditions emerge: (1) Jack pine is by far the most numerous tree in six stands, (2) paper birch is clearly more numerous in four stands, and (3) the two species are present in about equal numbers in two stands (table 8). In all three cases the birch are smaller in diameter which is reflected in the average basal area value for the type, birch contributing only 22 square feet of basal area in contrast to 112 square feet for jack pine (table 7). In those stands where jack pine is most numerous, there are generally fewer other associated tree species. Quaking aspen, balsam fir, and white spruce are important in those stands where birch is most numerous (table 8). Quaking aspen is much less prominent here than in the two previously described communities. While white spruce is important only in the stands where birch is important, it still is most abundant as a tree in this community. Mountain-ash is also most abundant as a tree in this type.

The tall shrub class is not as well represented as in the two deciduous communities (table 7). Bebb willow is present in all but one stand and is most abundant with an average density of over 600 stems per acre and a basal area of 0.8 foot in this type. Beaked hazel, mountain maple, pincherry, and green alder, each absent in at least two stands within the type, are about equally important with 0.2 square foot of basal area each. Juneberry, squashberry (*Viburnum edule*), fly honeysuckle, and speckled alder are also present. This is the only community in which squashberry was found. Unlike the previously described communities, round-leaved dogwood is not represented.

Paper birch and balsam fir are the most conspicuous tree seedlings with average densities over 5,000 stems per acre, coverages of over 4 percent, and high indices of commonness (table 7). Both species are consistently present re-

Table 6 continued

Species and ground cover	Presence in stands	Average frequency in sample plots within stands	Average density	Average basal area	Average cover	Average relative frequency	Average relative density	Average relative dominance	Average importance value	Commonness index 1/
	Percent	Percent	Stems per acre	Sq. ft. per acre	Percent	Percent	Percent	Percent	Percent	Presence X frequency
HERBACEOUS										
Aster macrophyllus	100	83	--	--	30	26	--	66	46	8,313
Aralia nudicaulis	100	51	--	--	6	16	--	14	15	5,125
Maianthemum canadense	100	33	--	--	1	10	--	3	6	3,313
Cornus canadensis	100	31	--	--	3	8	--	7	8	3,125
Gramineae	100	31	--	--	1	9	--	1	5	3,063
Linnaea borealis	88	19	--	--	1	5	--	2	4	1,695
Viola spp.	75	13	--	--	X	4	--	X	2	984
Galium triflorum	88	9	--	--	X	3	--	1	2	820
Streptopus roseus	88	8	--	--	1	2	--	1	2	711
Clintonia borealis	75	9	--	--	1	2	--	2	2	656
Aster ciliolatus	88	7	--	--	X	2	--	1	1	602
Trientalis borealis	75	7	--	--	X	2	--	X	1	516
Epilobium angustifolium	75	6	--	--	X	2	--	X	1	469
Lycopodium clavatum	50	6	--	--	X	2	--	1	1	313
Pyrola secunda	50	5	--	--	X	1	--	X	1	250
Cyperaceae	63	4	--	--	X	1	--	X	1	234
Anaphalis margaritacea	75	3	--	--	X	1	--	X	1	188
Goodyera repens	38	4	--	--	X	1	--	X	1	141
Lycopodium obscurum	25	4	--	--	X	1	--	X	1	94
Apocynum androsaemifolium	38	3	--	--	X	1	--	X	X	94
Coptis groenlandica	38	3	--	--	X	1	--	X	1	94
Actea rubra	38	1	--	--	X	X	--	X	X	47
Fragaria vesca	25	1	--	--	X	1	--	X	X	31
Anemone quinquefolia	13	1	--	--	X	X	--	X	X	16
Petasites palmatus	13	1	--	--	X	X	--	X	X	16
Lathyrus ochroleucus	13	1	--	--	X	X	--	X	X	16
Fragaria virginiana	13	1	--	--	X	X	--	X	X	8
Melampyrum lineare	13	1	--	--	X	X	--	X	X	8
Polypodium virginanum	13	1	--	--	X	X	--	X	X	8
Pyrola virens	13	1	--	--	X	X	--	X	X	8
Pteridium aquilinum	13	*	--	--	X	--	--	X	X	--
MOSS-LICHEN										
Other mosses	100	79	--	--	3	21	--	3	12	7,938
Other lichens	100	66	--	--	1	17	--	2	9	6,563
Callergionella schreberi	100	31	--	--	2	8	--	2	5	3,125
Dicranum spp.	100	15	--	--	X	4	--	X	2	1,500
Cladonia rangiferina	75	9	--	--	X	2	--	X	1	656
Hylocomium splendens	38	4	--	--	X	1	--	X	1	164
Cladonia sylvatica	38	3	--	--	X	1	--	X	X	94
Hypnum crista-castrensis	38	2	--	--	X	X	--	X	X	70
GROUND CHARACTERISTICS										
Litter	100	100	--	--	88	26	--	88	57	10,000
Dead wood	100	43	--	--	3	11	--	3	7	4,250
Live wood	100	16	--	--	X	4	--	X	2	1,625
Bare rock	75	9	--	--	1	2	--	1	2	656
Bare ground	13	1	--	--	X	X	--	X	X	16

X denotes values of less than one percent.
* indicates a species value for ground cover but no rooted frequency of occurrence in the sample plots.
1/ The commonness index is not always an exact product of presence and frequency here because these two factors were rounded for this table after the commonness index was determined.

gardless of whether jack pine or paper birch is most numerous in the canopy. Black spruce is present in all but one stand and has considerable average ground cover (3.6 percent) of larger but fewer individuals (850 stems per acre). A lower average density (150 stems) and cover (0.8 percent) characterizes white spruce seedlings, and they occur in only eight of the 12 stands. Less important are quaking aspen, mountain-ash, white-cedar, white pine, red maple, and jack pine. While not very common in any of the four communities, mountain-ash, white spruce, and white pine seedlings reach greatest abundance here (table 7). The future of this type is likely to be more complex than that of the aspen-birch and birch communities. However, the presence of balsam fir, paper birch, and black spruce seedlings indicates the same trend to fir-birch with a relative increase in the importance of black spruce, especially in those stands dominated by jack pine.

Bush honeysuckle is the most important species of the poorly represented low shrub group. It is present in 10 of the 12 stands with about 2 percent average cover. The rest of the low shrub group of species is much the same as in the previous two communities but is more poorly represented with only dewberry present in at least half the stands (table 7).

This community exhibits only about half the herbaceous cover of the other three communities. Based on the commonness index (table 7), this is the only one of the four types in which large-leaf northern aster is clearly not the most common herb. It occurs in all but one stand of the type and is the major cover in four of the stands, yet it is less important here than in the other three types. The most common species is bunchberry followed by the aster, with false lily-of-the-valley, twin-flower, and wild sarsaparilla among the most important of the 33 species encountered. Sweet bedstraw and grasses are notably less important in this type than in the others.

Table 7.--Summary of Frost Lake and Cherokee Lake wildfire areas jack pine-birch plant community

Species and ground cover	Presence in stands	Average frequency in sample plots within stands	Average density	Average basal area	Average cover	Average relative frequency	Average relative density	Average relative dominance	Average importance value	Commonness[1/] index
	Percent	Percent	Stems per acre	Sq. ft. per acre	Percent	Percent	Percent	Percent	Percent	Presence X frequency
TREES										
Betula papyrifera	100	70	1,388	22	--	41	41	19	34	7,000
Pinus banksiana	100	67	1,450	112	--	41	48	68	53	6,708
Sorbus americana	67	13	254	X	--	14	12	9	12	889
Abies balsamea	67	8	93	4	--	5	3	3	4	556
Populus tremuloides	58	9	86	6	--	5	2	4	4	535
Picea glauca	33	8	118	5	--	4	3	5	4	278
Picea mariana	42	6	60	1	--	4	2	1	2	260
Pinus strobus	8	1	3	X	--	X	X	X	X	4
TALL SHRUBS										
Salix bebbiana	83	21	646	1	--	25	30	38	31	1,736
Corylus cornuta	83	11	496	X	—	17	19	16	17	938
Amelanchier spp.	83	11	217	X	--	14	11	11	12	903
Acer spicatum	75	11	371	X	--	13	13	8	11	813
Prunus pensylvanica	83	10	154	X	--	12	7	13	11	799
Lonicera canadensis	42	2	54	X	—	3	2	1	2	87
Alnus crispa	17	2	92	X	—	2	4	4	3	28
Viburnum edule	8	1	92	X	—	X	1	X	1	7
Alnus rugosa	8	1	8	X	—	1	1	X	X	4
TREE SEEDLINGS										
Abies balsamea	100	78	5,142	--	4	37	42	31	37	7,750
Betula papyrifera	100	68	5,879	--	5	32	40	31	34	6,750
Picea mariana	92	36	850	--	4	16	9	28	18	3,285
Sorbus americana	67	13	254	--	X	5	3	1	3	889
Picea glauca	67	9	150	--	1	3	1	6	4	583
Populus tremuloides	42	6	275	—	X	2	2	1	2	260
Acer rubrum	33	3	25	--	X	1	X	X	1	83
Pinus banksiana	33	2	17	--	X	1	X	1	1	56
Pinus strobus	33	2	29	—	X	1	1	X	1	56
Thuja occidentalis	17	2	92	--	X	1	2	X	1	35
LOW SHRUBS										
Diervilla Lonicera	83	9	--	--	2	25	--	46	36	764
Rubus pubescens	67	7	--	—	X	21	--	16	18	472
Chimaphila umbellata	67	6	--	—	X	18	--	20	23	417
Vaccinium myrtilloides	42	5	—	—	X	17	--	10	13	208
Rubus strigosus	33	2	--	--	X	7	--	4	5	69
Rosa acicularis	25	2	—	—	X	3	--	3	3	52
Vaccinium angustifolium	17	1	--	--	X	1	--	1	1	14
Ribes glandulosum	8	1	--	--	X	1	—	X	X	4
Ribes spp.	8	*	—	--	X	—	—	X	X	--

Although mosses dominate the moss-lichen stratum, lichens (other than the *Cladonia* species) are the most common (table 7). This stratum has about the same percent cover as the jack pine community type--about double that of the two deciduous communities.

Jack Pine Community

The jack pine community has a tree stratum clearly dominated by jack pine which has an average density of 1,157 stems and 145 feet of basal area per acre (table 9). Paper birch, quaking aspen, and black spruce are present, but their combined basal area is only about one-tenth that of the jack pine. No other species of trees were encountered in the four stands comprising the type. Compared with the other types, the tree stratum has the lowest average density, 1,575 stems per acre, and yet the highest basal area, 160 square feet per acre. This is probably indicative of a general even growth of the numerous jack pine.

Beaked hazel with an average density of 1,575 stems and 0.8 square foot of basal area clearly dominates the shrub stratum (table 9). Green alder and pincherry also have appreciable average basal area, 0.7 and 0.3 square foot, respectively, but average only about 300 stems per acre. Other members of this stratum are bebb willow, mountain maple, juneberry, fly honeysuckle, and chokecherry. Like the jack pine-birch community, this type has a sparse tall shrub stratum with a total average density of 3,163 stems and only 2.3 square feet of basal area per acre. A lesser tall shrub component in coniferous community types was also noted in the mature upland communities of the BWCA (Ohmann and Ream 1971b).

The tree seedling class is characterized by the lack of significant numbers of balsam fir. In contrast to the other three types, it has an average of only 25 stems per acre, and fir occurred in only one of the four stands comprising the type. Paper birch is the only common seedling with an average density of 2,638 stems and an average cover of 1 percent (table 9). The larger but less common black spruce seedlings also have 1 percent cover but are present in only three of the four stands. Other

Table 7 continued

Species and ground cover	Presence in stands	Average frequency in sample plots within stands	Average density	Average basal area	Average cover	Average relative frequency	Average relative density	Average relative dominance	Average importance values	Commonness index 1/
	Percent	Percent	Stems per acre	Sq. ft. per acre	Percent	Percent	Percent	Percent	Percent	Presence X frequency
HERBACEOUS										
Cornus canadensis	92	48	--	--	6	19	--	26	23	4,354
Aster macrophyllus	92	32	--	--	7	17	--	32	25	2,941
Maianthemum canadense	100	25	--	--	1	11	--	6	9	2,542
Linnaea borealis	75	33	--	--	3	12	--	10	11	2,438
Aralia nudicaulis	75	16	--	--	2	8	--	7	8	1,188
Goodyera repens	83	6	--	--	X	3	--	1	2	486
Viola spp.	58	8	--	--	X	3	--	1	2	438
Gramineae	58	5	--	--	X	2	--	1	2	316
Clintonia borealis	50	6	--	--	1	2	--	2	2	292
Trientalis borealis	50	5	--	--	X	2	--	X	1	229
Epilobium angustifolium	58	4	--	--	X	3	--	4	3	219
Fragaria vesca	50	4	--	--	X	2	--	1	1	188
Pyrola secunda	50	4	--	--	X	2	--	1	1	188
Cyperaceae	50	3	--	--	X	2	--	1	1	167
Streptopus roseus	42	3	--	--	X	1	--	1	1	139
Galium triflorum	33	3	--	--	X	1	--	X	1	83
Lycopodium clavatum	25	3	--	--	1	1	--	2	1	73
Pyrola virens	25	1	--	--	X	1	--	X	X	31
Petasites palmatus	17	2	--	--	X	1	--	X	1	28
Lycopodium obscurum	17	1	--	--	X	X	--	X	X	21
Anemone quinquefolia	17	1	--	--	X	X	--	X	X	14
Coptis groenlandica	17	1	--	--	X	X	--	X	X	14
Pyrola elliptica	17	1	--	--	X	1	--	X	X	14
Lycopodium annotinum	8	1	--	--	X	1	--	1	1	10
Aster ciliolatus	8	1	--	--	X	1	--	X	X	10
Goodyera tesselata	8	1	--	--	X	X	--	X	X	7
Dryopteris spinulosa	17	1	--	--	X	X	--	X	X	7
Equisitum spp.	17	1	--	--	X	X	--	X	X	7
Fragaria virginiana	8	1	--	--	X	X	--	X	X	7
Lycopus spp.	8	1	--	--	X	X	--	1	1	7
Waldsteinia fragarioides	8	1	--	--	X	X	--	X	X	7
Lathyrus ochroleucus	8	1	--	--	X	X	--	X	X	4
Antennaria neodioca	8	1	--	--	X	X	--	X	X	4
Monesus uniflora	8	1	--	--	X	1	--	2	1	4
Mitela nuda	8	1	--	--	X	1	--	1	1	4
Melampyrum lineare	8	1	--	--	X	X	--	X	X	4
MOSS-LICHEN										
Other lichens	100	80	--	--	2	16	--	2	9	8,000
Other mosses	100	75	--	--	3	15	--	3	9	7,458
Calliergonella schreberi	100	64	--	--	7	13	--	7	10	6,375
Polytrichum spp.	100	43	--	--	2	9	--	2	5	4,333
Dicranum spp.	100	37	--	--	1	7	--	1	4	3,667
Cladonia rangiferina	92	26	--	--	1	5	--	X	3	2,406
Cladonia sylvatica	67	7	--	--	X	1	--	X	1	444
Hypnum crista-castrensis	75	6	--	--	X	1	--	X	1	438
Hylocomium splendens	25	2	--	--	X	X	--	X	X	42
GROUND CHARACTERISTICS										
Litter	100	100	--	--	78	20	--	79	49	9,958
Dead wood	100	43	--	--	4	8	--	4	6	4,250
Live wood	92	23	--	--	1	4	--	1	3	2,101
Bare rock	58	7	--	--	1	1	--	1	1	413
Bare ground	17	1	--	--	X	X	--	X	X	14

X denotes values of less than one percent.
* indicates a species value for ground cover but no rooted frequency of occurrence in the sample plots.
1/ The commonness index is not always an exact product of presence and frequency here because these two factors were rounded for this table after the commonness index was determined.

Table 8.--A comparison of the density of tree species in the jack pine-birch plant community in relation to the numerical dominance of jack pine or paper birch in the individual stands of the community1/

Species	Stands numerically dominated by		
	Jack pine	Paper birch	Jack pine and birch
Quaking aspen	3	193	120
Paper birch	558	2,774	1,108
Jack pine	2,268	226	1,443
Balsam fir	21	143	68
White spruce	5	347	--
Black spruce	59	61	--

1/ Density in stems per acre.

constituents of the seedling stratum are mountain-ash, red maple, quaking aspen, white-cedar, and jack pine, but they occurred in only one stand within the type. The total average seedling density of 2,975 stems per acre and cover of 2.4 percent are considerably below those of the other community types.

Low shrubs are not well represented; the highest index of commonness is well below 500 (table 9). No species dominates this stratum, although red raspberry and wild rose are the most important. Perhaps indicative of the more xeric conditions in this type is the presence of low juniper (*Juniperus communis*), found only here.

The herbaceous stratum contains fewer members than in the other communities, but the dominants are much the same with large-leaf northern aster, wild sarsaparilla, bunchberry, and false lily-of-the-valley being the most important (table 9).

Lichens and mosses are both common in the moss-lichen category (table 9). Although the total average cover for the mosses exceeds that

Table 9.--Summary of Frost Lake and Cherokee Lake wildfire areas jack pine plant community

Species and ground cover	Presence in stands	Average frequency in sample plots within stands	Average density	Average basal area	Average cover	Average relative frequency	Average relative density	Average relative dominance	Average importance value	Commonness index [1/]
	Percent	Percent	Stems per acre	Sq. ft. per acre	Percent	Percent	Percent	Percent	Percent	Presence X frequency
TREES										
Pinus banksiana	100	95	1,157	145	--	52	64	90	69	9,500
Betula papyrifera	100	53	273	10	--	28	20	6	18	5,250
Populus tremuloides	100	30	105	4	--	15	13	3	10	3,000
Sorbus americana	100	9	150	X	--	11	6	7	8	875
Picea mariana	75	11	40	1	--	6	4	1	4	844
TALL SHRUBS										
Corylus cornuta	100	30	1,575	1	--	34	49	44	42	3,000
Amelanchier spp.	100	13	250	X	--	14	10	4	9	1,250
Salix bebbiana	100	13	313	X	--	13	9	11	11	1,250
Acer spicatum	75	14	325	X	--	15	13	10	13	1,031
Prunus pensylvanica	50	6	213	X	--	6	4	9	6	313
Lonicera canadensis	50	3	100	X	--	3	4	5	4	125
Alnus crispa	25	3	375	1	--	3	6	12	7	63
Prunus virginiana	25	1	13	X	--	2	X	X	1	31
TREE SEEDLINGS										
Betula papyrifera	75	40	2,638	--	1	45	66	37	49	3,000
Picea mariana	75	9	88	--	1	9	2	26	13	656
Sorbus americana	75	6	75	--	X	7	2	3	4	469
Acer rubrum	50	5	50	--	X	7	2	3	4	250
Abies balsamea	25	3	25	--	X	2	X	1	1	63
Populus tremuloides	25	3	38	--	X	4	2	5	4	63
Thuja occidentalis	25	1	25	--	X	1	X	1	1	31
Pinus banksiana	25	1	38	--	X	1	1	X	1	31
LOW SHRUBS										
Rubus strigosus	75	5	--	--	X	27	--	12	19	375
Rosa acicularis	50	4	--	--	X	31	--	27	29	188
Chimaphila umbellata	50	3	--	--	X	15	--	7	11	125
Rubus pubescens	25	3	--	--	X	13	--	15	14	63
Vaccinium myrtilloides	25	1	--	--	X	8	--	13	11	31
Juniperus communis	25	1	--	--	X	6	--	14	10	31
Diervilla Lonicera	50	*	--	--	X	--	--	13	6	--
HERBACEOUS										
Aster macrophyllus	100	74	--	--	23	29	--	47	38	7,375
Aralia nudicaulis	100	55	--	--	12	22	--	23	22	5,500
Cornus canadensis	100	36	--	--	5	14	--	11	13	3,625
Maianthemum canadense	100	24	--	--	2	10	--	5	7	2,375
Lycopodium clavatum	75	14	--	--	2	5	--	4	4	1,031
Gramineae	75	11	--	--	1	4	--	2	3	844
Linnaea borealis	75	8	--	--	1	3	--	3	3	563
Goodyera repens	75	5	--	--	X	2	--	X	1	375
Trientalis borealis	75	4	--	--	X	2	--	X	1	281
Galium triflorum	50	5	--	--	X	2	--	X	1	250
Polygonum cilinode	50	3	--	--	X	1	--	X	1	125
Coptis groenlandica	50	3	--	--	X	1	--	X	1	125
Pteridium aquilinum	25	4	--	--	1	2	--	2	2	94
Streptopus roseus	50	1	--	--	X	1	--	X	X	63
Pyrola virens	25	3	--	--	X	1	--	X	1	63
Anapthalis magaritacea	25	3	--	--	1	1	--	2	1	63
Pyrola elliptica	25	1	--	--	X	1	--	1	1	31
Viola spp.	25	1	--	--	X	1	--	X	X	31
Cyperaceae	25	1	--	--	X	1	--	X	X	31
Corallorhiza maculata	25	1	--	--	X	1	--	X	X	31
Pyrola secunda	25	1	--	--	X	1	--	X	X	31
Clintonia borealis	25	*	--	--	X	--	--	X	X	--
Epilobium angustifolium	25	*	--	--	X	--	--	X	X	--
Apocynum androsaemifolium	25	*	--	--	X	--	--	1	X	--
MOSS-LICHEN										
Other lichens	100	86	--	--	4	20	--	4	12	8,625
Other mosses	100	83	--	--	5	19	--	5	12	8,250
Polytrichum spp.	100	36	--	--	1	9	--	1	5	3,625
Calliergonella schreberi	100	28	--	--	4	6	--	4	5	2,750
Cladonia rangiferina	75	28	--	--	X	6	--	1	3	2,063
Dicranum spp.	100	20	--	--	1	4	--	1	3	2,000
Cladonia sylvatica	25	3	--	--	1	1	--	1	1	63
Hypnum crista-castrensis	25	1	--	--	X	X	--	X	X	31
GROUND CHARACTERISTICS										
Litter	100	100	--	--	80	23	--	80	52	10,000
Dead wood	100	38	--	--	3	8	--	3	5	3,750
Bare rock	75	13	--	--	1	3	--	2	2	938
Live wood	50	9	--	--	1	2	--	1	1	438

X denotes values of less than one percent.

* indicates a species value for ground cover but no rooted frequency of occurrence in the sample plots.

1/ The commonness index is not always an exact product of presence and frequency here because these two factors were rounded for this table after the commonness index was determined.

of the lichens, the ratio of lichen cover to moss cover is higher here than in any of the other three types. This is also probably indicative of the more xeric nature of this type.

Environmental Parameters

Environmental factors are highly interrelated with each other and vegetation (Billings 1952), but it is useful to examine as many individual measures as possible. Of the general parameters--elevation, slope, position on slope, distance to water, and annual insolation, only elevation is significantly different among the four community types (fig. 5). This difference can be explained by the fact that the Frost Lake area is generally lower in elevation than the Cherokee Lake area and because all the birch community stands are from the Frost Lake burn while the stands composing the other types are either from the Cherokee burn area or from both areas.

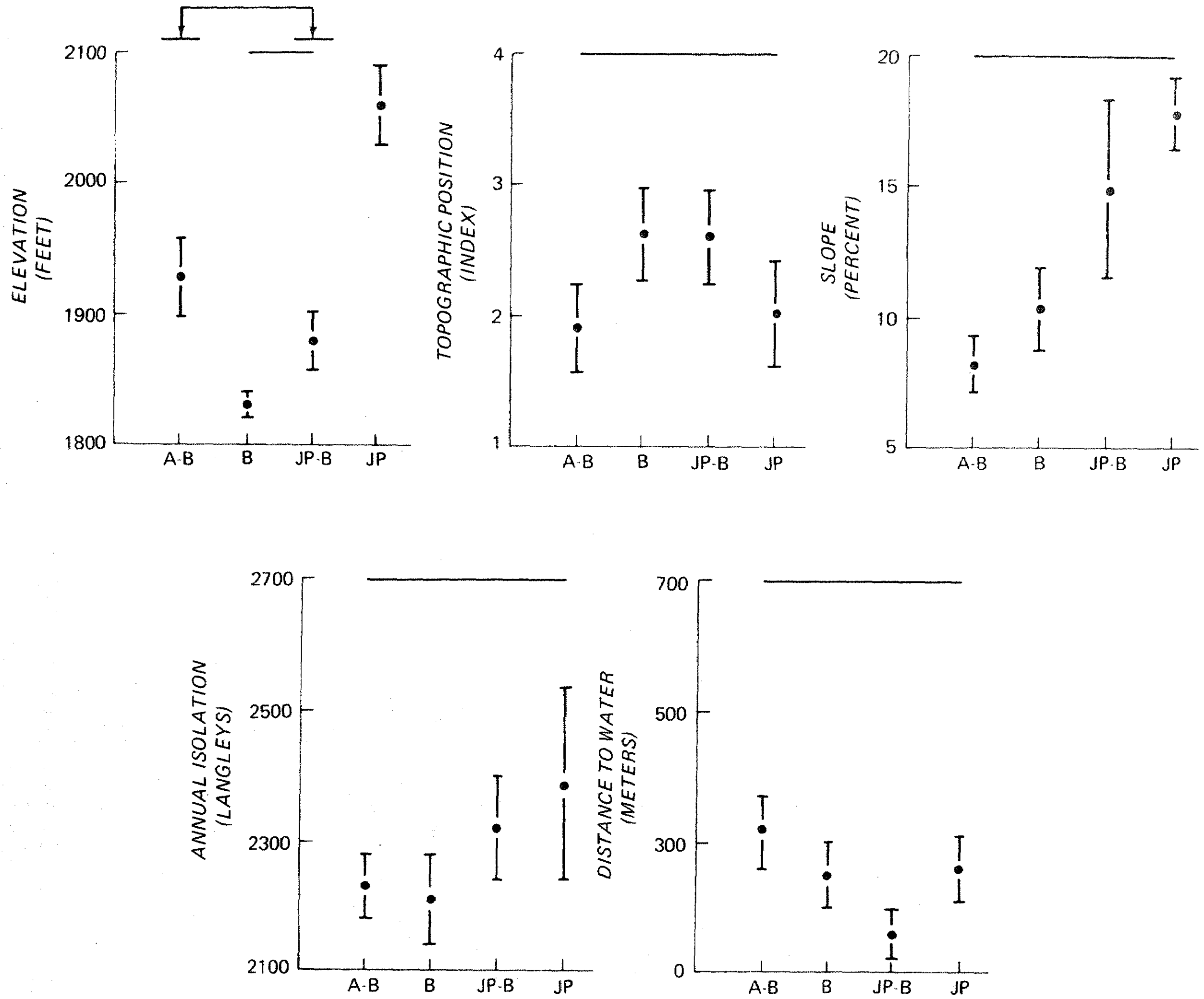

Figure 5.--Means and standard errors of means of general environmental parameters measured in community types from Frost Lake and Cherokee Lake wildfire areas. A-B, B, JP-B, and JP refer to aspen-birch, birch, jack pine-birch, and jack pine community types, respectively. Elevation in feet above sea level. Topographic position index based on 1 = ridgetop, 2 = upper slope, 3 = mid-slope, 4 = lower slope, and 5 = valley. Slope in percent based on an average of five readings taken within each stand. Total possible annual insolation in Langleys based on aspect and slope as determined from appropriate tables in Frank and Lee (1966). Distance to nearest body of water over 5 acres in meters. Any two means <u>not</u> connected by a line are significantly different (P = 0.05).

Most of the significant differences in soil characteristics are between the birch and the jack pine community types (figs. 6, 7, and 8). In summary, the birch type representing part of the Frost Lake burn area is lower in elevation, and the B-soil horizon is lower in available water, percent silt, and nitrogen, and is higher in percent total and coarse sand, total and percent bases, and calcium. The jack pine community, as representative of part of the Cherokee Lake burn area, is higher in elevation, and lower in percent bases while high in CEC, nitrogen, hydrogen, and potassium in the B-horizon soils. Within the Cherokee Lake area there are few differences between community types, with the aspen-birch community lower in CEC, hydrogen, and potassium than the jack pine community.

Preburn Vegetation

Two photo interpretations of the vegetation on sample locations were conducted on 1934 aerial photographs. One interpretation indicated only the major tree cover on those sample locations where stereo-photographic coverage was available (table 10, col. 2). Another interpretation included, in addition to the major tree cover, an estimate of whether the cover was of old or young growth, and an estimate of the degree of canopy cover over each sample point. The results of this interpretation are presented in the last three columns of table 10.

The stands of the aspen-birch and birch community types were interpreted as comprised of rather old open-grown broadleaf forest in 1934, 2 years before the wildfire. The stands of the jack pine-birch community type were classified as some combination of moderately dense to dense jack pine with some broadleaf component, and the stands of the jack pine type were classified as rather young dense jack pine before the fire.

The presence of old, open growth is verified by the narrative reports accompanying the 1936 individual fire reports for both fires. The reports emphasize that much of the areas had been subjected to insect and wind disturbance before the fires; e.g., "This area is quite hazardous, very brushy, with balsam reproduction and a lot of dead and down balsam" and "...burning in an old timber type and the ground very

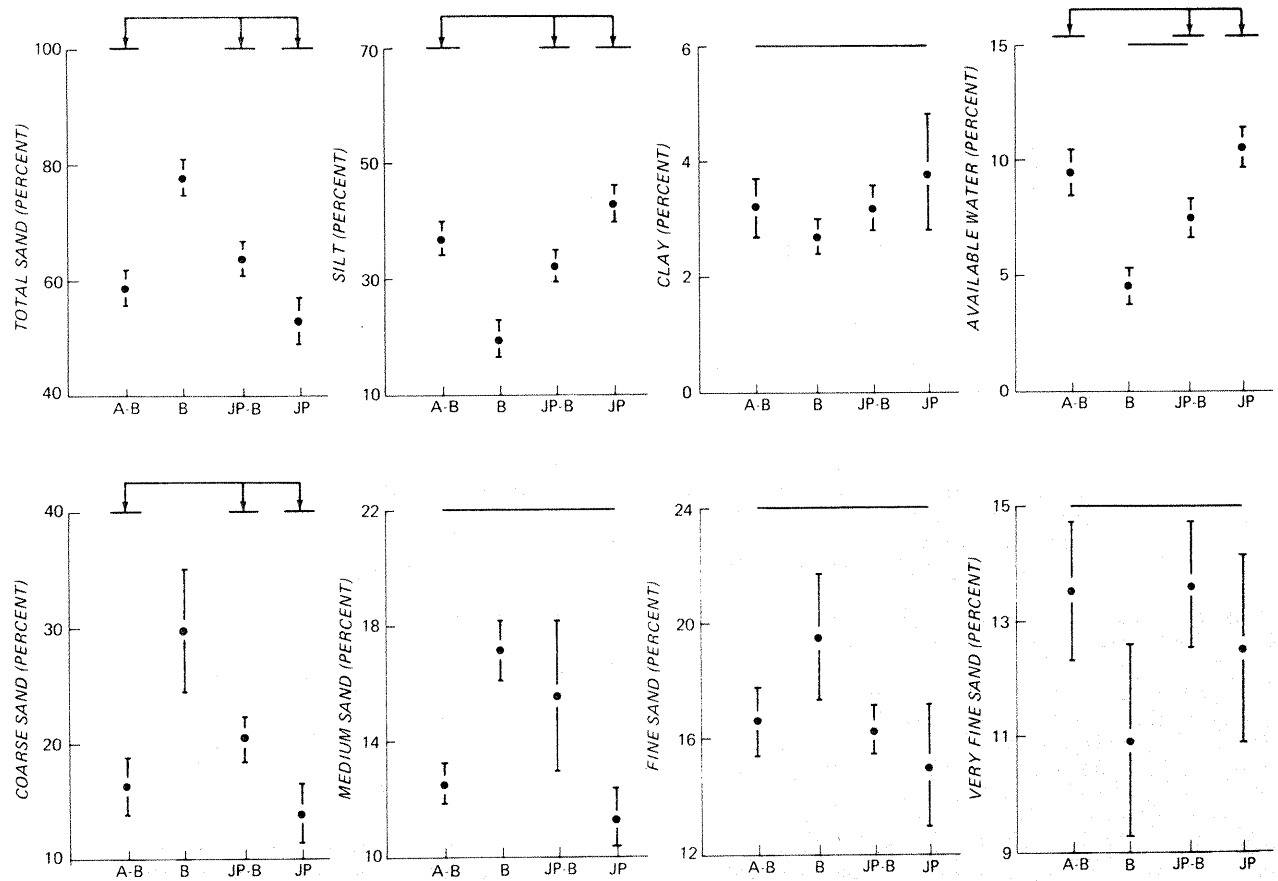

Figure 6.--Means and standard errors of means for B-horizon soil particle size and available water characteristics of plant communities of the Frost Lake and Cherokee Lake wildfire areas. All values are in percent. Significance of difference in means as indicated in figure 5.

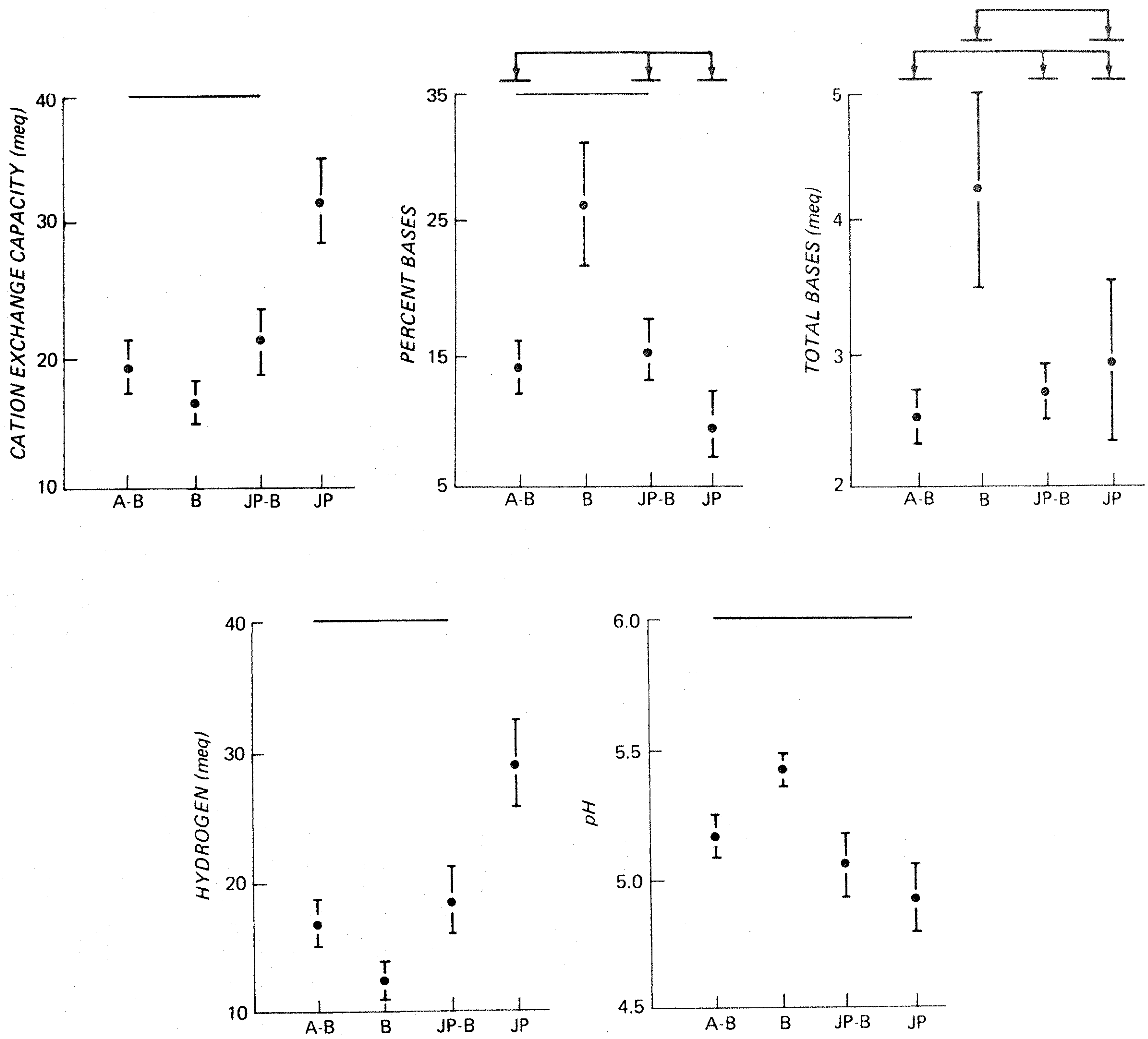

Figure 7.--Means and standard errors of means for B-horizon soil cation exchange capacity, percent bases, total bases, hydrogen ion concentration, and pH for plant communities of the Frost Lake and Cherokee Lake wildfire areas. Values in percent or milliequivalents (meq) as indicated. Significance of difference in means as indicated in figure 5.

heavily covered with insect killed blowdown timber mixed with brush and balsam undergrowth."

No doubt the variation in canopy cover and the age of the stands influenced fire intensity which in turn affected the resulting revegetation of the two areas. The presence of young dense jack pine before burning is apparently positively related to the present jack pine stands, and certain of the jack pine-birch stands. There is also a relationship between cover type, greater age, degree of canopy cover prior to burning, and the present aspen-birch and birch stands. To illustrate the relationship between the 1934 preburn vegetation type and the postburn vegetation, a portion of the Cherokee Lake area is portrayed in figure 9. Note the occurrence of present jack pine forest in areas of former young, dense, coniferous growth.

CONCLUSIONS

The virgin plant communities of intermediate age are much more limited in type, at least over this 6,000-acre area, than those of the mature virgin forest where succession operating over longer and varied periods of time has produced a wide variety of recognizable types (Ohmann and Ream 1971b).

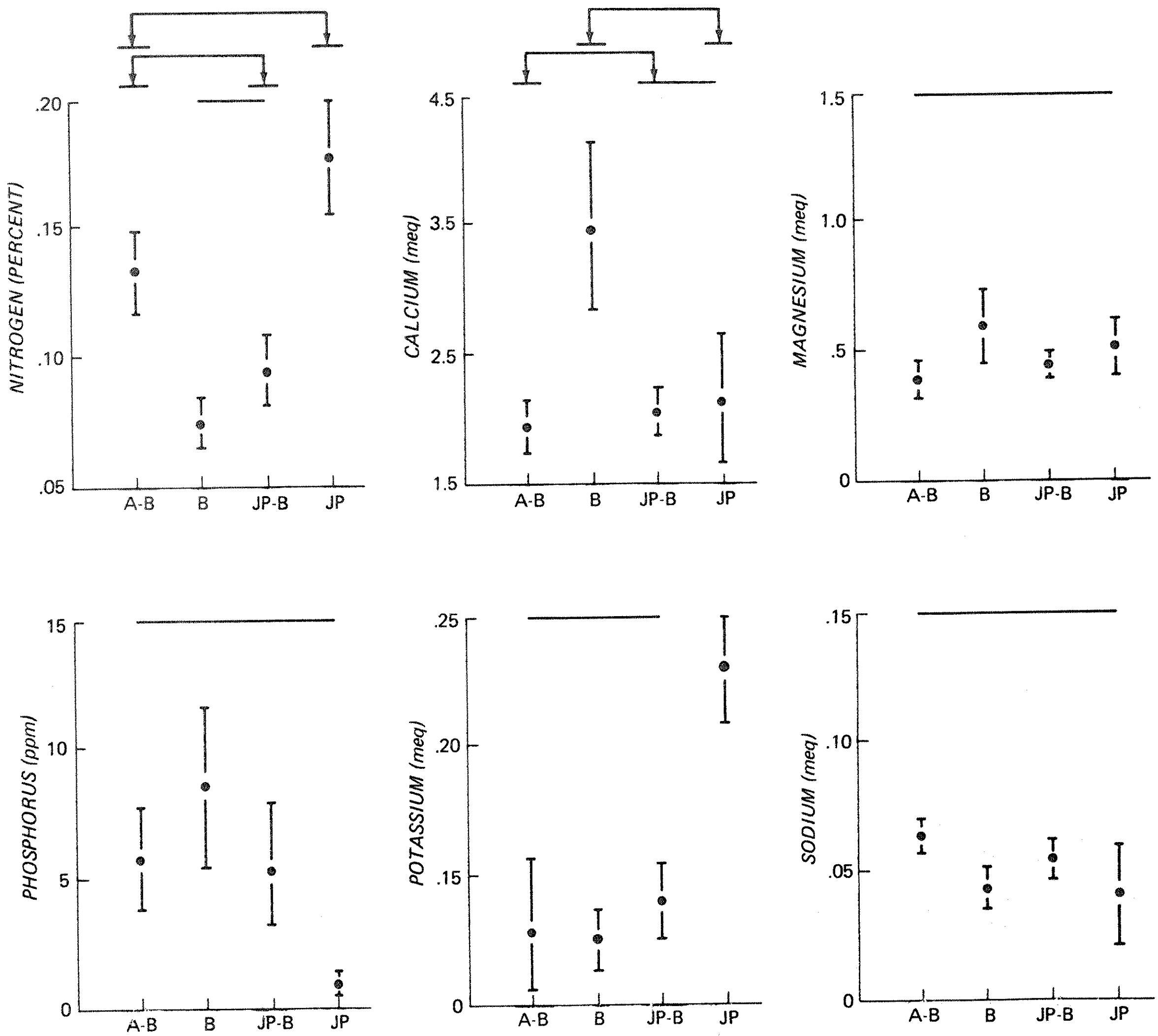

Figure 8.--Means and standard errors of means of B-horizon soil nutrients for plant communities of the Frost Lake and Cherokee Lake wildfire areas. Values in parts per million (ppm), percent, or milliequivalents (meq) as indicated. Significance of differences in means as indicated in figure 5.

Time elapsed since last major disturbance is important in determining community composition and structure, but this study indicates that the composition and structure of the community at the time of disturbance is also an important factor.

There are some environmental differences between community types that may be affecting composition and structure--birch type on coarser sands and jack pine on finer sands; however, some of those found make little sense ecologically, and others may well be reflecting the vegetation on the site now and even perhaps in the past as much as the site and soils themselves. For example, particle size is a basic physical property of soil and can therefore be expected to have an influence on the vegetation capable of occupying the site. The relationship present between the vegetation types of this study and the physical properties of the soils is unexpected. Normally jack pine is more likely than birch to be found on the coarser textured soils with lower water-holding capacity.

Contrary to physical properties, soil chemical properties are not independent of vegetation and partially reflect the vegetation type occupying the site. A higher CEC would normally

Table 10.--Sample point vegetation interpretation from 1934 aerial photographs of the Frost Lake and Cherokee Lake wildfire areas

Community type : stand number	Interpretation 1 : type[1/]	Interpretation 2 Type[1/]	Interpretation 2 Maturity	Interpretation 2 Canopy cover
Aspen-birch				
1	A-JP	JP some A	Old	Moderately open
2	A	A	Old	Very open
3	A	A	Old	Very open
4	A-JP	JP-A	Old	Moderately open
5	A-JP	A	Old	Moderately open
6	A-JP	A some JP	Old	Moderately open
7	A	A	Old	Open
9	A	A some JP	Young	Dense
25	JP	JP some A	Old	Dense
Birch				
22	A	A with scattered tall spruce	Old	Open
23	A	do.	Old	Open
24	A	do.	Old	Open
30	A-JP	A	Old	Open
31	JP-A	A some JP	Old	Very open
32	A	A	Old	Very open
33	A	A	Old	Very open
34	A	A	Old	Very open
Jack pine-birch				
10	JP	JP	Young	Dense
12	A	A some JP	Young	Moderately dense
13	A	A with scattered tall pine and spruce	Young	Dense
14	--	--		
15	--	--		
20	A	A	Young	Dense
21	A	A	Old	Open
26	A	JP some A	Old	Moderately open
27	JP	JP some A?	Old	Moderately dense
28	JP	JP some A?	Old	Moderately dense
29	A	JP some A	Old	Moderately open
35	--	--		
Jack pine				
11	--	JP	Young	Dense
16	A	A with scattered pine and spruce (near an area of dense young JP)	Old	Very open
17	--	JP	Young	Dense
18	--	JP	Young	Dense

1/ Type "A" indicates predominance of broadleaf tree species mostly quaking aspen, paper birch, or both--although other broadleaf species might be present. Type "JP" indicates coniferous species--usually jack pine, although other conifers may also be present.

be expected in finer-textured soils (occupied by the jack pine community) than in coarser-textured soils (occupied by the birch community) but bases would not be expected to be recycled as readily by jackpine as by birch. Thus much of the soil CEC in the jack pine type is likely occupied by exchangeable hydrogen, which is also indicated by the lower pH. Although there is a lower soil CEC under the birch type, more bases are likely being recycled resulting in a higher base saturation (especially calcium) and therefore, a higher pH.

We do not have a measure of the total potassium in the system within any of the community types (we don't know how much is tied up in the vegetation). The higher potassium in the soils of the jack pine type could be reflecting the lesser requirement of potassium by the coniferous jack pine cover thus leaving a greater potassium residual than in the soils under the birch cover type.

Thus, we feel the results of this study, while not conclusive, tend to support the hypothesis advanced by Ohmann and Ream (1971b) that time elapsed since last major disturbance and the type of vegetation present at the time of that disturbance are more important in determining the compostiion and structure of the present upland plant communities over a relatively small region than differences in environmental parameters.

These generalizations, of course, are oversimplified. In fact, many other factors ought to be considered if they could be determined, especially severity of the fire, presence of seed source following fire, postfire weather conditions, etc. It should also be recognized that these generalizations are not meant to apply to the quality of the vegetation (e.g., site index, productivity, biomass, etc.) where we recognize that differences in environment are more important.

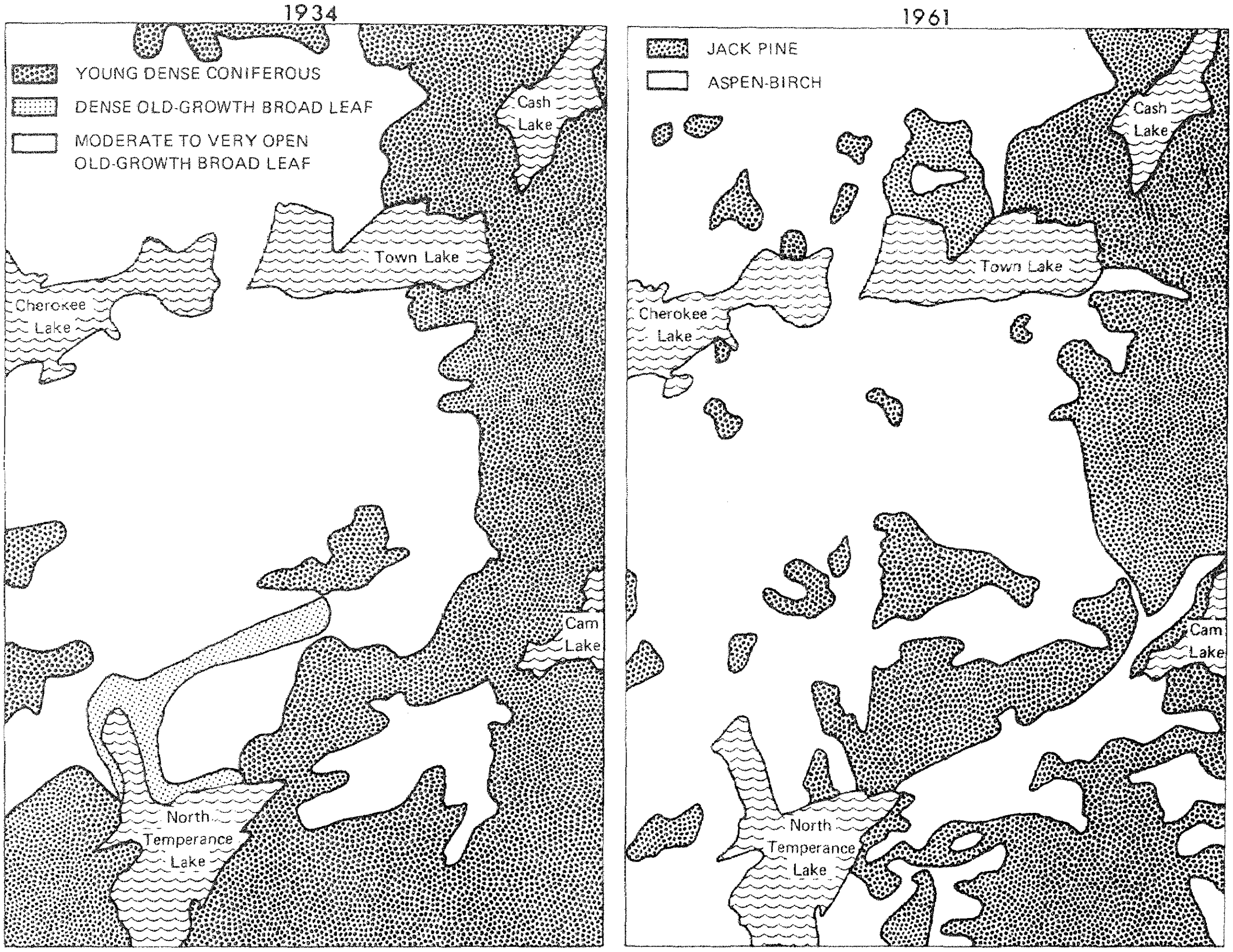

Figure 9.--Location (left) of 1934 vegetative cover on a portion of the Cherokee Lake wildfire area. Location (right) of 1961 vegetative cover on the same area.

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PART II. BROWSE PRODUCTION

Roger E. Lake

ABSTRACT

Woody browse production was measured in four upland community types on two adjacent 33-year-old wildfire areas. No difference in twig numbers were found between the burns for ten species studied. Only three of the ten browse species present in more than one community type showed differences in twig numbers among the types. Yields of the species groups, total shrub browse, and total tree seedling browse, differed among the types while total browse did not. Lack of a difference in total browse production is attributed to various species reaching peak yield in different community types, thus offsetting each other and maintaining an overall relatively stable level of production.

The study was conducted as an adjunct to the ecological study described in Part I. The objectives were to estimate browse production and to determine if it differed between burn areas and their plant communities.

The study area had never been logged, grazed, or farmed. There is an absence of data on browse production in such "natural" plant communities, but this may not be real in that most authors have not mentioned this distinction. Studies reporting on browse production in upland forests of the northeastern United States include Crawford and Leonard (1963), Dalke (1941), Krefting and Hansen (1969), Segelquist and Green (1968), and Shaw and Ripley (1965). These studies all indicate possible differences in browse production among cover types but present no statistical comparisons. Dzieciolowski (1969) found that seven Polish forest associations could be placed into two homogeneous groups which differed significantly in browse production. Segelquist and Pennington (1968, 1972) in Oklahoma and Arkansas reported no significant differences in browse yields among timber types. Only the study by Krefting and Hansen (1969) was conducted in community types similar to those of this study area.

METHODS

Browse was sampled in five milacre plots randomly selected from among the 20 shrub and seedling plots per stand. Twigs were counted that were greater than 1 inch in total length, occurred between 6 inches and 10 feet of the ground, and originated from stems rooted within the plot. White and black spruce (*Picea glauca* and *P. mariana*, respectively) were not sampled since no browsing of these species was noted.

Differences in browse production between burn areas and among community types were identified by using a series of t- and F-tests. The procedure consisted of checking for homogeneity of variances and then using the appropriate t- or F-test (Sokal and Rohlf 1969, Steel and Torrie 1960).

Names for tree species follow Little (1953) and for shrub species, Gleason (1963).

RESULTS

Total browse production was similar but highly variable on the two burn areas, with an average of 199,220 twigs per acre at Cherokee Lake and 256,080 at Frost Lake (table 1). Ten

Table 1.--Browse production on two 33-year-old wildfire areas by species, total tree seedlings, total shrubs, and total browse

(In twigs/acre with ±95 percent confidence limits)[1/]

Species	Cherokee Lake Area	Frost Lake Area
Abies balsamea	55,640 ±53,508	164,100 ±159,727
Corylus cornuta	74,550 ±48,907	26,260 ± 19,221
Betula papyrifera	10,420 ±12,564	38,740 ± 35,162
Acer spicatum	16,450 ±13,020	3,600 ± 4,751
Salix bebbiana	9,340 ± 6,851	12,600 ± 14,690
Amelanchier spp.	2,940 ± 4,288	2,550 ± 5,180
Lonicera canadensis	2,040 ± 3,983	2,710 ± 4,143
Prunus pensylvanica	2,310 ± 2,552	1,950 ± 2,554
Populus tremuloides	50 ± 100	1,000 ± 1,743
Sorbus americana	220 ± 317	100 ± 213
Thuja occidentalis	20,090 ±30,738	
Alnus crispa	5,050 ±10,700	
Pinus strobus		2,240 ± 3,974
Cornus rugosa		230 ± 479
Viburnum edule	120 ± 249	
Acer rubrum	10 ± 25	
Total tree seedlings	86,440[2/] ±76,760	206,180 ±169,615
Total shrubs	112,790[3/] ±56,705	49,900[3/] ± 24,186
Total browse	199,220 ±83,744	256,080 ±181,779

1/ Numbers of current annual twigs greater than 1 inch in total length occurring between 6 inches and 10 feet of the ground.
2/ Due to rounding errors, columns may not total exactly.
3/ Indicates a significant difference between areas at P = 0.05.

browse species were found on both burn areas. A series of t-tests showed that none of their mean numbers of twigs per acre differed at P = 0.05 between burn areas. When the data were grouped as total tree seedling browse, total shrub browse, and total browse, only total shrub browse showed a difference at P = 0.05 between burn areas (table 1).

Browse production by community type is presented in table 2. A series of F-tests indicated that only three species, beaked hazel (*Corylus cornuta*), paper birch (*Betula papyrifera*), and mountain maple (*Acer spicatum*), as well as the two characters' total tree seedling browse and total shrub browse, differed (at P = 0.05) in production among community types.

Table 2.--Browse production in the 33-year-old upland community types of the Cherokee-Frost Lake study area

(In twigs/acre with ±95 percent confidence limits)[1/]

Species	Community type				Significance level[2/]
	Aspen-birch	Birch	Jack pine-birch	Jack pine	
Abies balsamea	39,730 ± 55,204	244,030 ±333,567	105,130 ± 91,195		P = ns
Corylus cornuta	95,470[a][3/] ± 67,140	43,330[a,b] ± 35,145	6,150[b] ± 10,000	102,000[a,b] ±214,578	P = 0.050
Betula papyrifera	8,800[a,b] ± 15,240	22,400[a] ± 16,142	44,200[a,b] ± 49,504	2,050[b] ± 6,523	P = 0.050
Acer spicatum	28,270[a] ± 22,820	7,130[a,b] ± 9,963	2,120[b] ± 4,539	100[b] ± 318	P = 0.050
Salix bebbiana	14,530 ± 12,232	4,800 ± 9,557	15,330 ± 19,508	1,800 ± 5,728	P = ns
Amelanchier spp.		80 ± 177	4,450 ± 7,242	9,200 ± 25,599	P = ns
Lonicera canadensis	290 ± 666	5,430 ± 8,881		8,000 ± 25,456	P = ns
Prunus pensylvanica	3,960 ± 4,841	2,930 ± 5,560	950 ± 1,219		P = ns
Populus tremuloides	70 ± 154	130 ± 177	1,200 ± 2,411	200 ± 636	P = ns
Sorbus americana	110 ± 256	200 ± 473	230 ± 440		P = ns
Thuja occidentalis	37,960 ± 61,421				
Alnus crispa	9,530 ± 21,984				
Pinus strobus		4,480 ± 8,680			
Cornus rugosa		450 ± 1,064			
Viburnum edule			170 ± 367		
Acer rubrum			20 ± 37		
Total tree seedlings	86,670[a,b][4/] ±112,476	271,230[a,b] ±342,925	150,780[a] ±122,143	2,250[b] ± 6,339	P = 0.050
Total shrubs	152,040[a] ± 77,866	64,130[b] ± 44,477	29,170[b] ± 18,632	121,100[a,b] ±225,805	P = 0.050
Total browse	238,710 ±117,244	335,350 ±361,671	179,950 ±132,365	123,350 ±224,227	P = ns

1/ Numbers of current annual twigs greater than 1 inch in total length and occurring between 6 inches and 10 feet of the ground.

2/ A "P" value in the last column (significance level) indicates the level of significance of an overall test for differences among the communities in mean browse production by that species.

3/ For the three species (*Corylus cornuta*, *Betula papyrifera*, and *Acer spicatum*), total tree seedlings, and total shrubs showing an overall difference among the communities at P = 0.05, values within a row followed by the same letter are not significantly different (at P = 0.05).

4/ Due to rounding errors, columns may not total exactly.

For these same five characters t-tests were run to determine which means were different. Beaked hazel showed only one difference among the communities, with production in the aspen-birch type differing from that in the jack pine-birch. For paper birch the birch type differed from the jack pine. Two differences were apparent for mountain maple where production in the aspen-birch differed from that in both the jack pine-birch and the jack pine types. Total tree seedling twig yield in the jack pine-birch type differed from that in the jack pine type. Total shrub production in the aspen-birch type differed from that in both the birch and jack pine-birch.

Although there were no statistically significant differences in total browse production among the communities, production was highest in the birch type, with 335,350 twigs per acre. The second most productive type was the aspen-birch, with 238,710 twigs per acre. The two coniferous communities produced fewer twigs, averaging 179,950 and 123,350 twigs per acre for the jack pine-birch and jack pine types, respectively.

The species contributing most heavily to total production varied with community type. In the aspen-birch type balsam fir (*Abies balsamea*), beaked hazel, and white-cedar were the most prolific producers. Balsam fir was the dominant producer in both the birch and jack pine-birch types, while most of the production was by beaked hazel in the jack pine community.

DISCUSSION

Even without statistical analysis it was apparent that there were differences in the vegetation occupying the two burn areas. This was evident during the fieldwork and was supported by the unequal distribution of community types between the burn areas. Thus, an overall comparison of production between the two burn areas involved in part a comparison of community types. The significant difference in total shrub browse production between burn areas was thus confounded by the effects of community type.

Statistically significant differences in production among the community types were limited to three browse species plus total tree seedling browse and total shrub browse. Some other species, such as balsam fir, displayed more than a fivefold difference among the types, yet without statistical significance. This apparent anomaly relates to the nature of statistical tests and their dependence upon the variability of the data, which was generally great. Highly variable data for browse production have also been found by other authors, including Blair (1959), Stearns et al. (1968), and Van Dyne et al. (1963). As Shafer (1963) remarked, production would have to vary "considerably" between areas before significant differences can be detected.

Lack of a significant difference among the types in total browse production reflected more than the variability of the data. Peak production by certain species was offset by the relatively poor development of others (table 2). In the birch and jack pine-birch communities, the tree seedlings reached peak production while the yield of shrub browse was low. The converse was true of the aspen-birch and jack pine types with their low tree seedling and high shrub production. Thus, a relatively stable level of production was maintained among the communities. This, along with the high variance estimates, allowed no significant differences in total browse availability even while individual species and species groups did vary significantly.

Comparison of these data with browse production estimates from other studies was difficult due to different means of measurement. This study included all twigs greater than 1 inch in total length--nearly all the twigs in the stand. Halls et al. (1970), similarly defining a twig and tallying all twigs within 5 feet of the ground, found more than 300,000 twigs per acre in east Texas pine hardwood forests. Their data compare favorably with my estimates of 123,350 to 335,350 twigs per acre while their zone of availability was considerably less than the 1/2 to 10 feet used in this study. Although their data are hardly comparable, they support my feeling that browse production was, in fact, low in the dense forest communities of the Cherokee-Frost Lake area which were probably past the optimum age for browse production.

The low browse production found in this study has implications for management in that a low carrying capacity may be expected in these community types 30 years postfire, although the forest may again become more productive of browse with age. It is also instructive to note that the predominant species here were beaked hazel and balsam fir. These species are not regarded as high-quality forage for the large mammalian herbivores, although moose are known to use balsam fir in winter. The balsam fir present, however, were generally small seedlings and hence not likely to be browsed. A further implication concerns the relationship between preburn and postburn community types described in the companion article. There the age and composition of the preburn vegetation were found to largely determine the postburn vegetation and, by extension in this study, the level of browse production and its species composition. Therefore, given knowledge of the age and composition of the preburn vegetation and the length of time since fire, we ought to be able to predict the postfire production, albeit with less accuracy as the forest matures.

Future studies of this type should place more emphasis on the browsing habits of the animals. Although moose are known to browse twigs growing 10 feet or more above the ground, Dodds (1960) found that moose prefer to browse plants within easy reach. He found that over 90 percent of the browsing took place within 6 feet of the ground, even in an area of high moose density. Thus, if even the largest herbivore on the study area browses mainly on low-growing forage, the zone of availability may be more practically confined to 6 feet. Another refinement commonly found in the literature is to restrict browse surveys to only those twigs showing more than 1 inch of current annual growth because, as Stearns et al. (1968) suggested, twigs shorter than 1 inch are seldom browsed and they contribute little to total production. These two refinements, arbitrarily reducing the zone of availability and tallying only the more preferred, rapidly growing twigs, would allow a greater number of sample plots with concomitant lower variance estimates. As Newbould (1967) advocated, one should direct effort toward minimizing errors in the major components while tolerating larger errors in the minor components.

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PART III. SMALL MAMMAL POPULATIONS

James R. Beer
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Charles T. Cushwa

ABSTRACT

Small mammals were snap-trapped for 5,326 trap-station days during summer 1969. Of 142 individuals captured, 103 were either *Peromyscus maniculatus gracilis* or *Clethrionomys gapperi*. Reproductive histories for these two species are discussed. An attempt was made to relate distributions of small mammals to vegetative community types. The sketchy evidence suggests a uniform distribution with no strong linkages to any of the four types. The latter are described in a companion paper.

The distribution, composition, and habitats of small-mammal populations have not been adequately described in the Boundary Waters Canoe Area (BWCA). An intensive study was conducted between 1950 and 1970 around Basswood Lake (T64N, R10W) (Beer et al. 1954; Beer, unpublished data; Frenzel 1957). Ahlgren (1966) trapped small mammals for four seasons in the area of Bearskin and Grass Lakes (T60N, R9W), and Rom (1940) carried out a minor trapping effort (some 600 trapnights) near Kekekabic Lake (T65N, R6W). Collectively these works comprise the information on small-mammal populations in and near this million-acre area of the Superior National Forest.

Here we report on a study of small mammal populations in the 3,500- and 3,300-acre Cherokee and Frost Lakes (T64N, R4W) wildfires. Collections were made in 1969, 33 years after the fires, in conjunction with a study of plant communities in the BWCA. The latter study is discussed in Part I of this report. Objectives in our study were (1) to prepare a listing of small mammals and (2) to describe correlations between small mammals and plant communities in the wildfire areas of Frost and Cherokee Lakes.

METHODS

One meandering transect was established in each of 33 stands (fig. 1 and table 10, Part I). Paired standard snap traps (1-1/2" x 3") baited with a mixture of peanut butter and rolled oats were placed at each of 50 stations located at 30-foot intervals along the transect.

Each trapline was operated for 3 consecutive trapnights during the period June 10 to August 31. An exception was stand one, which was trapped for two 3-day and one 2-day periods.

Traplines were checked daily and carcasses removed and preserved in a 10 percent formalin solution. In the laboratory, carcasses were identified as to species, sexed, and measured for tail, ear, and total length. Testes were noted as abdominal or scrotal, and the epididymis as undeveloped or with discernible tubules. The reproductive status of females was characterized by the condition of the mammae (undeveloped or lactating), a perforate or imperforate vaginal orifice, placental scars in the uterus, corpora in the ovaries, and embryos.

RESULTS AND DISCUSSION

Species Captured

During a total of 5,326 trap-station days (a trap-pair set for 24 hours = 1 TSD) 142 mammals representing nine species were captured (table 1). One of these, the woodland jumping mouse (*Napeozapus insignus*), is rarely found in Minnesota. The other eight species, some represented by only one or two individuals, are more common to this region.

Capture Indices

Capture indices (CI), the number of animals captured per 1,000 trap-station days, ranged from 1.3 to 14.1 for species represented by more than two individuals (table 1).

Table 1.--Capture indices[1/] of small mammals in four community types

Community type	Trap-station days	Species: *Peromyscus m. gracilis*	*Clethrionomys gapperi*	*Eutamias minimus*	*Blarina brevicauda*	*Sorex cinereus*	Other[2/]	Total
Aspen-birch	1,534	[3/]2.6 (4)	11.7 (18)	1.3 (2)	1.3 (2)	2.0 (3)	2.0 (3)	20.9 (32)
Birch	1,248	5.6 (7)	13.6 (17)	0.0 (0)	2.4 (3)	2.4 (3)	3.2 (4)	27.2 (34)
Jack pine-birch	1,902	6.3 (12)	18.9 (36)	1.6 (3)	2.1 (4)	5.3 (10)	0.0 (0)	34.2 (65)
Jack pine	642	7.8 (5)	6.2 (4)	3.1 (2)	0.0 (0)	0.0 (0)	0.0 (0)	1.7 (11)
All types	5,326	5.3 (28)	14.1 (75)	1.3 (7)	1.7 (9)	3.0 (16)	1.3 (7)	26.7 (142)

1/ CI = (4) (1,000/1,534) = 2.6.
2/ Includes species represented by one or two individuals: *Microtus pennsylvanicus, Zapus hudsonius, Napaeozapus insignis, Sorex arcticus.*
3/ Number captured is in parentheses.

In order to gain perspective, these data were compared with a long-term study of small-mammal populations in the Basswood Lake area, a region of mature birch-aspen resulting from logging and burning in the early years of this century (Beer, unpublished data). During 3,000 trap-station days in July 1969 the CI for deer mice (*Peromyscus maniculatus gracilis*) was 22. Over a period of 21 years at Basswood, Beer reported that CI's for deer mice varied from 16 to 135 with an average of 49. Ahlgren (1966) trapped deer mice during July for 3 years (1961-1963) in a "relatively homogeneous, mature jack pine stand" in the BWCA and obtained CI's ranging from 50 to 80. It thus appears that the **density of deer mice at Frost-Cherokee Lakes, as reflected by a CI of 5, is close to the lowest reported in the BWCA.**

The redback vole (*Clethrionomys gapperi*) is normally the second most commonly trapped small mammal, after the deer mouse, in upland habitats of this region. Seventy-five individuals were trapped at Frost and Cherokee Lakes for a CI of 14.1. This is higher than the CI of 7 during the same period at Basswood Lake. Based on 21 years of data from the Basswood area, Beer reported an average CI of 11 and a range from 3 to 37. Ahlgren (1966) obtained CI's ranging from 0 to 150 during his 3-year study. While a CI of 14 for redbacks in the Frost and Cherokee Lakes study is not the lowest reported for the general area, it suggests low population densities in the Frost-Cherokee Lakes area.

The CI's for species other than deer mice and redback voles were too low in our study to make valid comparisons. Other studies in northeastern Minnesota have reported the same.

Reproduction

Sixteen of 28 (57 percent) deer mice captured at Frost and Cherokee Lakes were females (table 2). Three of the 16 were pregnant and eight others had placental scars, the latter indicating parturition during 1969. Only five of the 12 males showed signs of being or having been reproductively active. This activity is lower than that of the females and is probably due to the slower maturing of males (Clark 1938)

Table 2.--Status of reproductive systems of the small mammals captured

Species	Total captured	Males: Total	Males: Fecund	Females: Total	Females: Fecund	Females: With embryos
	Number	Number	Number	Number	Number	Number
P. m. gracilis	28	12	5	16	11[1]	3
C. gapperi	77	43	26	34	29	20
M. pennsylvanicus	1	1	0	--[2]	--	--
Z. hudsonius	1	--	--	1	1	1
N. insignis	2	1	--	1	--	--
E. minimus	7	5	0	2	0	0
B. brevicauda	9	5	--	4	3	0
S. cinereus	16	6	--	10	--	0
S. arcticus	3	1	--	2	--	0

1/ Number of animals in a reproductive status as indicated by mammae, embryos, placental scars, or ovarian corpora.
2/ Positive determinations were not made.

and their higher mortality rate (Beer and MacLeod 1966).

No pregnant females nor reproductively active male deer mice were captured during the August trap period, although three or four females were lactating or had been recently. This suggests that reproduction ceased by the end of July. While sample size is inadequate for firm conclusions, the reproductive histories of mature female deer mice captured during June and July suggest that individuals produced 3.3 litters, assuming the breeding season starts about the first of April (Davis 1956).

Based on three sets of embryos and eight sets of placental scars, the average number of implantations per pregnancy in deer mice was 4.6. Preimplantation loss, based on a comparison of ovarian corpora and implantations, was 8.3 percent. If the 2.1 percent postimplantation loss reported by Beer et al. (1957) holds for this population, litter size would be about 4.5. Thus, reproductively active females produced approximately 15 young (3.3 litters x 4.5) between April and the end of the breeding season.

Thirty-four of 77 (44 percent) redback voles captured were females. Twenty of these contained embryos and nine others had borne litters as indicated by placental scars. We captured pregnant females throughout the study; i.e., to the end of August. This supports Beer's observation that the breeding season for redbacks extends from the first of April to the end of September. It so, then fecund females produced 6.9 litters in 1969. Based on 20 sets of embryos and six sets of placental scars and associated ovarian corpora, the potential litter production for redbacks was 5.9. Average implantation was 5.4, so that preimplantation loss was 8.5 percent. There were two dead embryos among the 108 observed, which agrees with the 1.3 percent *in utero* loss reported by Beer et al. (1957) for redbacks in the Basswood Lake area. Following these data and estimates, each female redback would have produced about 37 young by the end of September.

Seasonal Variation in Capture Indices

We expected that CI's would increase during the reproductive season and then decrease. Mean CI for deer mice was 2.9 (s_x = 1.1) for June-July and 2.4 (s_x = 0.7) during August. This is a significant decline ($p < .01$) and supports our conclusion that reproduction in the deer mouse population had ceased by the end of July.

Mean CI for redback voles, on the other hand, increased significantly ($p < .01$) from 5.0 (s_x = 1.0) to 9.3 (s_x = 1.6) over the same period. This is supported by our finding that redbacks were reproductively active to the end of the trapping season (late August).

Total CI (all species) also increased significantly ($p < .01$), from 9.9 (s_x = 1.7) to 17.3 (s_x = 2.9) from June-July to the end of August.

The fact that there is a season effect, negative for the deer mouse and positive for other species, could confound attempts to relate population density to vegetative community types. If, for example, trapping were done in one type early in the season and in another toward the end, then we could not be sure if a significant difference in CI's were due to factors intrinsic in the community types or if it were simply a reflection of the fact that populations in the last type trapped had more time to reproduce or, conversely, more time to suffer mortality.

Therefore, we now advocate that community types be trapped on a random time schedule. We were not able to follow such a schedule and thus may have biased results insofar as we attempt to relate CI's to community types. For example, most of our trapping in June and July was in the aspen-birch type and in late August most was in the birch type. This possible bias is not accounted for in the discussion following.

Capture Indices in Relation to Vegetation Types

Grant and Morris (1971) proposed a model of the distribution of animals in relation to habitat structure. Their model integrates two hypotheses: (1) the spatial distribution of animal activity in a patch environment (such as deciduous woodland habitat) is determined more by structural features of the habitat than by population (intrinsic) factors; (2) variations in animal density will modify the relationship between animal and plant distribution; e.g., at at low density only the most suitable habitat is occupied. They cite several authors who have found strong associations between animal and vegetation density in woodland habitat.

Thus, for Frost-Cherokee Lakes, we should expect distribution (as reflected in the number of traplines producing animals) to be relatively more even in the more structurally homogeneous vegetation types (birch and jack pine) than in the structurally diverse types (aspen-birch and jack pine-birch). If the effect of population density is considered alone, then we should expect the animals to be aggregated, since, as we have shown, the populations exhibited very low densities.

While our study design was such that Grant and Morris' model might have been subjected to a valid test, the low numbers of animals captured within vegetation types did not allow us to generate indices of animal dispersion, such as Morisita's (cited in Grant and Morris 1971), and thus we can do no more than suggest where linkages of animals and habitat type are more pronounced. Only data for deer mice and redback voles are considered.

Capture indices for deer mice were similar in all four vegetation types, and the density of redbacks was significantly higher in jack pine-birch than in the other three types (table 1).

Evidence for aggregation within a vegetation type might be found by comparing the frequency of capture among traplines within type. For deer mice, traplines in birch and jack pine-birch types were most productive, while redbacks were captured readily in all types, but with greatest success in jack pine-birch and jack pine (table 3).

Twenty of the 35 traplines (57 percent) produced no deer mice, while seven of the 35 (20 percent) yielded two or more animals. Only six of 35 (17 percent) traplines produced no redbacks, while 18 of 35 (51 percent) yielded two or more animals. This is further evidence of the low density of deer mice and relatively high density of redbacks in the study area.

In conclusion, densities of deer mice and redback voles were extremely low compared with results from other studies in the BWCA. Because of limited numbers of animals captured within plant community types, we were not able to test the basic model of animal distribution (Grant and Morris 1971), which for northeastern Minnesota most likely would show aggregations of the animals in the most suitable habitats. The sketchy evidence suggests a uniform small-mammal distribution with no strong linkages to any of the four vegetation types in the Frost-Cherokee area. We suspect that this may be due to missing elements of food and/or shelter, although we cannot be certain because we know so little about the habitat requirements of the deer mouse and the redback vole in virgin

Table 3.--Percent of traplines by community types that produced specimens of a given species

Community type	Number: trap-lines	Species: *Peromyscus m. gracilis*	*Clethrionomys gapperi*	*Eutamias minimus*	*Blarina brevicauda*	*Sorex cinereus*	Other
Aspen-birch	11	36 (4)[1/]	64 (7)	18 (2)	18 (2)	27 (3)	27 (3)
Birch	8	50 (4)	88 (7)	0 (0)	38 (3)	12 (1)	38 (3)
Jack pine-birch	12	50 (6)	92 (11)	25 (3)	33 (4)	33 (4)	0 (0)
Jack pine	4	25 (1)	100 (4)	50 (2)	0 (0)	0 (0)	0 (0)
All types	35	43 (15)	83 (29)	20 (7)	26 (9)	23 (8)	17 (6)

1/ The number of traplines that produced at least one mouse; 4 ÷ 11 = 36 percent.

plant communities. It is evident that plant communities in the Frost-Cherokee area are different in some respects than younger or older virgin communities. Ohmann in Part I of this report, for example, notes that the blueberries (*Vaccinium*) and wintergreen (*Gaultheria*) are far from being reestablished at Frost-Cherokee, and that this is probably due to the severity of the drought-year (1936) fire which may have consumed the seed sources of blueberries and wintergreen. Other possible components of small-mammal habitat may likewise be missing or in short supply because of the intensity of the fire.

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