VEGETATION OF A PORTION OF THE REGIONAL COPPER - NICKEL STUDY AREA, NORTHEASTERN MINNESOTA

June, 1980

VEGETATION OF A PORTION OF THE REGIONAL COPPER - NICKEL STUDY AREA, NORTHEASTERN MINNESOTA

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By

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ABSTRACT

Classification of the vegetation within a 1,450 square kilometer portion of the Regional Copper-Nickel Study Area was based on analysis of data from 277 Braun-Blanquet releves (floristic surveys). These surveys provided a record of the structure and species composition of each stand, with estimates of cover for each species within each structural layer.

Two hundred and forty-three of the releves were grouped by cluster analysis based on absolute distance (Orloci, 1967) into 11 major community types. An additional 34 stands, omitted from the analysis because of the absence of trees of canopy height, were classified manually on the basis of species composition and structure. Objective analysis fails to classify most stands harvested and replanted within the past 20 years into either their previous or projected canopy types. The 17 anomalous stands of this age spectrum that were misclassified by the cluster analysis were reassigned to the type for which they are being managed. The resultant classification defines the habitat types used by the Regional Copper-Nickel Study in its analyses of avian and small mammal data.

With the exception of two community types that were not sampled quantitatively, the communities recognized by cluster analysis were further characterized by the quantitative attributes of 62 stands for which tree species density and basal area, shrub species density and basal area, and herb species coverage are available.

In order better to understand the relationship of the classified communities to each other, the method of synecological coordinates (Bakuzis, 1959) was employed to define the positions of the communities in edaphic and climatic fields. A measure of the canopy similarity within communities was provided by the percent of total dispersion of clusters in the cluster analysis. In addition to this measure, Jaccard's coefficient of similarity was used as an independent measure of the total floristic similarity between communities.

The five major wetland communities recognized by this study are restricted to those with woody components. These five communities include black spruce bog, tamarack bog, cedar swamp, ash swamp, and shrub carr. Sedge fens, which are present in the area, were sampled only in the survey and are clustered either with shrub carrs or with conifer wetlands, depending on their floristic affinities. The single contiguous wetland in T 59 N, R 11 W was not sampled and may not be represented by this community classification based on data from isolated small wetlands.

Upland communities can be related to those recognized in studies of the neighboring BWCA (Ohmann and Ream, 1971; Grigal and Ohmann, 1975). Upland types recognized by the Regional Copper-Nickel Study include: jack pine, red pine, aspen-birch, aspen-birch-fir, and mixed conifer-deciduous. Aspen-birch is the most widespread naturally occurring

community in the study area. In part, this community is a result of logging and is more widespread at the present time than at the time of the General Land Office Survey. Aspen-birch communities in the study area are more variable than those in the BWCA and present a continuum from nearly pure stands to the mixed conifer-deciduous type. Although the commonly accepted upland "spruce-fir" climax of the region is uncommon in the study area, there is some evidence that the fir-spruce-birch community recognized by previous workers (Cooper, 1913; Buell and Niering, 1957; Kell, 1924) may be represented in its early stage in the mixed conifer-deciduous community.

Pine communities within the study area are mainly a result of disturbance and planting within the last 80 years. Despite the fact that the present distribution of upland communities appears to be very much influenced by historical factors, the red pine and aspen-birch communities are more floristically similar to each other than are any other communities and occupy similar positions in the edaphic and climatic fields.

Attempts to define successional relationships among communities sampled by the Regional Study were inconclusive, but they suggest that a mixture of deciduous and coniferous components can be expected to prevail on a long-term basis in the study area.

Independent cluster analyses for the high shrub, low shrub, and herb layers of the same 277 survey stands show a great variation in the clustering of sets of stands between different strata. Wetlands exhibit the highest association of clusters from different structural layers as well as the best relationship of clusters to environmental variables such as logging history and soil type. Clusters dominated by hazel in the tall shrub layer are significantly correlated with aspen-birch canopy types, whereas a significant proportion of stands in the mixed conifer-deciduous type has no shrub layer.

Herb clusters with a high proportion of woody seedlings contribute strongly to the low shrub cluster dominated by raspberry and hazel. In general, herb clusters are more closely associated with soil type and geographic location than with canopy type. Especially notable is a group of 11 stands in the Toimi Drumlin field that cluster together despite broad differences in canopy type.

It appears that there is greater variability within communities in the Regional Copper Nickel Study Area than within the same communities in the BWCA. This greater variability is probably a result of the greater degree of disturbance within the Copper-Nickel Study Area.

ACKNOWLEDGMENTS

The following discussion of vegetation in a 1450 km^2 area of northeastern Minnesota is an integration of the results of portions of three studies, which shared the common concern of gaining an understanding of terrestrial ecosystems in an area likely to receive environmental impacts from heavy metal mining.

The first of these studies, conducted in the summers of 1972 and 1973, was the preparation of a vegetation map for the Gabbro Lake SW, Kangas Bay and Babbitt, NE 7½' quadrangles, northeastern Minnesota conducted under a grant from the All-University council on Environmental Quality to Dr. E. J. Cushing and Dr. H. E. Wright, Department of Ecology, University of Minnesota.

The second of these studies, conducted from 1973 to 1975, was the preparation of a logging history map covering the Minnesota Department of Natural Resources MINESITE study area, and prepared for that study. The preparation and field-verification of this map provided the author with a broad understanding of the treatment history of the MINESITE study area.

The third of these studies, reported here in depth, is the characterization of vegetation undertaken by the Minnesota Environmental Quality Board's Regional Copper Nickel Study from 1976 to 1979. Because direct impacts of copper-nickel mining (exclusive of smelting) are expected to influence only a restricted area near mining-operations, the Regional Study's vegetation sampling was restricted to the MINESITE portion of the larger (5180 km^2) Regional Copper-Nickel Study Area. Both the vegetation mapping and Regional Copper Nickel

Study projects were team efforts and although the author was a principal investigator in both studies this report integrates the field work of many people. Braun-Blanquet relevé data were collected for the mapping project by Dr. E. J. Cushing, Dr. G. L. Jacobson and Dr. R. S. Rogers, in addition to the author. The following personnel of the Regional Copper Nickel Study made significant contributions to the collection of field data used in the analyses: D. Shubat, P. Muir, B. Coffin, J. Kronick, K. Kramer, S. Jatnieks, R. Grahn, and K. Bradbury. M. Sheridan, N. A. Aaseng, L. Pfannmuller, G. Burnett, and Dr. W. A. Patterson all contributed in the analysis of the data.

In addition to these co-workers, this report also relies in part on the work of the following contractors, who provided special services to the Regional Study: R. Barclay, collection and identification of mosses; Dr. C. Wetmore, collection and identification of lichens; Dr. D. Grigal, canonical analysis of 62 stands for comparison with communities in the BWCA; and R. Sloss, preparation of a multiplicative computer model of forest succession for the portion of the area located on the Gabbro Lake SW, Kangas Bay, and Babbitt NE 7½'quadrangles.

Voucher specimens for the 62 Regional study plots are deposited at the University of Minnesota herbarium, with duplicate specimens at the Olga Lakela herbarium, University of Minnesota, Duluth. Specimens have been verified by Dr. Gerald Ownbey (University of Minnesota herbarium) or Dr. Paul Monson (Olga Lakela herbarium). All sedges were verified by Gerald Wheeler, University of Minnesota herbarium.

LIST OF FIGURES AND APPENDICES

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INTRODUCTION

The Regional Copper-Nickel Study Area is a 5,180 square kilometer area in northeastern Minnesota lying northeast of the city of Virginia and southwest of the Boundary Waters Canoe Area (BWCA). A zone of copper-nickel mineralization has been identified along a narrow band on the east side of the Giant's Range where the contact between the Duluth Gabbro and underlying formations lies near the surface. It is anticipated that direct impacts of copper-nickel mining on terrestrial ecosystems will be confined to areas lying near this mineralized zone. Vegetation studies conducted by the Regional Copper-Nickel Study for the purpose of ecosystem characterization were restricted to an eastern portion of the Regional Copper-Nickel Study Area concurrently being inventoried by the DNR's MINESITE project. This 1,450 square kilometer portion of the Regional Copper-Nickel Study Area is illustrated in Figure 1 and is hereafter referred to in this report as the "study area."

The vegetation of an area depends on landscape features such as topography and soil type and on historical factors that have influenced the development of the area's flora. The discussion that follows presents an overview of the formation and geography of major landscape features in the study area, the history of the vegetation, and a summary of previous studies in northeastern Minnesota.

Physiography and Glacial History of the Regional Cop[illegible] Nickel Study Area

The most prominent physiographic feature in the study area is the Giant's Range, a granite batholith extending from north of Grand Rapids to Birch Lake, southeast of Ely (Figure 2). The range has a relief of 200-400 feet above the surrounding landscape and is flanked on the southeast by the Biwabik Iron Formation marked by a belt of large open-pit taconite mines. The Biwabik Iron Formation in turn is intruded on the east by the Duluth Gabbro Complex. Along the contact of these two formations lies a narrow (2-4 km) zone of copper-nickel mineralization. Vegetation samples in the study area were confined to an intensive study zone lying along the zone of mineralization, extending eastward as far as Cadotte Lake on the south and Gabbro Lake on the north.

Both north and south of the Giant's Range, the landscape is dominated by glacial features. At least two ice lobes directly affected the area. The Rainy Lobe of the Laurentide ice sheet advanced from the northeast over the entire area, eroded the landscape north of the Giant's Range, and deposited the eroded material to the south (Winter et al., 1973). Two phases of this advance left their record in the area. In the St. Croix phase of the Rainy lobe, the Toimi Drumlin Field was formed. During the Vermilion phase, the Vermilion moraine was deposited at the same time as the Superior lobe advanced out of the Lake Superior basin to terminate at the Highland Moraine, east of Isabella (Wright, 1972). Stark (1977) believes that the Superior lobe at this time extended westward beyond the Highland Moraine into the study area between the Little Isabella River and Slate Lake. After the retreat of the Rainy lobe, the St. Louis sublobe of the Des Moines lobe in its Alborn phase advanced eastward through the Red Lakes Lowland and entered the west side of the study area.

Nine physiographic regions can be distinguished within the study area (Figure 2). The Giant's Range and area of the Biwabik Iron Formation comprise one of these regions. The eight regions of glacial origin are discussed below.

The southeast portion of the study area is characterized by parallel northeast-southwest trending hills rising 9 to 15 m above intervening wetlands. The area is generally known as the Toimi Drumlin Field (Wright and Watts, 1969), although it is designated by Olcott and Siegel (1978) as the Drumlin Bog Physiographic Province. The parallel hills, or drumlins, were produced during the St. Croix phase of the Rainy lobe, perhaps 20,000 years ago.

Topography north of the Toimi Drumlin Field reflects the later Vermilion phase of the Rainy Lobe. During its retreat, a series of still-stands produced a set of three parallel end moraines between the drumlin field and Birch Lake. This Vermilion moraine complex (Wright and Watts, 1969) has been separated by Stark (1977) into the first (most southerly), second, and third moraines. The area between the moraines is rolling ground moraine with some exposed bedrock. Olcott and Siegel (1978) consider this area as part of their extensive Shallow Moraine Bedrock Province, which continues northward on the east side of Birch Lake through an area with thin soils and exposed bedrock.

From the Stony River eastward toward Isabella, the three end moraines are confluent and create a topography characterized by knobby hills and small lakes. This portion of the study area constitutes the Outwash-Moraine Complex Province (Olcott and Siegel, 1978).

The broad plain of the Seven Beaver-Sand Lake Wetland Province (Olcott and Siegel, 1978) is today occupied by an extensive peatland, with peat deposits up to 5 m deep (Finney, 1966), drained by the North and Stony rivers. Elevations range from 1,600 to 1,800 feet, with the Laurentian Divide passing through the wetland. Deposits at the north end of the wetland are associated with the Outwash-Moraine Complex Province. Underlying deposits have not been traced throughout the entire basin.

Large, flat plains in the central and southwestern portions of the study area are the result of glacial lakes from several periods. The Embarrass-Dunka Rivers Sand Plain Province (Olcott and Siegel, 1978) was formed by the impoundment of normal drainage patterns by ice during the Vermilion phase of the Rainy Lobe. The Dunka River section of this plain is comprised mainly of outwash materials, today occupied by a large wetland lying in the bed of Glacial Lake Dunka. The finer sediments that occur in the bed of Glacial Lake Norwood support agricultural land uses in the valleys of the Pike and Embarrass rivers. Northwest of Glacial Lake Norwood lies an area of undefined glacial lake sediments whose history has not been investigated (Winter et al., 1973) but which contains up to 10 m of peat near Lost Lake (Finney, 1966). South of the Giant's Range, the flat agricultural lands in the valleys of the Swan and St. Louis rivers between Hibbing and Virginia lie in the bed of Glacial Lake Upham, which was most recently formed behind the terminal moraine of the St. Louis sublobe in its Alborn phase. The area had previously been occupied by a lake at the same time as glacial lakes Norwood and Dunka. At that time, the Superior lobe blocked the outlet of the St. Louis River, resulting in the impoundment of the first Lake Upham and the deposition of red clays in the lakebed.

The Aurora-Markham Till Plain Province (Olcott and Siegel, 1978) lies south of Aurora and buries the west edge of the Toimi Drumlin Field in red clay till. Because of the red-clay nature of the till, the area has sometimes been considered to have been glaciated by the Superior Lobe. A more reasonable explanation (Wright, 1969; Winter *et al.*, 1973) is that while the St. Louis River was impounded during the Automba phase of the Superior Lobe, Lake Upham I accumulated sediments whose origin was in the Lake Superior Basin. After the retreat of the Superior Lobe and the recession of Lake Upham I, the St. Louis Sublobe overrode the lake's bed and deposited red, clayey till over the western portion of the Toimi Drumlin Field. Elevations of the till plain range from 1,400 to 1,500 feet. A mixture of forests and agricultural lands prevail in this province today.

Vegetation History

Visitors are familiar with northeastern Minnesota as an area of conifers, such as pine and spruce, and deciduous species such as paper birch and aspen, in contrast with other portions of the state where maple and basswood or oaks dominate the forests. This modern distribution of forests has not always been the case.

Since the retreat of the last glacier, about 10,000 years ago, the vegetation of Minnesota has been slowly changing. The evidence of this change is present as fossil pollen grains buried in lake sediments. Immediately after deglaciation, pollen grains from the surrounding vegetation were deposited on the surface of lakes and settled with the sediments. Since then, progressively younger sediments have accumulated so that the surface sediments contain pollen grains from the modern vegetation and the most deeply buried sediments contain the oldest pollen grains. Stratigraphic studies examine the proportion of pollen grains of different species in sediments of different ages. Studies at several sites in northeastern Minnesota (Baker, 1965; Fries, 1962; Janssen, 1968; Wasylikowa and Wright, 1969; Craig, 1968; Bradbury and Waddington, 1973) have enabled paleoecologists to reconstruct the regional postglacial vegetation history. Weber Lake, in the southeast part of the study area, provides the best history for the area (Fries, 1962).

Fossil plant fragments and pollen grains of sedges and grasses suggest that the area was apparently occupied by tundra vegetation immediately after deglaciation (Wright and Watts, 1969). Shortly before 10,000 years ago, there is evidence of an extensive dwarf birch shrubland. This vegetation was followed by a period dominated by spruce forests with tamarack and black ash surrounding the lakes. Between 11,000 and 10,000 years ago, a warming trend brought about the replacement of spruce by jack or red pine, which invaded the state from the east. An increase in paper birch accompanied the decline of spruce (Fries, 1962; Craig, 1968). Balsam fir, alder, and white pine did not arrive until after the jack or red pine and birch were well established, around 8,000 years ago. White pine became important at Weber Lake about 7,300 years ago and reached its maximum development, concurrent with the all-time low in spruce, during the midpostglacial warm period (Fries, 1962). Vegetation throughout the state was considerably modified during this period. Prairie extended eastward into areas now occupied by forest (McAndrews, 1966) leaving a record of increased ragweed and chenopod pollen at Weber Lake. After the end of the warm period, about 5,000 years ago, red pine and jack pine increased in numbers in northeastern Minnesota and white pine expanded westward (Wright, 1969).

Since their migration into the area, pine species have remained important in the vegetation. The importance of natural fires in the perpetuation of pine forests is revealed by the forest history studies of Heinselman (1973) and the paleoecological studies of Swain (1975) in the BWCA. Pine stands were regenerated by recurrent fires at intervals of 50 to 350 years (average interval 100 years) until the institution of fire suppression in the early part of this century. Sediment cores from both Weber Lake and Shagawa Lake near Ely (Bradbury and Waddington, 1973) show a drop in the percentage of pine pollen near the sediment surface. This pine fall, attributed to logging, is concurrent with or follows a rise in the percentage of ragweed pollen that indicates the opening of agricultural lands in western Minnesota.

Original Vegetation

The General Land Office Survey provided for the establishment of townships, each composed of 36 sections. In the course of laying out the townships, the surveyors marked every section corner and half section and established 4 "witness trees" at the section corners and 2 at half-section corners. The species of the witness trees, their diameter, and their distance and compass bearings from the corner were recorded as part of the survey notes. Most of the study area was surveyed in the late 1880s, before logging commenced in the area[1]

In 1930, F.W. Marschner of the Lake States Forest Experiment Station compiled a map of the original vegetation of Minnesota based on the General Land Office Survey Records. The boundaries of Marschner's vegetation types in the northern part of the study area relate well to the original survey notes. The broad patterns of original vegetation in the study area (Figure 3) appear to correspond with broad physiographic provinces (Figure 2). Mixed hardwood-pine forests appear to have been restricted to the Giant's Range. East and north of the Giant's Range, aspen-birch forests were well developed in the Toimi Drumlin Field, in the area just northwest of Birch Lake, and in a portion of the Shallow Moraine Bedrock Province south of Gabbro Lake centering around August Lake. White and red pine flanked the south side of the Giant's Range from Biwabik to the south end of Birch Lake and extended north around the east side of Birch Lake, thence west to Lake Vermilion. Islands of red and white pine occurred in the uplands near Skibo and in the Complex Moraine Bedrock Province. Jack pine was best developed in the Shallow Moraine Bedrock Province on the east side of Birch Lake from the first moraine northeastward to the BWCA. Wetlands followed the same distribution that they have today.

Previous Studies

The vegetation of northeastern Minnesota has long been recognized as a mosaic of forest communities. Common canopy species of the area have centers of origin lying either within the Lake States or farther to the east and south (sugar maple, basswood, northern red oak, white pine, red pine) or in Canada (spruce, fir, aspen, paper birch). In general, the vegetation of the area has affinities with forests of the Lake States (Nichols, 1935; Braun, 1950; Bakuzis, 1959; Rowe, 1972).

On the broad regional scale, vegetation can be characterized either in descriptive terms or with reference to "climax" theory. The climax theory assumes an orderly process of succession whereby the dominant species occupying a broad area create conditions unsuitable to their perpetuation and are replaced by new species assemblages better able to live under these conditions. Clements' (1916) climax theory proposed that the orderly process of succession is culminated in a single, self-perpetuating community controlled by the climate of a region and composed of the same species throughout. The search for a single climax community has been based on either of two premises: that the community will succeed in the direction of dominance by increasingly shade-tolerant species; or that succession will progress in the direction of more long-lived species.

The school favoring dominance by shade-tolerant species such as spruce and fir traces its origins to a study by Cooper (1913) on Isle Royale in Lake Superior. Cooper investigated a series of successional stages and concluded that the process ended in a community co-dominated by fir, spruce, and birch. Kittredge (1934) in a study in Cass County concluded that white pine forest would eventually be replaced by sugar maple, beech, and hemlock, or by spruce, fir, and birch in areas beyond the range of hemlock (such as northeastern Minnesota). At the same time, Grant (1934) studied the vegetation of Itasca County and concluded that the climax community was "a transitional forest of fir (and white spruce) from the northern coniferous forest and of basswood, red oak, hard (sugar) maple, and yellow birch from the eastern deciduous forest."

The most recent hypothesis of a climax based on domination by increasingly shade-tolerant species is that expounded by Grigal and Ohmann (1975). In a study of upland forests of the BWCA, they suggest a trend toward upland white cedar as the potential climax forest. Their conclusion is based on the position of communities ordinated in canonical (abstract) space. They recognize an apparent trend of increasingly shade-tolerant communities leading in the direction of white cedar.

The second school of thought has favored long-lived species, such as white pine, as the climax for the area. Braun (1950) called northeastern Minnesota the "pine area" of her hemlock-white pine-northern hardwoods region and recognized red and white pine as the climax species. In this conclusion she followed Stallard (1929), who believed that the longevity of white pine assured its dominance in the climax forest. Waring (1959), in a study centering on the Babbitt area, reached the same conclusion mainly because of the susceptibility of the shade-tolerant species to windthrow and depredation by spruce budworm. Rowe (1972), in discussing the nearby Quetico Region of Canada, suggests that the soils and climate favor dominance by pine but that logging and recent fires have resulted in the prominence of boreal (spruce, fir) and pioneer (aspen, birch, jack pine) species.

Rowe's hypothesis is supported for our area by the findings of Buell and Niering (1957). In an investigation of spruce-fir-birch sites in northern Minnesota, they could not find a site that had been continuously occupied by this forest type, although they believed that it could perpetuate itself once established. All their stands were on sites formerly dominated by pine.

The importance of white pine blister rust in preventing the re-establishment of extensive white pine stands may be the single most important factor contributing to the replacement of white pine by other species. At the same time, recurring droughts at intervals of approximately twenty years, coupled with epidemics of spruce budworm set back succession from a climax of spruce and fir to pioneer species such as aspen.

Studies by Curtis (1959) and his students in Wisconsin are based on the individualistic hypothesis of Gleason (1926) but still recognize separate forest types in broad geographic regions. The individualistic hypothesis probably provides the best theoretical framework for considering the vegetation of the study area, because it takes into account the responses of individual species to environmental factors such as soil type, fire, disease, and drought. Methods of ordination, such as those of Curtis, or the use of synecological coordinates (Bakuzis, 1959) allow the researcher to develop an understanding of community-wide responses to environmental variables on the basis of the responses of individual species.

Wetlands

In addition to the work of Curtis (1959) in Wisconsin, which recognizes seven types of wetlands that could be related to communities in the study area, five studies in Minnesota are useful in developing an understanding of study area wetlands. The studies of Heinselman (1970), Hofstetter (1969), and Gorham et al. (1978) all concentrate on large wetland systems in the Lake Agassiz basin. Within such extensive wetlands landscape features such as ribbed fens and string bogs have an opportunity to develop because of differences in nutrient status and hydrology. Similar landscape features in the study area occur only in the Seven Beaver-Sand Lake wetland that straddles the Laurentian

Divide in the east part of the study area (T 59 N, R 11 W) and was not sampled by the Regional Study. The only previous work in this large wetland is that of Finney (1966), who provides a characterization of the peat but little insight into the vegetation of the area.

The works of Conway (1944) in central Minnesota and Dean (1971) in the BWCA are more applicable to wetlands of the study area because these authors examined smaller wetlands more analogous to those sampled in the study area. Both studies are limited in their value to this study because of their small sample size. Dean classified wetlands in the eastern BWCA according to their nutrient status, following Heinselman (1970), and found that balsam fir was important on minerotrophic (nutrient-rich) and weakly minerotrophic sites, whereas tamarack was unimportant in Gunflint Trail wetlands.

Uplands

Several previous attempts have been made to classify vegetation in northeastern Minnesota, including those of Waring (1959), Grigal (1968), Grigal and Arneman (1969), Ohmann and Ream (1971), Grigal and Ohmann (1975), MPCA (1977), and Kurmis *et al*. (1978, 1979).

Waring (1959) studied both recently disturbed and undisturbed stands in Cook and northern Lake and St. Louis counties. Field data were collected by the Braun-Blanquet method, similar to the methods used in the Regional Study. Waring used Bakuzis' (1959) method of synecological coordinates to define three major communities based on the assumption that long-lived pine species would constitute the regional climax. Waring's Type I (Pinetum gaultheriosum) was characteristic of the most nutrient-poor, dry sites on shallow, sandy soils. Red (and white) pine were considered the climax species for this forest type because they regenerated immediately after disturbance on such sites without intermediate successional stages or competition from shrubs. Type II (Pinetum lycopodiosum) was dominated by white (and red) pine with an understory of balsam fir and spruce and occurred on sandy loam to loam soils. After disturbance, hazel, raspberry, and deciduous-tree sprouts (aspen and birch) formed dense undergrowth, out-competing the conifers. Waring considered this the most extensive type in the region, and it appears to correspond to most of the communities investigated as part of the Regional Copper-Nickel Study. Type III (Pinetum parviflorum) was best developed on deep, loamy soils and characterized by white pine as the climax species. Understory and herbaceous species indicated a moister, shadier environment. These species included balsam fir, white spruce, northern white cedar, mountain ash, and herbs such as bishop's cap (Mitella nuda) and twinflower (Linnaea borealis). The shrub layer was dominated by shade-tolerant species such as mountain maple.

A more recent study that uses the Braun-Blanquet method is that of Wheeler and Glaser (MPCA, 1977) in the Grand Rapids area. Their study includes sites that lie approximately 80 km west-southwest of the study area. Their most northeasterly sites may well be more comparable to the Lake Upham portion of that study area than are stands north of the Giant's Range investigated as part of the Regional Study. By use of phytosociological tables, Wheeler and Glaser identified ten vegetation associations on the basis of character species of trees, shrubs, herbs, or graminoids restricted to given community types. Their thorough floristic survey of graminoids enabled them to differentiate wetland communities beyond the level of differentiation possible with the Regional Study's data. Associations identified in the Grand Rapids area include: sugar maple-leatherwood, trembling aspen-woodrush, red pine-northern bedstraw, jack pine-bindweed, chickweed-raspberry, white cedar-lady fern, silver maple-greenbriar, hedge nettle-cinquefoil, black spruce-Labrador tea, and leather leaf-bog cranberry. Eight of these associations correspond, at least in part, to communities identified by the Regional Copper-Nickel Study.

Grigal (1968) and Grigal and Arneman (1969) sought to demonstrate quantitative relationships between vegetation and soil types in an area roughly comparable to that studied by Waring (1959). The 40 upland stands used in their study had not been disturbed in the last 40 years. Numerical classification by cluster analysis generally produced groups of stands that could be assigned to one of six Society of American Foresters (1954) cover types: white pine, red pine, jack pine, aspen-birch, balsam fir, or northern hardwoods. Classification based on canopy species was not closely related to classification of the same stands on the basis of soil characteristics. On the other hand, classification based on frequency of all species that occurred in more than one stand was more closely related to classification based on soil properties and to synthetic environmental gradients of heat, moisture, and nutrients. Grigal (1968) believed that this closer relationship reflects the greater sensitivity of the understory to environmental variation.

Ohmann and Ream (1971) studied 106 undisturbed upland stands in the BWCA and classified the stands by clustering them on the basis of frequency of occurrence of all species. They provide a characterization of the structural and floristic attributes of each of 12 plant communities. In their community summaries, they draw heavily on the methods used by Curtis (1959) to summarize vegetation data for Wisconsin. The 12 undisturbed upland communities recognized in the BWCA include lichen, jack pine (oak), jack pine (fir), jack pine-black spruce, black spruce-jack pine, aspen-birch, maple-aspen-birch, white pine, red pine, budworm-damaged, and white cedar. The community composition of Ohmann and Ream's aspen-birch and black spruce-jack pine communities corresponds well with similar communities identified by the Regional Study. The undisturbed nature of Ohmann and Ream's stands is probably responsible for the less close correspondence between their other communities and the managed and disturbed vegetation of the study area.

Grigal and Ohmann (1975) extended the work of Ohmann and Ream (1971) by incorporating 68 disturbed stands into Ohmann and Ream's sample and by reclassifying the communities. Thirteen communities were differentiated by the new classification, with two types differing from those designated by Ohmann and Ream. A set of diagnostic species and discriminant functions was generated for the 13 communities, enabling Grigal and Ohmann to classify any upland stand in northeastern Minnesota into one of their community types. The 174 BWCA stands were ordinated in canonical (abstract) space to show the relationship between communities.

Ongoing studies in Voyageurs National Park (Kurmis et al., 1978, 1979) include reconnaissance and collection of quantitative data from stands throughout the park. Communities were initially separated into 15 canopy cover types. The method of synecological coordinates was used for further characterization of the sites.

The MINESITE project (MDNR, 1975) is a hectare-by-hectare inventory of 28 environmental and cultural variables with the capability of providing computer maps and cross tabulations of variables. All but 2 of the 277 stands included in the Regional Copper-Nickel Study's vegetation survey lie within the 1,450 square kilometer MINESITE study area. A vegetation map prepared from aerial photos by use of standard Society of American Foreters cover types is included in the MINESITE inventory. This map distinguishes 23 cover types, several of which are of anthropogenic nature, such as industrial and residential areas, farms, mines, and harvested areas. Classification of forested areas corresponds well with that developed by Cushing et al. (1972) for the Kawishiwi watershed. The latter study used Braun-Blanquet releves to determine the dominant species in visually separable units distinguishable on aerial photos at a scale of 1:15,840. The releves generated by Cushing et al. have since been incorporated into the Regional Study data base.

METHODS

Introduction

The vegetation of any region is comprised of a suite of species (the flora), which usually are distributed in non-random patterns that reflect the preferences of the individual species for various growing conditions. Patterns in the height and spacing of plants make up the structure of the community. Synusia, or structural layers, include the top tree layer (canopy) and subcanopy layers of high shrubs and saplings, low shrubs and tree seedlings, and groundcover. Groundcover is comprised of rock and mineral soil, dead organic matter (litter), and several types of vegetation including graminoids (sedges and grasses), forbs (broadleaved herbs other than graminoids), mosses, lichens, and ferns. Horizontal patterns in the distribution of the vegetation are referred to as "patchiness." Patchiness is often related to differences in the microenvironment such as moisture or shade, but it may also be caused by disturbance and by the methods of seed dispersion or vegetative reproduction of each species. For example, large patches of young aspen result from sprouting from the root system of a parent tree that no longer occupies the site, whereas patches of Sphagnum moss in a damp forest will only occur in depressions where water can accumulate.

Floristic studies are directed at documenting the presence and geographic range of species in a given area. Thus, Lakela's (1965) A Flora of Northeastern Minnesota documents the presence of species in Lake, Cook, and St. Louis counties. Vegetation studies attempt to understand the relationships in space and time among plant species and between plants and environmental factors. Environmental influences include both abiotic factors, such as moisture, nutrients, heat, and light; and biotic factors, such as competition from other plants. Vegetation studies also attempt to quantify the abundance of species, growth forms, or functional groups. Sampling of distinct plant communities is usually done within a homogeneous stand or site. Data from distinct homogeneous stands are easily analyzed by methods that classify vegetation into discrete types.

Communities that intergrade are usually sampled at points along transects that traverse a gradient in community composition or in some environmental variable. Data from transect studies lend themselves to methods of ordination that arrange the sampled points along an axis that relates to a real variable such as moisture (Curtis, 1959) or an abstract combination of variables (Grigal and Ohmann, 1975). Samples of distinct plant communities are easily ordinated after they are classified, but it is difficult to classify data from intergrading vegetation into distinct community types.

Field Methods

The main objective of the Regional Copper-Nickel Study vegetation survey was to characterize the vegetation of the area in a way that would relate cover type maps as used by planners and foresters (MLMIS, 1978; MDNR, 1975; SAF, 1954) to structural, functional, and floristic characteristics that were expected to be important to the wildlife and songbirds.

A total of 277 stands was surveyed by a modification of the semiquantitative Braun-Blanquet releve method (Kuchler, 1967; Shimwell, 1971; Mueller-Dombois and Ellenburg, 1974; Van der Maarel and Westhoff, 1975). Two sets of releves were used, the existent set collected as part of a vegetation mapping project in the Kawishiwi watershed (Cushing et al., 1972, 1973) and a series collected by the Regional Study in stands used for quantitative sampling of vegetation, small mammals, and birds. The locations of all releve sites are listed in Table 1. Figure 4 indicates the location of 62 stands sampled as part of the Regional Study's quantitative sampling program.

The modified Braun-Blanquet releve method provides a visual estimate of cover for each structural class present in a stand, regardless of its species composition, as well as an estimate of the coverage of each species in each layer. Two or more Kuchler classes may be combined if they appear to form a continuous layer in the stand. Combinations of Kuchler classes vary from stand to stand depending on the actual structure of the vegetation. Where height classes are visually separated, they are recorded separately even though the same species may be present in both. Species are listed separately for each stratum in which they occur, even though they may not attain the maximum height of that layer. Nomenclature for plant species followed Gray's Manual of Botany, 8th edition. Because releves were conducted by several individuals (Table I), raw data for all stands were reviewed by the author, who was acquainted with the field knowledge of each colleague. Data were adjusted so that all questionable species were treated at the generic level. Voucher specimens of species recorded in the 62 Regional Study plots are deposited at the University of Minnesota herbarium.

Releves were supplemented by quantitative data from 62 stands used in small mammal and bird surveys. The exact size and locations of the 62 stands were determined by the needs of the mammal trapping program (Batten, 1978).

Within each stand, five 15 x 15 meter (m) quadrats were sampled using the placement of quadrats illustrated in Appendix I. Trees were tallied by species and diameter at breast height (dbh) within each quadrat. The size of plots within each quadrat used to sample high shrubs, low shrubs, and herbs varied to assure that the size of a plot was large enough to include a representative sample within each layer. The distribution of plots used in sampling the understory is illustrated in Appendix I. High shrubs and saplings taller than 1 m were tallied by diameter class and species in four contiguous 2 x 2 m plots. Woody plants less than 1 m in height ("low shrubs") were tallied by species in three 1 x 1 m plots, which were also used to estimate cover of herb and graminoid species. A "bird's eye view" of groundcover was also recorded for the 1 x 1 m plots. This groundcover estimate takes into account the proportions of nonliving groundcover such as rock, water, mineral soil, litter, and deadfall greater than 7 cm in diameter, as well as the coverage of mosses, lichens, graminoids, ferns, and forbs. The method overestimates tall components of the groundcover and underestimates those components hidden by them. Complete field instructions used in sampling are included in Appendix I.

Sampling for mosses and lichens was completed in separate field seasons. Mosses were sampled in the summer of 1975 from 23 stands in the releve series. All moss species present in each stand were collected for identification but no attempt was made to quantify the abundance of each species within the stand. A similar method of collection was used for lichens in 1976, with collections from 48 quantitatively sampled stands.

Analytical Methods

Releve data were used in three ways -- to classify communities in the study area, to ordinate sites according to the method of synecological coordinates, and to elucidate the relationship between structural components of the vegetation.

The Braun-Blanquet method was originally developed as an agglomerative method of classifying stands on the basis of their species composition by means of manually constructed phytosociological tables which rearrange stands and species until stands with similar species composition lie close to each other (Shimwell, 1971; Mueller-Dombois and Ellenberg, 1971; Van der Maarel and Westhoff, 1975). Such groups of stands are defined as communities and named after the dominant species in the canopy and ground layer. The method allows the development of a hierarchy of community types and has been used extensively in Europe where broad regional vegetation types have been ranked into class, order, alliance, association, subassociation, varient, and facies (Kuchler, 1967; Shimwell, 1971). Closely related communities in smaller geographic areas can also be distinguished by this method, as has been illustrated by Wheeler and Glaser (MPCA, 1977).

The similarity of the phytosociological method to agglomerative cluster analysis has been recognized by Mueller-Dombois and Ellenberg (1974), who point out that the use of cluster analysis and ordination allows for a statement of the degree of variation among the units that cannot be achieved by inspection of a phytosociological table.

Cluster analysis provides a method for distinguishing groups of stands that are similar to each other. Such methods may be agglomerative, starting with individual stands and combining them; or divisive, starting with a complete data set and dividing it into successively smaller groups of stands. The program OPTAGG, a modification by E.J. Cushing (University of Minnesota) of Orloci's (1967) optimal agglomeration method, was used in this study to define communities on the basis of overall similarity in polythetic attributes.

Clustering is based on the dispersion of a group of entities (stands in this case) in an abstract multidimensional space. The number of dimensions in the abstract space is equal to the number of attributes (species in this case) being considered. The position of each group of entities (community) in the abstract space is the centroid (average value) of all stands comprising it. A measure called the "within-group dispersion" is the sum of the squared distance between every point and the group's average. Groups are combined so that the difference between the within-group dispersion of the new group and the centroids of the two combinant groups is smaller than it would be if either of the combinants were fused with any other group.

Community classification was based mainly on clusters produced from data for the canopy layer (defined as Kuchler classes 3-5, 4-5, and $\geq$ 5). Thirty-four of the 277 stands did not have any members of these height classes and were assigned to community types on the basis of the species composition of the tallest layer or on the basis of cluster analyses of other layers. A classification based mainly on clusters generated from cover-abundance has the advantage of producing community types closely related to those distinguishable on aerial photographs at a scale of 1:15,840 and used for management and planning purposes (SAF, 1954; MDNR, 1975). Although several objective methods exist for distinguishing the level of clustering used to define communities

(Pielou, 1977), none of these "stopping rules" was used in this study because communities were distinguished at the level of dispersion which produced clusters recognizable as types on aerial photos (Cushing *et al.*, 1972). The disadvantage of classifications based on canopy composition is their restricted sensitivity to site characteristics such as soil type, nutrient status, and moisture. Inclusion of understory species in community classification may provide a system of classification more closely related to such site conditions (Rowe, 1956; Bakuzis, 1959; Grigal, 1968).

The method of synecological coordinates (Bakuzis, 1959) was used to ascertain whether communities distinguished by cluster analysis of individual structural layers, such as the canopy and herb layer, could also be recognized as distinct groups with respect to site characteristics. The method is an ordination technique that provides an indirect assessment of moisture, nutrient, heat, and light characteristics of each community. The only field data required are lists of 20-25 species or more from each site. For each species, synecological coordinate values have been previously determined on a scale of 1 to 5 for each environmental variable. Values were initially determined from the literature and have been adjusted for the range of preferred conditions in Minnesota (Bakuzis, 1959). The unweighted average of synecological coordinates for all species at a site produces a set of coordinates for the site itself. The position of sites in various community types can then be plotted, two variables at a time, in either the edaphic field (moisture and nutrients) or the climatic fie.. (heat and light). The resulting ecographs for different communities based on data from all 277 stands illustrate relative positions along putative environmental gradients.

Heinselman's (1970) indicator species were also used to assess the nutrient status of wetlands. The number of indicator species differs for ombrotrophic, weakly minerotrophic, and minerotrophic wetlands. Because the number of sampled stands in each wetland community also varies, the number of possible occurrences of each type of indicator was calculated by multiplying the number of that type of indicator species by the number of stands in a community. The varying percents of possible occurrences were then used as an indication of the nutrient status of each of five wetland communities. It should be noted that the percentages of the three types of indicators in a community type are independent of each other both within and between community types.

Two measures of community homogeneity were used in this study. The average within-group dispersion as percent of total reflects differences in the matrix values of canopy species that were used to calculate the distances between stands and the group centroid. Within-group dispersion for cluster analysis based on canopy species reflects the floristic homogeneity of the canopy layer only. For this reason, Curtis' (1959) index of homogeneity was used to compare the overall floristic homogeneity of the community to that of the canopy. This index is the ratio of the sum of the presence values for prevalent species (defined below) to the sum of presence values for all species in a community. Values for the Index of Homogeneity can range from 0.00 for sets of stands with no species in common to 100.00 for communities whose stands all have identical floras.

Prevalent species (Curtis, 1959) were determined for each community by summing the percent presence of all species and dividing the sum by 100 to ascertain the "species density" (equal to the number of prevalent species, x). All species were ranked in order of the proportion of stands in which they occurred (percent presence) and the top x species were designated as prevalent species.

Modal species (Curtis, 1959) were defined as those attaining their highest percent presence within a given community. Modal species were not calculated for communities represented by three or fewer stands because the small sample size would result in an inordinately large number of species with high presence values. For example, every species occurring in the single example of a grassland would have a presence of 100 percent, thereby attaining its modal value in this community.

For the sake of consistency in the analysis of small mammal and vegetation data, all statistical tests used nonparametric methods. The Mann-Whitney test (Snedecor and Cochran, 1967) was used to test significance of differences between communities. Unless otherwise specified, tests were considered significant at the 95 percent confidence level.

The total number of species found within a community type and the average number of species per stand in that type are used to characterize community diversity. Curtis' (1959) index of distinctness is used as a measure of the uniqueness of a community. This index is the ratio of the number of prevalent modal species to the number of prevalent species and gives a sense of whether the prevalent species in a community are more likely to be found in that community than in any other vegetation type.

Although the cluster analysis illustrates relationships among stands, relationships among communities are shown in only a broad way. As one way of elucidating the relationships among communities, Jaccard's coefficient of community (Grieg-Smith, 1964) was calculated for pairs of communities. The resulting similarity matrix is presented in Table 2. The formula used was

$$S = \frac{c}{a + b - c}$$

where S is equal to the similarity, c equals the number of species shared by the two communities, a equals the number of species in the first community, and b equals the number of species in the second community.

Quantitative data from the 62 Regional Study sites sampled in 1977 were used to characterize quantitative attributes of the communities, such as the density, basal area, or coverage of structural layers and individual species.

Frequencies of 48 upland species were used to compare the 62 quantitative study sites with upland stands in the BWCA. Five species were deleted from the list of 53 diagnostic species used by Grigal and Ohmann (1975) in their community classification of 174 wilderness stands. The recalculated functions were then applied to the 62 Regional Study stands to classify them into 9 of the 13 communities reported by Grigal and Ohmann. The 62 study area stands and the original 174 wilderness stands were separately ordinated in canonical space, providing a means of comparison between stands in the BWCA and in the study area. A full presentation of this analysis and comparison of communities is found in the discussion section of this report.

RESULTS AND DISCUSSION

Community Classification

Eleven plant communities were distinguished in the study area with the aid of cluster analyses of various structural layers. Cluster analysis based on absolute distance for all woody species (physiognomic categories D, M, E, and B) in Kuchler height classes 5 (5-10 m) and greater, 3-5 (.5-10 m), and 4-5 (2-10 m) grouped 243 of the 277 stands into seven major clusters, illustrated by the dendrograms in Figure 5. Sites without individuals in these height classes were excluded from the analysis. Such sites are of two major types, treeless wetlands and harvested areas or young plantations with trees too small to be detected in the canopy analysis. An eighth vegetation type, shrub carr, was designated by using the results of independent analyses of all species in all layers and of the high shrub and low shrub layers. In the analysis based on all species, most treeless wetlands were clustered together as a group representing the shrub carr community. Young plantations and regenerating stands were assigned subjectively to the canopy type for which they are being managed. These assignments generally agree with the communities in which they are placed in the analysis based on all species. Table 3 lists the final assignment of stands to each community type.

The first and sixth major canopy clusters were divided into distinctive subcommunities that are related to Society of American Foresters cover types. The first group (conifer wetlands) was considered as three communities: spruce bogs, tamarack bogs, and cedar swamps. The sixth cluster contained four subgroups, two of which were retained in the final classification. One of these was composed of anomalous stands (mainly clearcuts) that were reassigned subjectively to appropriate clusters and one consisted of pure aspen stands that were not represented by quantitative data. The remaining two subgroups were treated as two communities, an aspen-birch community and an aspen-birch-fir community. Three white spruce plantations of different ages were not distinguished as a separate community type by the cluster analysis and are not treated as such in this report because of their extreme variability.

Independent cluster analyses based on density, frequency, and basal area of canopy species for the quantitatively sampled stands produced the dendograms presented in Figure 6. Stands with high frequencies, densities, and basal areas of the dominant species were grouped much as they were in the analysis based on releve data. Stands with low frequencies variable in species composition formed a cluster not analogous to any produced by cluster analysis of releve data. Eight of these eleven stands also exhibited low or variable enough densities to fall into a similar group with indistinct canopy dominance in the cluster based on density. Analysis based on basal area generally classified stands with high basal areas of one or two species into clusters that relate to their community types as determined from analysis of the releve data set. Stands with lower basal area more equably distributed among species were placed in a group that does not relate well to the releve analysis.

Although the community types distinguished by the Regional Study are based on cluster analysis of the canopy layer, independent analyses of the high shrub, low shrub, and herb layers indicate that recurring species associations in lower strata vary in their fidelity to the canopy layer. Cluster analysis of the high shrub layer produced ten types, summarized in Table 20. Only nine communities, summarized in Table 21, were distinguished by analysis of the low shrub layer. Table 22 indicates the dominant species of the seven distinct clusters recognized by analysis of the herb layer.

The distribution of major communities in the study area is illustrated in Figures 7a and 7b, MLMIS maps of the Regional Copper-Nickel Study

Area. These maps do not accurately reflect the mosaic nature of the vegetation because they lump all vegetation within a 40 acre (16 ha.) area into the predominant type. The extent of this lumping can be seen by comparing the appropriate section of these maps with Figure 7c, a portion of the map produced by the Kawishiwi mapping project (Cushing et al., 1972). The latter map more accurately illustrates the grain of the vegetation mosaic as does the vegetation map for the Minesite area included in the MINESITE DATA MANUAL (MDNR, 1975).

Although the objective of the Regional Study's vegetation study was not to assess commercial forestry potential of the sampled sites, timber information for mature and pole stands is present in Table 4. This information may aid the reader acquainted with forestry variables to visualize the sampled stands. The range of variability of other parameters including density, frequency, and basal area of trees and high shrubs, density and frequency of low shrubs, and cover and frequency of herbs can be ascertained from the raw stand summary data, available from the state's MLMIS system.

Community Characterization

Black Spruce

Cluster analysis based on canopy species unites a group of 45 spruce stands into a distinct subgroup of the wetland conifer cluster. Within the black spruce cluster, three subgroups are differentiated; stands dominated by spruce with sparse canopies (Figure 5a, 8 stands, G48-

S07), closed stands dominated by spruce (Figure 5a, 30 stands, C05-G42), and closed stands with jack pine as a canopy associate (Figure 5a, 7 stands, R71-S13). After the cluster analysis was completed, 9 stands lacking a canopy layer were added to this group (R56, R57, R60, S26, N10, N20, D01, T28, and G01), because in each of these stands matrix values for black spruce are higher than or equal to those for any other species in the tallest structural layer. One stand, G48, was moved from the black spruce bog cluster to the shrub carr cluster, because its classification in the black spruce group was based on the presence of a few isolated individuals in a community dominated by high shrubs. Seven stands (G01, G02, G03, G06, G44, T05, and G30) comprise the quantitative sample.

The average within-group dispersion of the black spruce community (21.5%) is low, less than that of upland communities. However, Curtis' index of homogeneity, based on species from all structural layers, is lower than for any other wetland community (.50) suggesting that despite their homogeneous canopies, black spruce stands are less similar floristically to each other than are stands within the other wetland conifer groups. The greater dissimilarity between black spruce stands may be partly a result of the much larger sample size and greater geographical area from which the stands were sampled.

The black spruce community is most similar floristically to the mixed black spruce-jack pine community, with a similarity coefficient of .500. It is least similar to the red pine, shrub carr, and ash communities (Table 2).

Black spruce bogs are well developed throughout the study area except in the Toimi Drumlin Field, where they are replaced by alder carrs. Marschner's (1930) map suggests that at the time of the General Land Office Survey spruce bogs were more extensive in the Drumlin Field than they are today, and it is likely that their limited development there today is a result of the 1936 Palo-Markham-Aurora fire. Within the boundaries of this fire shrub carrs dominate the lowlands, but east of the fire boundary spruce bogs prevail. North and east of the Giant's Range, spruce bogs occupy narrow draws between rocky ridges and encircle small lakes. Portions of the extensive Seven Beaver-Sand Lake wetland are occupied by spruce bog, as are portions of the bed of Glacial Lake Dunka. In the central portion of the study area, spruce bogs are well developed along the major streams, especially in the upper forks of the Dunka River. The more extensive nature of these bogs has resulted in their commercial use. Customary practice usually involves clearcutting in strips, as recommended by Heinselman (1959). Natural regeneration from seed is usually good. Field data confirm the success of thinning endeavors in areas such as logged spruce bogs along Twenty-Proof Creek, where trees left after thinning have achieved greater diameter than their unthinned counterparts. Where spruce bogs grade into heath and nutrient supplies are poorer, such as parts of the Sand Lake wetland, dwarfed, open-grown and symmetrical trees have been harvested because of their commercial value as Christmas trees. Calculated site indices for sampled black spruce bogs in the study area are significantly lower than those of other commercial species.

Black spruce accounts for between 9% and 13% of the Forest cover on commercial forest lands outside the Superior National Forest in Lake and St. Louis counties, between 9% and 10% within the Superior National Forest, and 9% of the MINESITE area.

The black spruce community is characterized by the highest average density of trees (1,883 trees/ha) with basal areas that are about average for commercial forest types in the study area (23.4 m^2/ha). Taken together, these figures reflect the large number of small-diameter trees in this community. The canopy is dominated by wetland conifers, with 98 percent of the density and 22 percent of the basal area accounted for by black spruce. Figures 8 and 9 compare the relative densities and basal areas of tree species across community types. Paper birch (Betula papyrifera), balsam fir (Abies balsamea), and jack pine (Pinus banksiana), are present in less than half the stands in low densities.

Th density of the tall shrub-sapling layer is the lowest of any natural community (6,350 stems/ha). Figures 10 and 11 reveal that the dominant species in the tall shrub layer are black spruce (density 1,536 trees/ha, basal area 1.93 m^2/ha) and speckled alder (Alnus rugosa) (density 2,463 stems/ha, basal area .53 m^2/ha). Low shrubs are more important than in upland communities (density 265,000 stems/ha) but approximately a third the density found in tamarack bogs (Figure 11). Both Heinselman (1959) and Conway (1949) note that the low shrub layer is stimulated by opening of the canopy. The relationship between open canopy and high density of low shrubs is illustrated by stand G02, where the average canopy density is 462 trees/ha (community average 1,883 trees/ha) and the low shrub density is 847,000 stems/ha, compared with a community mean of 265,000 stems/ha. The dominance of Labrador tea (Ledum groenlandicum) in the low shrub layer of shadier spruce bogs and of leatherleaf (Chamaedaphne calyculata) in more open stands and tamarack bogs, is in agreement with the findings of both Conway (1949) and Brown (1973).

The groundlayer is dominated by Sphagnum mosses, with less than one-fifth as much area covered by forbs, graminoids, and litter. Sphagnum has a high water retention capacity and insulating value because of the air spaces in its leaves. The insulative capacity of Sphagnum delays spring thawing, augmenting the effect of cold air drainage in causing a cool microclimate in conifer bogs (Curtis, 1959). This microclimate may help explain the importance of bogs for outlying populations of boreal non-moss species rare in Minnesota, such as the northern comandra (Geocaulon lividum), present in plot T05. Additional mosses occurring with a frequency of 100 percent in stands sampled for mosses were Dicranum drummondii, Pohlia nutans, Tetraphis pellucida, Ptilium crista-castrensis, and Pleurozium schreberi (see Appendix II). None of the six lichen species occurring in all five sampled black spruce stands was restricted to this community (see Appendix III).

Although the percent cover of herbs is relatively low (Figure 13), it is interesting to note that all but one of the prevalent herb species has a berry or fleshy fruit. Curtis (1959) comments on this feature of the shrub layer in Wisconsin bogs. The high percentage of berry-bearing fruits does not appear to be an adaptation to allow for greater dispersion, because the greatest proportion of birds in conifer bogs are pickers and gleaners off tree-trunks (Pfannmuller, 1978) and the small mammal population is dominated by insect-eaters (Batten, 1978).

Two hundred and sixty-six species in 41 families were recorded for the black spruce community. Leading families were the daisy family (*Compositae*), rose family (*Rosaceae*), and heath family (*Ericaceae*)(Table 5). Of the 266 recorded species, over half occurred in 3 or fewer stands, with only 3 species that occurred in two-thirds or more of the stands: black spruce (*Picea mariana*), sedge (*Carex* spp.) and Labrador tea (*Ledum groenlandicum*). This distribution of species in the stands helps explain the low index of distinctness (10.5) and indicates that most of the prevalent species grow better in some other community type. Quantitative data for the 19 prevalent species are presented in Table 5. Only black spruce and creeping snowberry (*Gaultheria hispidula*) reach their maximum percent presence in this community. Although the small size of sampled spruce bogs prohibits their receiving all nutrients from precipitation alone, a higher proportion of possible occurrences of ombrotrophic indicators (Heinselman, 1970) was present than of minerotrophic or weakly minerotrophic indicators (Table 6).

Synecological coordinates for the black spruce community cover a wider range of values than for any other wetland type and overlap the range of values for conifer wetlands (Figure 15). The range of synecological coordinates for the black spruce community overlaps both Waring's (1959) Pinetum lycopodiosum and Pinetum parviflorum communities, and extends beyond them in the direction of lower nutrient and higher moisture coordinates.

Grigal (1968) found that classification systems based on canopy species are less sensitive to differences in environmental parameters than are classifications based on the frequency of species from all layers. Cluster analysis of the 277 Regional Copper-Nickel Study releves based on cover-abundance values for all species in all layers does not distinguish black spruce from tamarack bogs, but divides the combined canopy types into two major groups. These two groups appear to be related to the openness of the canopy. Stands in the two groups are more clearly separated from each other in both the edaphic and climatic fields (Figure 15) than are the tamarack and black spruce groups generated by canopy analysis.

Both Conway (1949) and Dean (1971) note that the presence of balsam fir (Abies balsamea) in Minnesota conifer bogs may represent the first stage of succession toward a mixed forest similar to the regional climax postulated by Cooper (1913). Dean concluded that invasion by balsam fir was unlikely in her two most stable spruce bogs, although fir dominated the sapling layer of her more mesic sites. Despite the shade tolerance if fir, established spruce bogs on Sphagnum are likely to perpetuate themselves because of the greater capacity of black spruce to regenerate by branch layering and the susceptibility of fir to spruce budworm epidemics.

Tamarack

A group of 6 stands (Figure 5, stands J14, S17, S23, T14, S20, and G31) forms the tamarack subgroup of the wetland conifer community in the cluster analysis based on canopy species. Five stands lacking trees in the canopy layer were added after the cluster analysis (J13, S12, T15, T16, G45). These stands were dominated by tamarack in the high shrub-sapling layer. Two of the 11 stands (G31 and G45) were sampled quantitatively. Stand G31 is atypical of tamarack bogs because of its higher proportion of spruce and its greater structural and floristic diversity. The dissimilarity of stand G31 from the rest of the sample is reflected in the fact that G31 is the last stand joined in the cluster analysis and that its addition to the cluster raises the average within-group dispersion from 9 to 14 percent. Comparison of releve data shows that speckled alder reaches higher cover-abundance in the high shrub-sapling layer of G31 than in the community as a whole and that the low shrub layer is more sparse than in the other tamarack stands. Leatherleaf, the third most important species in the community as a whole, with coverages around 50 percent, is absent from G31. Thirty-eight percent of the species that occur in only one stand of the tamarack community are found in G31.

The structure and floristic composition of G45 are more similar to other tamarack stands in the releve data set. The tall shrub-sapling layer is dominated by tamarack. Leatherleaf dominates the low shrub layer with coverage the same as the community average. Because of the anomalous chracter of plot G31, quantitative values for plot G45 are more representative of the tamarack community than are average values for the two stands.

The average within-group dispersion of tamarack is 14 percent of the total, less than that of any other community. This low dispersion reflects the structural and floristic similarity of the canopies of the 11 stands. Curtis' index of homogeneity (.63) implies that tamarack bogs are floristically less variable than all wetlands other than cedar and comparable in variability to upland stands.

Tamarack stands are most similar floristically to other wetland stands of minerotrophic tendency such as ash, cedar, and shrub carr and least similar to the jack pine community, whose range of synecological coordinates lies at the opposite end of the moisture axis. Along with shrub carrs, tamarack stands are most dissimilar from most upland communities (Table 2).

The distribution of tamarack bogs within the study area is similar to that of heath bogs and black spruce bogs, with which tamarack bogs intergrade. Such bogs are best developed on peat soils in draws between rocky ridges in the Kawishiwi watershed, around lakes, and overlying extensive outwash plains in the bed of Glacial Lake Dunka and the Seven Beaver-Sand Lakes wetland.

Tamarack accounts for between .6 and 3.1 percent of commercial forest lands outside the Superior National Forest in Lake and St. Louis counties, approximately .2 percent of commercial forest lands within the national forest, and 3.6 percent of the MINESITE area. Figures based on commercial forest lands may be low because open bogs with short canopies that are not likely to produce commercial timber in fifty years are classified by foresters as "unproductive swamp", and tamarack is not currently managed as a commercial species.

As is to be expected from the light-loving habit of the dominant species and the prevalence of Sphagnum in the groundlayer, synecological coordinates for tamarack bogs are high on the light scale and low on the heat scale (Figure 15). Synecological coordinates for light in tamarack bogs are significantly higher than in cedar bogs. In the edaphic field, tamarack bogs are the community highest in moisture and lowest in nutrient coordinates. The position of the tamarack community in the edaphic field is higher in moisture and lower in nutrients than any of Waring's (1959) three community types.

Tamarack bogs in the study area are generally characterized by open, short canopies similar to that of stand G45 (density 2,870 trees/ha in the tall shrub-sapling layer). Black spruce is a common associated tree species. Broadleaf species are generally less important in the tall shrub layer. Despite the high average values for speckled alder, resulting from the influence of stand G31 on the community average, bog birch (Betula pumila) is a more common high shrub species. This species reaches densities of 10,380 stems/ha in stand G45.

The low shrub layer is more important in tamarack bogs than in any other community (Figure 12). The average density for this layer is 631,000 stems/ha, with densities in stand G45 averaging 870,000 stems/ha. In response to the open nature of the canopy, the light-loving leatherleaf is the dominant species. Leatherleaf accounts for 57 percent of the low shrub density when both stands G31 and G45 are considered, 74 percent for G45. Other light-loving members of the heath family that are common in tamarack bogs are bog rosemary (Andromeda glaucophylla) and bog laurel (Kalmia polifolia).

Groundcover is dominated by Sphagnum mosses, which account for over three-fourths of the coverage in stand G45 (Figure 14). Characteristic forbs are the bog cranberry (Vaccinium oxycoccos), false Solomon's seal (Smilacina trifolia), and carnivorous pitcher plant (Sarracenia purpurea).

Only three moss species, Sphagnum centrale, Sphagnum capillifolium, and Aulocomnium palustre, exhibited a frequency of 100 percent in tamarack stands sampled for mosses (see Appendix II). A single lichen species Cetraria sepincola was restricted to this community and occurred in both stands sampled for lichens (see Appendix III).

Tamarack bogs are the most floristically depauperate of the major communities. Eighty-three species of 32 families are present in the 11 stands (63 species if stand G31 is excluded). Of the 83 species, 50 occur in only one stand and 12 in two-thirds or more of the stands. Leading families were the rose family (8 species) and heath family (7 species). The daisy and fern (Polypodiaceae) families were less important than in any other community (Table 5). Tamarack bogs have the highest number of prevalent modal species (17), giving the community the highest index of distinctness (77.2). Half the members of the heath family recorded in this study are prevalent modal species in the tamarack community. Although Heinselman (1970) and Dean (1971) consider tamarack bogs as weakly minerotrophic wetlands, among the tamarack stands included in this study a higher proportion of ombrotrophic than of weakly minerotrophic indicators were present (Table 7). Quantitative data for the prevalent species are presented in Table 8. Prevalent modal species are annotated in this table with an asterisk.

Tamarack is a pioneer species in wetland succession because of its intolerance of shade. Dean (1971) noted the absence of tamarack stands in the Gunflint Trail area and postulated that wetlands in that area were too advanced successionally for tamarack to be common. Because wetland succession around lakes is an ongoing process and because the direction of wetland succession can be reversed by raising of water levels, it seems likely that some other factor is operating to make tamarack more uncommon in the eastern part of the Boundary Waters Canoe Area than in the Regional Copper-Nickel Study Area.

White Cedar

The wetland white cedar community is represented by three sites; all located within three kilometers of each other in the bed of Glacial

Lake Dunka. Cluster analysis based on canopy species recognizes these three stands (G43, T17, and G46) as a distinct subgroup of the conifer wetland cluster. Stand G46 is quite dissimilar from the other two stands; its addition to the cluster raises the within-group dispersion of white cedar stands from 6 to 32 percent. The dissimilarity of this stand arises in part from the inclusion of an area of wet sedge meadow with scattered ash but few cedar. Unlike the other two stands, where the sampling grid was laid within the bounds of a homogeneous stand, the grid at G46 was laid to transect the seepage from Erie Mining Company's Dunka Pit. The sedge meadow was included so the seepage channel would bisect the plot. Inclusion of this open area reduces the overall cover-abundance values for the canopy, especially for cedar. The high Curtis' index of homogeneity reflects the floristic affinities of the three cedar stands when all structural layers are considered.

Although cluster analysis recognizes an affinity between the tamarack and cedar communities, Jaccard's coefficient of similarity suggests that cedar stands are most similar floristically to the black spruce and aspen-birch-fir communities (Table 2). This similarity to both an upland and a wetland community reflects the intermediate moisture and high nutrient status of cedar stands in the edaphic field and lends credence to theories of succession that regard white cedar as a regional climax species (Gates, 1942; Grigal and Ohmann, 1975).

The distribution of cedar swamps northeast of the Giant's Range is confined mainly to the margins of lakes, such as August Lake. In such situations, the cedar canopy often does not shade an extensive enough area to favor development of unique associated understories. South of the Giant's Range, especially in the bed of Glacial Lake Dunka, cedar dominates those areas of broad conifer wetland near the borders of uplands where nutrient runoff is greater. Cedar is reported (MINESITE, 1975) in an upland area of the Colvin Creek watershed east of USFS 113. Cedar stands along USFS 1422 south of Hoyt Lakes are confined to strips within a few hundred meters of the road and contain a high proportion of weedy herbaceous species. Extensive stands of cedar are rare. The proximity of most stands to mining or logging operations or roads may partially account for the high species diversity of the sampled stands.

White cedar accounts for between 3 and 6 percent of commercial forest lands in Lake and St. Louis counties outside the Superior National Forest, between .02 and .1 percent of such lands within the national forest, and 1.1 percent of the MINESITE area. At this time, cedar is not an important commercial species in the study area and stands are not intensively managed.

Cedar stands occupy a portion of the edaphic field that is overlapped by both black spruce bogs and shrub carrs (Figure 15). Cedar stands are higher in nutrient supply and significantly lower in moisture and light than tamarack stands. Although the moisture range of ash stands is similar, their nutrient range is higher than that of the three cedar stands.

Cedar bogs are characterized by a higher average density (1,524 trees/ha) than any community other than black spruce bogs. Average basal area (35.8 m^2/ha) is higher than in any other wetland community. The canopy is dominated by white cedar (74 percent of the density, 75 percent of the basal area), with black spruce and balsam fir as common associates. The density (10,450 stems/ha) and basal area (3.08 m^2/ha) of tall shrubs and saplings is higher than in spruce and open tamarack bogs (Figures 10 and 11).

The most important tall shrub is speckled alder, which accounts for over 70 percent of the individuals and over 50 percent of the basal area. Fir accounts for the same proportion of the density in the tall shrub-sapling layer and the canopy, whereas black spruce is more numerous in the canopy than in the tall shrub layer (Figures 8 and 10).

Low shrubs are less important in cedar swamps than in either spruce or tamarack bogs. Of wetland communities, only the ash community compares with cedar in cover-abundance values for low shrubs. In keeping with its tolerance for shade, Labrador tea is the only member of the heath family that is important in the low shrub layer (Figure 12). This species accounts for almost three-fourths of the stems in the low shrub layer, with speckled alder accounting for an additional 6 percent.

The groundcover of cedar bogs is floristically related to that of both conifer bogs and shrub carrs. Groundcover is fairly evenly divided between mosses, litter, and graminoids, with half as many forbs as graminoids. The high cover of graminoids is similar to that of the shrub carr community. Although mosses are important, cedar bogs differ from other coniferous bogs in the lower proportion of Sphagnum. Only one of the moss species (Sphagnum squarrosum) collected in the single sampled cedar bog was restricted to that habitat. Of note among the forbs is the presence of 12 minerotrophic indicators (Heinselman, 1970), a higher proportion of possible occurrence of minerotrophic indicators than in any other wetland community sampled. The coverage of dewberry (Rubus pubescens) in cedar bogs is comparable to that of upland community types, higher than in any other wetland community. Deadfall over 7 cm in diameter is common, probably partly because of the slow rate of decay of cedar. The presence of such deadfall may contribute to the high proportion of rare lichens found in cedar bogs. Thirty percent of all collected lichens rare in the study area are found in two cedar bogs (Appendix III), including the first state record of Parmelia revoluta.

One hundred and nineteen species in 37 families were recorded in the 3 cedar stands. Of the 119 species, 62 occur in a single stand and 26 in all 3 stands. Leading families include the daisy family (11 species), rose family (8 species), and heath family (7 species). Quantitative data for the 67 prevalent species are presented in Table 9. Modal species and the index of distinctness were not calculated for the cedar community because of the small sample size.

Both Conway (1949) and Dean (1971) suggest that the presence of fir and paper birch (Betula papyrifera) in Minnesota conifer bogs may imply a trend toward convergence of upland and wetland communities in the direction of Cooper's (1913) birch-spruce-fir regional climax. The equal proportion of fir in the canopy and high shrub-sapling layers of the three cedar bogs in this study suggests that fir may be invading these stands. The successional status of cedar stands in the study area is clouded by their disturbed character and small size. These factors may enhance the possibilities that many of these stands may succeed to a mixed coniferous-deciduous forest type. More unlikely is the convergence of both upland and wetland succession in the direction of the white cedar climax postulated by Grigal and Ohmann (1975) on the basis of the high shade tolerance of cedar. Although mature closed cedar stands have maintained themselves in upland areas of the BWCA in the absence of biotic and abiotic disturbance such undisturbed sites are not present within the study area.

Black Ash

A group of eleven stands dominated by black ash is distinguished by the cluster analysis based on canopy species (Figure 5). The same eleven stands cluster together in the analysis based on all species, suggesting that it is not only the presence of black ash that separates this community from other communities. Average within-group dispersion in the cluster based on canopy species is 41 percent, higher than the within-group dispersion of the entire wetland conifer group. This higher dispersion may arise from the fact that two types of ash stands were surveyed floodplains and stands on peat soils. The cluster based on all species also exhibits a high level of within-group dispersion, which, together with the fairly low Curtis' index of homogeneity (.50), reflects structural and floristic differences of subcanopy layers in these two types of ash stands. Quantitative vegetation samples were not obtained from the black ash community because all known stands were too small to be included in the general Regional Copper-Nickel Study sampling design.

Ash stands are a minor community in the study area and are distributed in the floodplains of major rivers, such as the Kawishiwi River, on peat soils in draws along the second Vermilion moraine, and in disturbed cedar stands and sedge meadows. Lowland hardwoods account for between 4 and 5.4 percent of commercial forest lands in Lake and St. Louis counties outside the Superior National Forest, .1 to .6 percent within the national forest, and 3.9 percent of the MINESITE area. At the present time, ash is not being harvested as a commercial species in the study area.

The ash community is most similar floristically to the shrub carr and cedar communities and least similar to upland communities, such as jack pine, aspen-birch, and aspen-birch-fir.

Synecological coordinate values in both the edaphic and climatic fields are similar to those for cedar (Figure 15). Like cedar, ash stands exhibit higher nutrient values than spruce and tamarack stands. The open nature of the canopy is reflected in the higher light coordinates of ash than of other wetland communities.

Ash stands are characterized by fairly open canopies (less than 25 percent cover) dominated by black ash (Fraxinus nigra). Floodplain stands (J18, J20, J21, S41, and S49) contain silver maple (Acer saccharinum) as a common canopy associate. On peat soils, cedar is more common. Floodplain stands subject to annual flooding differ structurally from stands on peat soils. The high shrub and low shrub layers are less important in floodplain stands. As is common on floodplains (Curtis, 1959), vines have a higher percent presence than in other study area communities. Ash stands on peat soils are structurally and floristically allied to alder carrs and cedar bogs. Speckled alder dominates the high shrub layer with an average cover less than 25 percent. The sparse low shrub layer contains speckled alder and meadow-sweet (Spiraea alba).

The groundlayer of stands subject to annual flooding is sparse and includes patches of bare mud, whereas that of unflooded stands is characterized by a variety of graminoids (e.g. sedges and Calamagrostis), tall forbs such as swamp blue aster (Aster puniceus) and meadow rue (Thalictrum spp.), and ferns such as marsh fern (Dryopteris cristata), oak fern (Gymnoparpium dryopteris), royal fern (Osmunda regalis), and lady fern (Athyrium filix-femina). Mints such as water horehound (Lycopus uniflorus) are common along with such species as blue flag (Iris versicolor), and marsh marigold (Caltha palustris). Ash stands were not sampled for mosses, but a single supplementary ash stand sampled for lichens provided not only three species restricted to the community but a new state record for Lobaria quercizans.

One hundred species of 30 families were recorded for the ash community. Forty-nine of the species occurred in a single stand. Four species were present in more than two-thirds of the stands. Leading families were the rose family (10 species), daisy family (7 species), and willow family (Salicaceae) (7 species). Eleven of the 24 prevalent species, listed in Table 10, are modal in this community, giving the ash community an index of distinctness comparable to that of alder carrs and lower than tamarack. A higher proportion of minerotrophic indicators (Heinselman, 1970) than of weakly minerotrophic or ombrotrophic indicators is present in the ash community.

The ability of black ash to withstand periodic flooding would appear to assure its perpetuation in floodplain sites, but the successional status of black ash in draws is unclear.

Shrub Carr

The shrub carr community consists of 13 stands without canopies that are dominated by wetland shrub species. The group of releves includes a variety of stands ranging from four alder stands (T22, T24, G18, and G48) to stands dominated mainly by ericaceous shrubs such as stand D24. The term shrub carr is used in a broad sense and includes stands that Curtis (1959) would assign to shrub carr, alder thicket, and open bog. These subcommunities are not separated, because if stands in this group were divided into several possible communities, each community would contain very few stands and only one community would be represented quantitatively. The variability of stands assigned to the shrub carr group may help account for the fact that this community has the lowest Curtis' index of homogeneity.

Shrub carrs are present throughout the study area, but species composition varies in the different physiographic provinces. Shrub carr in the Shallow Moraine Bedrock Province is more likely to be dominated by dwarf birch (Betula pumila) in association with ericaceous species. In the Toimi Drumlin Field, the shrub carr communities that are found in draws between the drumlins are mainly dominated by speckled alder, red osier dogwood (Cornus stolinifera), and willow. The two quantitative samples from the shrub carr community are both of the latter type. Marschner's (1930) map (Figure 3) suggests that conifer wetlands were more extensively developed at the time of the General Land Office Survey in lowlands of the Toimi Drumlin Field that are now occupied by alder carr. Lowland shrub communities are generally classified by foresters as "unproductive swamp" and are lumped with other unproductive areas in the forest inventory of the Arrowhead Region. Within the MINESITE area, unproductive swamp accounts for 2 percent of the area. The shrub carr community has no commercial forest use at the current time and lowland shrub communities are generally left unmanaged.

Synecological coordinates for the shrub carr community lie high on the moisture axis and range from nutrient values similar to those of tamarack stands to those more nearly like cedar and ash stands (Figure 15). The range of coordinate values thus lies within the range of the black spruce community. The proportion of minerotrophic indicators (Heinselman, 1970) is higher than that of ombrotrophic or weakly minerotrophic indicators (Table 7), but much lower than in the floristically related cedar and ash communities.

High shrubs are the most important structural component of the shrub carr community with an average density of 62,500 stems/ha and basal area of 10.86 m^2/ha, higher than in any other natural community. Speckled alder accounts for 90 percent of the density in the two stands that were sampled. Other species in the high shrub layer are red osier dogwood, black alder (<u>Ilex verticillata</u>), and pussy willow (<u>Salix discolor</u>). The low shrub layer, with an average density of 102,500 stems/ha, is less well developed than in spruce and tamarack bogs but better developed than in cedar swamps (Figure 12). Speckled alder and raspberry dominate the low shrub layer of the two alder carrs that were sampled quantitatively, but in the community as a whole, meadowsweet and leatherleaf are also common in the low shrub layer. Stands in which the latter two species occur are generally those with more open high shrub layers and often lie near water. Meadowsweet is more common in shrub communities near flowing water and leatherleaf at the margins of lakes.

The ground layer of the shrub carr community exhibits a fairly equable division of cover, with the proportion of graminoids, mosses, litter, and forbs most similar to the cedar community (Figure 14). Wetland species dominate the herb layer, with sedges, violets, water horehound, and marsh fern (*Dryopteris cristata*) attaining their highest percent cover in this community. Coverage of *Sphagnum* moss is similar to that in the cedar community. The single alder carr sampled for mosses produced two species unique to this community, *Drepanocladus aduncus* v. *polycarpus* and *Campylium radicale* (Appendix II). No lichen species were restricted to the alder carr community (Appendix III).

Ninety-five species in 35 families are recorded in the 13 stands. The daisy and willow families are the leading families, together accounting for 16 species (Table 5). Although the community is a somewhat arbitrary grouping of stands, the high index of distinctness (.55) results from the presence of 11 modal species among 20 prevalent species (Table 1). The following species reach prevalent modal status in the shrub carr community: St. John's Wort (*Hypericum* spp.), blue-joint grass (*Calamagrostic canadensis*), meadowsweet (*Spiraea alba*), water horehound (*Lycopus uniflorus*), marsh cinquefoil (*Potentilla palustris*), bulrush (*Scirpus* spp.), marsh fern (*Dryopteris cristata*), red osier dogwood (*Cornus stolonifera*), marsh bellflower (*Campanula aparinoides*), curly dock (*Rumex crispus*), and pussy willow (*Salix discolor*).

Although shrub carrs in the study area are most similar floristically to ash and cedar communities (Table 2), their successional status is unclear. Areas dominated by ericaceous shrubs are closely related to open tamarack communities and appear to represent an early successional stage of tamarack and spruce communities. Areas dominated by tall shrubs such as alder and willow are closely related to wet meadows (Curtis, 1959). Gates (1942) suggests that in northern lower Michigan, dogwood-willow thickets are an intermediate successional stage between meadows dominated by blue-joint grass and lowland hardwoods or cedar.

The alder carr community is best developed in lowlands of the Toimi Drumlin Field within the boundaries of the 1936 Palo-Markham-Aurora fire, whereas east of the fire line black spruce bogs are more common. Areas presently dominated by alder are represented on Marshner's map by conifer bog, suggesting that alder carr is a stage of post-fire succession.

Black Spruce-Jack Pine

Cluster analysis based on canopy composition assigns 22 stands to a group that is characterized by constant presence of both black spruce and jack pine in the canopy. Two of the stands in this group (G25 and G26) were sampled quantitatively, but these stands were reassigned to the jack pine community because their floristic composition resulted from the inclusion of pockets of wetland in otherwise xeric pine plantations. No other stands in the mixed black spruce-jack pine cluster were sampled quantitatively.

Average within-group dispersion for the black spruce-jack pine community is 38.5 percent, higher than that of the related jack pine and black spruce communities. Curtis' index of homogeneity is .61, comparable to that of other upland communities in the study area, higher than Ohmann and Ream's (1971) jack pine-black spruce community, and lower than their black spruce-jack pine community.

The black spruce-jack pine community is more prevalent in the Kawishiwi watershed than elsewhere in the study area. Like the jack pine-black spruce community described by Grigal and Ohmann (1975), it occupies slopes between the rocky jack pine community and black spruce bogs. The black spruce-jack pine community was not distinguished by Marschner (1930) on his map of the original vegetation of Minnesota, nor is it designated as a separate cover type by the MINESITE and MLMIS inventories. On the other hand, upland black spruce is recognized as a local cover type within the Superior National Forest, where it accounts for 1.6 percent of commercial forest lands. Natural stands are harvested as a commercial type and reforestation efforts are directed toward jack pine rather than a mxture of pine and spruce.

The range of synecological coordinates in the edaphic field overlaps the lower range of moisture values of the black spruce community and the upper range of moisture and nutrient values for the jack pine community (Figure 15).

The canopy is dominated by black spruce and jack pine, with a higher proportion of spruce than pine. Balsam fir, paper birch, juneberry, and mountain ash are present in the canopies of more than one-third of the stands. Both shrub layers are less well-developed than in deciduous upland communities. Those stands with high cover of mosses are characterized by sparse shrub layers and interrupted herb layers.

Hazel, birch, and Bebb's willow are common high shrubs, with blueberry and Labrador tea as prevalent low shrubs. Ground pines (Lycopodium annotinum and Lycopodium obscurum), bunchberry, (Cornus canadensis), and twinflower (Linnaea borealis) dominate the herb layer. Mosses account for nearly 50 percent of the groundcover. In contrast with black spruce bogs, which are dominated by Sphagnum, common moss of the black spruce-jack pine community include the feathermosses Pleurozium schreberi and Hypnum crista-castrensis.

One hundred and seventeen species in 34 families are reported for the black spruce-jack pine community (Table 5). Of the 117 species, 43 occurred in a single stand and 11 in two-thirds or more of the stands. Of the 26 prevalent species, 4 reach their modal values in this community: jack pine, (Pinus banksiana); blueberry (Vaccinium angustifolium); stiff clubmoss (Lycopodium annotinum); and goldthread (Coptis groenlandica). The resulting low index of distinctness accentuates the fact that most prevalent species of this community attain their modal values in other communities. The mixed black spruce-jack pine community is most similar to the mixed conifer-deciduous community, with which it intergrades (Table 2). It is least similar to the tamarack, shrub carr, cedar, and ash communities.

Jack Pine

Twenty-nine releves with a subset of 9 quantitative study sites comprise the sample of the jack pine community. Sixteen of these stands were grouped by the cluster analysis into the jack pine cluster

(Figure 5). The cluster is divided into two subgroups: a group of 9 pure jack pine stands and a group of 7 stands in which birch and other species are associated with jack pine in the canopy. Cluster analysis based on canopy species recognized a greater affinity between jack pine stands and the transitional black spruce-jack pine community than between jack pine and red pine stands. This greater affinity with the black spruce-jack pine community may arise from the fact that several of the jack pine stands were of natural origin, often with spruce as a major canopy associate, whereas all the red pine stands in the sample were plantations, and although spruce was present in a comparable proportion of stands it was important as a major canopy associate in only one stand.

In the case of major commercial forest types, an effort was made to sample several age classes. The 13 stands that were assigned to the jack pine community after cluster analysis are mainly stands that were chosen to represent this community in younger age classes, such as saplings and seedlings, or to complete a series of jack pine samples on a single soil type. In some cases, such as stands G25 and G26, stands that were chosen to represent a commercial forest type were assigned by the cluster analysis to a different community. In the case of these two stands, which were assigned by the cluster analysis to the black spruce-jack pine community, the presence of ravines containing wetland species within the study plots affected the overall species composition of the plots. In the final community classification, the management type was taken into account and such stands as G25 and G26 were reassigned to the type for which they are being managed.

Average within-group dispersion for the jack pine community is 16.62 percent, less than that of any other community except tamarack bogs. The low dispersion is mainly accounted for by the great similarity of the 9 nearly pure stands. Curtis' index of homogeneity is .61, nearly the same as that of all upland communities. The very similar index of homogeneity for upland communities probably results from the prevalence of a group of ubiquitous upland species such as large leaved aster (*Aster macrophyllus*), wild sarsaparilla (*Aralia nudicaulis*), and bunchberry (*Cornus canadensis*) in all upland communities.

The jack pine community is present throughout the study area. Jack pine stands in the southern part of the area lie on either clay soils of the Aurora Till Plain Province or loam soils of the Toimi Drumlin Field. These stands generally take their origin as plantations post-dating the 1936 Palo-Markham-Aurora fire (Lease, 1962). Jack pine is not generally expected to become dominant on such fine soils (Fowells, 1965). General Land Office Survey records show that the original pineries in the southern part of the study area were dominated by white and red pine and admixtures of these species with hardwoods. At the time of the Land Survey, jack pine was best developed in the Shallow Moraine Bedrock Province where the few remaining natural stands occur today (Figure 3).

Jack pine is notable for its adaptation to forest fires. Not only are mature trees resistant to ground fires, but the cones are often covered with a waxy (serotinous) substance that prevents them from opening and shedding seed unless temperatures reach those attained in forest fires. This adaptation assures that the seed will fall on mineral soil where they are most likely to survive. Because of this adaptation to fire, natural jack pine stands in northeastern Minnesota are even-aged, dating from years with a record of extensive forest fires (Heinselman, 1973). Stands north of Kangas Bay (Birch Lake) and south of state highway 1 take their origin in fires of approximately 1910, with natural stands in the outwash plain of Glacial Lake Dunka dating back as far as 1886.

Jack pine accounts for between 2 and 3 percent of commercial forest in Lake and St. Louis counties outside the Superior National Forest, 11 to 17 percent of national forest lands, and 3.2 percent of the MINESITE area. The higher figures for the Superior National Forest reflect the fact that jack pine is one of the preferred commercial species. Despite the effectiveness of fire as a management tool, current management practices do not include extensive prescribed burning as a method of site preparation. The effect of forest fires is similated in silvicultural practice by rock-raking and barrel scarification, both procedures that remove the litter layer of the soil. Many of the herb species of the forest floor have the capacity of reproducing vegetatively for years, of withstanding forest fire or other disturbance, and of blooming only under conditions of high light that follow disturbance. Examples of such species are the large-leaved aster and fireweed (Epilobium angustifolium). Studies near the study area (Noble et al., 1977) suggest that standard site preparation treatments do not significantly modify the nature of the vegetation as a whole.

The practice of rock-raking, which was favored five to ten years ago, included bulldozing the forest floor and piling slash in windrows several meters high. Invasion of herbaceous weedy species such as pearly everlasting (Anaphalis margaritacea) and other members of the daisy family depends on several factors. The degree of soil disturbance, distance from seed sources, competition from persistent forest floor herbs, and rate of regeneration of shade producing trees all influence the establishment of weedy species. The presence of windrows favors development of a patchy shrub layer, usually dominated by raspberries (Rubus idaeus, var. strigosus), along the windrows. Where stand conversion from deciduous species has taken place, competition from aspen suckers and hazel is often severe. Jack pine is customarily "released" from such competition by the application of herbicides, such as 2-4-D, that are specific to broadleaf species. In general, the higher the site index, the greater the need to control competition from deciduous species. Average site index for sampled jack pine stands in the study area ranged from 39 for the most xeric site on a bedrock outcrop to 64 for a virgin stand on till (Table 4), about average for jack pine in the North Central States (Benzie 1977). Jack pine plantations are not customarily thinned before final harvest at the age of 70 years. Clearcutting is recommended as the mode of harvest, thus facilitating reforestation with a future generation of shade-intolerant jack pine.

The synecological coordinate range of jack pine stands is very similar to that of red pine in both the edaphic and climatic fields (Figure 15). Over half the jack pine stands fall into the range of edaphic coordinates characteristic of Waring's (1959) Pinetum gaultheriosum community, the pine community of the driest sites. A much smaller proportion of red pine and mixed black spruce-jack pine stands lie in this range, suggesting that these two communities lie slightly higher than jack pine on both the moisture and nutrient axes.

The jack pine community is most similar floristically to the red pine community and least similar to the shrub carr, ash, and tamarack communities (see Table 2).

Jack pine stands are generally more open than red pine, cedar, and black spruce stands. Average density is 1,000 trees/ha, with a basal area of 22.1 m^2/ha. Jack pine is the dominant canopy species and accounts for 83 percent of the density and 96 percent of the basal area (Figures 8 and 9). The most important canopy associates are black spruce and trembling aspen.

Shrubs are generally less important in the jack pine community than in deciduous uplands. Densities in the high shrub-sapling layer of jack pine stands (14,825 stems/ha) are half again as high as in red pine stands and densities of low shrubs are almost twice as high. Although the relative density of hazel is greater than that of any other species in the high shrub layer, paper birch accounts for approximately one-third of the basal area in that layer (Figure 10). Green alder (Alnus crispa) reaches its highest relative densities in pine stands, but is higher in red pine than in jack pine stands. Although the number of stems of aspen and juneberry (Amelanchier spp.) are important in jack pine stands, these species contribute little to the basal area (Figures 10 and 11). Hazel and Labrador tea are the most important shrubs in the sparse low shrub layer. Despite their high densities along windrows in young stands, raspberries are generally less important than in other upland communities, except the mixed conifer-deciduous community. Sweet fern (Comptonia peregrina) occurred only in the jack pine and mixed black spruce-jack pine communities.

Groundcover in pine stands is dominated by litter and forbs (Figure 14). As in most upland types, the dominant forb is large-leaved aster (Figure 13). Blueberries (Vaccinium spp.) reach their highest coverage in the jack pine community and dewberries (Rubus pubescens) are common. Both wild sarsaparilla (Aralia nudicaulis) and bracken fern (Pteridium aquilinum) exhibit their lowest percent cover in the jack pine community. Although there are no significant differences in the groundcover of species between the jack pine and red pine communities, both wild sarsaparilla and bracken fern are significantly lower in jack pine stands than in deciduous communities. Table 13 presents a summary of quantitative data for prevalent species in the jack pine community.

No moss species was constantly present in all jack pine stands that were sampled. Four species with single occurrences were restricted to this community (Appendix II). The two lichen species that occurred in all seven sampled jack pine stands were ubiquitous species. Three lichen species with single occurrences in the study area were found in this community (Appendix III).

Two hundred and three species of 44 families were recorded for the jack pine community, the highest number of species recorded in any community. Of the 203 species, 70 were recorded in only one stand and 15 occurred in two-thirds or more of the stands. Leading families were the daisy and rose families, each with more species than in any other community (Table 5). Eight of the 39 prevalent species reached their modal values in the jack pine community, producing a low index of distinctness (22.5). Modal species include: strawberry (Fragaria spp.), juneberry (Amelanchier spp.), Bebb's willow (Salix bebbiana), dogbane (Apocynum androsaemifolium), green alder (Alnus crispa), pearly everlasting (Anaphalis margaritacea), sweet fern (Comptonia peregrina), and spinulose wood fern (Dryopteris spinulosa).

Because of its light-loving habit, jack pine is generally recognized as an early successional species. Although individual trees and stands may become overmature after the age of 70, the community is capable of self-perpetuation wherever fire is part of the ecosystem. Before the advent of fire suppression, jack pine forests in northeastern Minnesota were regenerated by natural wild fires at an average of every 100 years (Heinselman, 1973). It appears from Marshner's (1930) map that the proportion of the intensive study area covered by jack pine was greater before fire suppression and logging than it is today. Since the forests of the area began to be managed, jack pine has been a favored species. At this time, the "successional status" of the jack pine community is a question of forest management policies.

Red Pine

Cluster analysis based on canopy species clusters 17 stands into the red pine community (Figure 5). Five stands with lower canopies were added to the group after clustering. Of the 22 red pine stands, 11 were sampled quantitatively. As was the case in other commercial forest types, red pine stands chosen for quantitative study were selected to include three size classes: seedlings, saplings, and mature trees. Three subgroups are distinguished by the cluster analysis within the red pine group. Six stands (S20, N27, S24, T03, S11, and R06) contain jack pine as the major canopy associate, another six (T32, G20, G21, T04, J07, and N04) contain aspen and birch, and the remaining five stands (N18, G23, G24, T26, and N02) are nearly pure red pine stands. All stands classified in the red pine group had higher matrix values for red pine than jack pine. The average within-group dispersion of the red pine community is 41.22 percent of the total, two and one-half times that of the jack pine community. The overall higher dispersion is accounted for by the high dispersion of the jack pine and aspen-birch subgroups. Pure red pine stands have a low dispersion, around 12 percent. Although cover-abundance values of dominant species in red pine stands do not vary greatly, species composition of the stands is more variable. Curtis' index of homogeneity (.64) is comparable to that of other upland communities.

Red pine stands in the study area are almost exclusively plantations and are scattered throughout the area. Marschner's (1930) map shows that red pine was mixed with white pine at the time of the General Land Office Survey, and that the community was concentrated at the east end of the Giant's Range and along the east side of Birch Lake, in the Complex Moraine Province, and along the first moraine just northwest of the Seven Beaver-Sand Lake Lowland (Figure 3). In all these areas, soils are deeper than in the Shallow Moraine Bedrock Province where jack pine was concentrated at the time of the General Land Office Survey.

Mature red pine resembles jack pine in its resistance to fire, although it lacks the serotinous cones that make jack pine dependent on fire for regeneration. Good seed crops in red pine occur every 4-7 years (Fowells, 1965). This long cycle of good seed production may have been important as an historical factor in the regeneration of red pine stands. A coincidence of good seed years and fire would have been necessary for the best natural regeneration.

Red pine accounts for less than 1.32 percent of commercial forest lands in Lake and St. Louis counties outside the Superior National Forest, between 1.2 and 11.0 percent within the national forest, and .9 percent of the MINESITE Area. It is probably the most intensely managed species. Because of the undependability of natural seeding, red pine plantations are generally established by planting or aerial seeding. Before planting, sites are usually prepared by barrel scarification (or, formerly, by rock-raking). Current management guidelines differ somewhat from those of the last 40 years, because they do not encourage conversion of deciduous sites to pine stands. Plantations established on sites formerly occupied by deciduous species, such as aspen, require release from competition by use of herbicides or hand-thinning. Unlike jack pine plantations, red pine are usually thinned two to three times at 15-year intervals before final harvest at ages of 120 to 180 years. Thinning to a basal area of 80 ft^2 per acre (18.4 m^2 per hectare) is common. Average site index for red pine stands sampled by the Regional Study was 63, above the average for red pine stands on Rainy till in northeastern Minnesota (Alban, 1976).

Synecological coordinates for the red pine community are similar to those of jack pine in both the edaphic and climatic fields (Figure 15). The low moisture coordinates reflect the preference of pines for drier sites. The unexpectedly narrower range of values for red pine than jack pine on the light axis may reflect the fact that all red pine stands in the sample were managed, whereas a portion of the jack pine stands were natural and contained a larger number of shrubs and shade-tolerant understory trees. Within the edaphic field, synecological coordinates for the major proportion of red pine stands in the study area appear to fall within the range of Waring's (1959) *Pinetum lycopodiosum* type. Despite its synecological similarity to the jack pine community, Jaccard's coefficient of similarity suggests that the red pine community is floristically most similar to the aspen-birch-fir community (Table 2). Such a similarity between red pine and aspen-birch communities has been noted also by Janssen (1967) in northwestern Minnesota.

Average canopy density (1,472 trees/ha) and basal area (36.7 m^2/ha) attain their highest values in the red pine community, perhaps because of intensive management. Red pine is the dominant canopy species and accounts for 86 percent of the stem density and 93 percent of the basal area. The average basal area is almost twice that recommended by the Forest Service after thinning. Both the high basal area and variable species composition may be accounted for by large number of stands below the age of first thinning (15 years).

Both the high shrub and low shrub layers are less important in the red pine community than in any other upland type (Figures 10 and 12). Although there are more stems of hazel, aspen attains a higher basal area in the tall shrub layer. Green alder (*Alnus crispa*) reaches its highest relative density under red pine, significantly higher than in deciduous stands. The low shrub layer is similar to that of the jack pine community, although Labrador tea is absent.

The high proportion of litter in the groundlayer is characteristic of upland stands in general. Deadfall greater than 7 cm in diameter has a lower coverage than in any other upland type (Figure 14).

There are no significant differences between coverage of species in the herb layer of the jack pine and red pine communities. The higher coverage of bracken fern in the red pine community approaches that of deciduous stands. Although the velvet-leaf blueberry (Vaccinium myrtilloides) exhibits its highest percent presence in this community, the percent cover of both blueberry species is lower in the red pine than the jack pine community. Coverage of bunchberry (Cornus canadensis) is significantly higher in red pine stands than in aspen-birch, whereas that of wild sarsaparilla (Aralia nudicaulis) is significantly lower.

Both the moss and lichen floras of sampled red pine stands appear to consist mainly of ubiquitous upland species. The first state record for one moss, Trematodon ambiquus, was found in plot T03.

One hundred and fifty-eight species of 37 families were recorded fin the 22 red pine stands. Of these species, 59 occurred in only a single stand and 19 were present in two-thirds or more of the stands. Leading families were the daisy family (24 species) and the rose family (14 species), with the wintergreen family (Pyrolaceae), which reaches its highest numbers (9 species). The index of distinctness (39.4) is generally lower than those of wetland communities but higher than any other upland community. This index reflects the high proportion of prevalent modal species (Table 14). These species are: bunchberry (Cornus canadensis), red pine (Pinus resinosa), false lily-of-the-valley (Maianthemum canadense), wild rose (Rosa acicularis), bush honeysuckle (Diervilla lonicera), dewberry (Rubus pubescens), velvet-leaved blueberry (Vaccinium myrtilloides), wood anemone (Anemone quinquefolia), mountain rice (Oryzopsis spp.), raspberry (Rubus idaeus var. strigosus), violet (Viola spp.), fireweed (Epilobium angustifolium), American vetch (Vicia americana), aster (Aster ciliolatus), chokecherry (Prunus virginiana), cow wheat (Melampyrum lineare), and downy arrow-wood (Viburnum rafinesquianum).

The successional status of red pine in the study area is dependent on disturbance. Regeneration has been related historically to the distribution and frequency of fire (Heinselman, 1973) with little evidence of natural conversion from aspen to pine in Minnesota (Heinselman, 1954). In the absence of fire, present red pine stands in the study area have originated as plantations. In the event of a westward spread of Scleroderris canker, the importance of both red pine and jack pine in the study area could decrease in the future.

Aspen-Birch

Cluster analysis based on canopy species groups 70 stands into a broad aspen-birch community equivalent to the MLMIS aspen-birch cover type. Four major subgroups are distinguished: 17 anomalous stands, 20 aspen-birch stands, 21 aspen-birch-fir stands, and 12 pure aspen stands (Figure 5).

The 17 anomalous stands are open-canopied sites that were clusterd with the aspen-birch community because of the presence of scattered individual aspen and birch trees in the canopy layer. They are generally young successional stages of other upland types or wetlands with isolated aspen or birch trees. These 17 stands were reassigned to appropriate communities as shown in Table 15.

Nine of these stands were members of the quantitative data set. Of these 9 stands, cluster analysis based on frequency of canopy species rejected 2 and assigned 5 to an anomalous group of stands with low and variable frequencies. The remaining two stands, T11 and T18, were clustered with other aspen-birch dominated stands (see Figure 5).

Nine immature aspen-birch stands (R21, R34, S09, S37, T11, G07, G08, G39, and R83) were added to the mature aspen-birch cluster after the cluster analysis. These stands were originally clustered with the anomalous aspen-birch group or were not clustered because of the absence of any species in the canopy layer. The 20 stands that were originally clustered in the mature aspen-birch group (Figure 5, stands C08-R83) fall into two major subgroups based on species composition and cover abundance. Stands containing jack pine were fused with those whose proportions of aspen and birch were similar, and stands containing spruce were fused with the most similar aspen-birch stands. Average within-group dispersion of the mature aspen-birch cluster is 29 percent, higher than that of the pure aspen cluster and lower than those of the aspen-birch-fir and mixed conifer-deciduous communities. Curtis' index of homogeneity is similar to those of the aspen-birch-fir and mixed conifer-deciduous communities but lower than that of the pure aspen group.

Deciduous stands dominated by aspen and birch are widespread throughout the study area (Figure 7a). Admixtures of conifer species are more frequent in the Shallow Moraine Bedrock Province. Maple and basswood are more frequent canopy associates in the Toimi Drumlin Field and along the Giant's Range. In the northern part of the study area, basswood is confined to stands under the climatic influence of large lakes, such as White Iron and Fall lakes. Marschner's (1930) map shows that at the time of the General Land Office Survey, the aspen-birch community was most extensive in the Toimi Drumlin Field, in the Outwash Moraine Complex Province, and in the Aurora Till Plain (Figure 3).

Aspen-birch accounts for between 41 and 53 percent of commercial forest lands in Lake and St. Louis counties outside the Superior National Forest, between 38 and 50 percent of national forest lands, and 41 percent of the MINESITE Area.

The aspen-birch community is important as a commercial forest type because of the usefulness of aspen as pulpwood. Both species are cold-tolerant, short-lived, light-loving species that are considered to be pioneers in the successional series, replaced by longer-lived species such as red and white pine or more shade-tolerant species such as spruce and fir. When aspen-birch stands are disturbed by fire or logging, they regenerate vegetatively to form even-aged stands. Aspen forms suckers from the roots, whereas birch forms stump sprouts. Complete removal of the canopy results in better stocking by aspen suckers, because residual mature trees inhibit suckering. For successful aspen regeneration, clearcutting is recommended, followed by burning to reduce competition from other species (USFS, 1973). Deciduous uplands in the Partridge River watershed of the study area are an example of the inhibitory effect of residual trees on sprouting. Serial examination of aerial photographs at roughly ten-year intervals reveals that in many parts of townships 59 and 60 N, ranges 12 and 13 W, scattered mature aspen were left after logging in the 1940s and reforestation was delayed by several years after cutting. The resulting natural regeneration of aspen was spotty and today these areas support a heterogeneous mosaic of poorly stocked aspen and birch, upland shrubs, and interspersed conifer plantations, including stands G04 and G05. Calculated site indices for aspen-birch stands (Table 4) suggest a wide range in the quality of sampled sites.

Synecological coordinates for the aspen-birch community lie within the range of Waring's (1959) Pinetum lycopodiosum, the pine type that he found subject to most serious competition from deciduous species unless it was managed. Coordinates for the aspen-birch community (Figure 15) overlap the ranges of all other communities except the tamarack and alder carr communities, which are also the most floristically dissimilar (Table 2). Despite the light-loving habit of aspen, the range of light coordinates for the aspen-birch community is similar to the range for the mixed conifer-deciduous and black spruce-jack pine communities, which could be considered as later successional types. Floristically, the aspen-birch community is most similar to the red pine and aspen-birch-fir communities.

Density of the canopy layer in the aspen-birch community (982 trees/ha) is comparable to that of the jack pine community (1,000 trees/ha) and lower than that of the red pine or aspen-birch-fir communities (Figure 8). The basal area is nearly equivalent to that of the aspen-birch-fir community, reflecting the greater diameter of trees in the purer community. Aspen and birch are the dominant species, with aspen accounting for approximately one-third more density and basal area than birch. Canopy species diversity in the aspen-birch and aspen-birch-fir communities is higher than in any of the other types. As can be seen from Table 16, the mature aspen-birch community is at the low end of a continuum of increasing importance of coniferous elements. Conifers are less important than in the aspen-birch-fir community, the mixed conifer-deciduous community, and aspen-birch communities of the Boundary Waters Canoe Area (Ohmann and Ream, 1971).

The high shrub layer is very important, with an average density of 36,800 stems/ha (Figure 10). Hazel is the most important high shrub species and accounts for 50 percent of the stems. The density of hazel is significantly higher than in the related red pine and aspen-birch-fir communities. As is the case with other communities of low canopy density, the low shrub layer is more important than in communities with high canopy density, such as the red pine and mixed conifer-deciduous cover types. A large proportion of the woody species in this layer are tree seedlings and are not accounted for in Figure 12. Hazel and raspberry are the most important of the shrub species, together accounting for approximately 40 percent of the individuals.

Herbs reach their greatest proportion of the groundcover in the aspen-birch community, with litter concomitantly lower than in any other upland forest type (Figure 14). The herb layer is dominated by large-leaved aster (Aster macrophyllus) and sarsaparilla (Aralia nudicaulis), both of which reach their highest percent cover in this habitat. Percent cover of large-leaved aster is significantly higher in aspen-birch stands than in either the aspen-birch-fir community or the mixed conifer deciduous community. Wild sarsaparilla and bracken fern (Pteridium aquilinum) both exhibit significantly higher coverages than in the jack pine community. The higher cover of bracken fern probably accounts for the fact that ferns in general reach their highest percent cover in this community. Stands in the Toimi Drumlin Field exhibited a higher presence of spring ephemerals such as spring beauty (Claytonia caroliniana) and related herbs of mesic deciduous forests such as hepatica (Hepatica americana), and wild ginger (Asarum canadense).

Six mosses and 7 lichens represented by single collections were found in the aspen-birch community. A large suite of lichen species occurred more frequently in aspen-birch and aspen-birch-fir than in all other communities (Appendix III).

One hundred and forty-four species of 43 families were recorded in the aspen-birch community. Fifty of the 144 species occur in only a single stand and 18 occur in two-thirds or more of the stands. Leading families were the rose (12 species) and daisy (11 species) families. Although a larger number of species of the grass family (Gramineae, 10 species) were recorded for this community than for any other, not all members of this family were identified in any of the communities and the higher number of species probably reflects a greater proportion of easily recognized grasses. Only five species, trembling aspen (Populus tremuloides), large-leaved aster (Aster macrophyllus), wild sarsaparilla (Aralia nudicaulis), bracken fern (Pteridium aquilinum), and sweet bedstraw (Galium triflorum) attain their highest percent presence in the aspen-birch community, contributing to the low index of distinctness (.15). Summary data for prevalent species are presented in Table 17.

The aspen-birch community is generally regarded as a pioneer broadleaf community that will be succeeded by longer-lived pine species or shade-tolerant spruce and fir in the absence of fire or other disturbance. Since the advent of fire suppression and logging, aspen-birch forests have expanded their acreage in the study area because of the abilities of both species to reproduce vegetatively. The distribution of forests at present represents a fairly young stage of secondary succession, with the most mature aspen-birch stands resulting from regeneration following logging after the turn of the century. If these stands were left unharvested, an increasing number of conifers might be seen with larger acreages of aspen-birch-fir and mixed conifer-deciduous stands. Because it is likely that a large proportion of the aspen-birch stands in the area will be cut before they become overmature, future acreages of this forest type will depend on forest management practices. If the current policy continues, there may be less conversion of deciduous sites to pine stands than in the recent past and the proportion of the area in aspen-birch may remain much the same as at present.

Aspen-Birch-Fir

Cluster analysis based on canopy composition assigns 21 stands to the aspen-birch-fir group (Figure 5, stands G12-T08). Although the cluster is comprised of some stands whose canopy composition is restricted to the three dominant species and others whose canopies contain additional species, the two major sub-clusters do not appear to be defined merely by canopy composition. Three stands with canopies too short to be included in the analysis were later assigned to this community (N40, G37, and R05). Average within-group dispersion was 49.5, higher than that of the aspen-birch community and lower than that of the mixed conifer-deciduous community. Curtis' index of homogeneity is the same as in the aspen-birch community (.63).

Aspen-birch stands containing fir as a major canopy associate are present throughout the study area, but are generally not separated from the aspen-birch community on cover type maps. Although Marschner's (1930) map did not separate the two communities, the original survey notes report coniferous elements in the same sections as aspen and birch at least as far south as T 59 N. (Survey notes for townships 57 and 58 have not been read by the author.) Because of the small sample size and widely spaced samples, unless trees are recorded at the same section corner, it is difficult to judge whether such records reflect patchy vegetation or a mixture of conifer and deciduous species.

The aspen-birch-fir community is less desirable than aspen-birch as a marketable timber type because its mixed species composition, small diameter trees, and likelihood of dead standing fir make it more difficult to harvest. During the 1960s, aspen-birch-fir stands were one of the targets of site conversion and considerable areas of this forest type were rock-raked and converted to pine in the Kawishiwi watershed.

Synecological coordinates for the aspen-birch-fir community lie in the same range as those of the aspen-birch community, with aspen-birch-fir stands lying in a narrower range along the moisture axis (Figure 15). The aspen-birch-fir community is most similar floristically to the red pine and mixed conifer-deciduous communities and differs most from the tamarack and shrub carr communities (Table 2).

Average canopy density is 1,231 trees/ha, higher than that of the aspen-birch community, with higher relative densities of all conifer species (Table 16). Fir is present in 95 percent of the stands with 11.9 percent of the density and 5.9 percent of the basal area. The relative density of fir is comparable to that of aspen-birch stands in the Boundary Waters Canoe Area (Ohmann and Ream, 1971), but black spruce, white pine, and white spruce are less important in the study area than in the BWCA (Table 16). The relative density of birch is higher than that of aspen, but the greater diameter of aspen trees results in a higher basal area for that species.

Density of the high shrub layer is significantly lower than in the aspen-birch community. Although hazel accounts for 73 percent of the stems, its density is significantly lower than in aspen-birch stands. Aspen, fir, green alder, and juneberry are also important in the high shrub layer (Figures 10 and 11). The low shrub layer is comparable in density to that of the red pine community (Figure 12) and is dominated by hazel, raspberry, and gooseberries (Ribes spp.).

Groundcover is characterized by a higher proportion of litter than forbs (Figure 14), with graminoids twice as important as in the aspen-birch community. The lower proportion of ferns reflects the significantly lower coverage of bracken fern compared to aspen-birch stands. Other dominant herbs are similar to those of the aspen-birch community. Quantitative data for prevalent species are presented in Table 18.

Eleven lichen species collected from a single stand were found in the aspen-birch-fir community, with a large suite of species that occurred more frequently in this and the aspen-birch communities than in any other (Appendix III).

One hundred and seventy-eight species of 48 families are recorded for the aspen-birch-fir community. Fifty-one species occurred in a single stand, and 19 were present in two-thirds or more of the stands. Leading families were the daisy, rose, and buttercup (Ranunculaceae) families, followed by the fern (Polypodiaceae), honeysuckle (Caprifoliaceae), and wintergreen families. The index of distinctness is low (.17) and reflects the presence of only 7 modal species: hazel (*Corylus cornuta*), paper birch (*Betula papyrifera*), twisted stalk (*Streptopus roseus*), starflower (*Trientalis borealis*), mountain maple (*Acer spicatum*), and red maple (*Acer rubrum*).

Mixed Conifer-Deciduous

Cluster analysis based on canopy species fuses 53 stands into a mixed conifer-deciduous community co-dominated by aspen, birch, fir, and black spruce. Three major subgroups are recognized. The first group (Figure 5, stands R01-S39) is comprised of 18 stands dominated by aspen, fir, and jack pine, with all but 5 stands containing spruce. The second group, with 14 stands (Figure 5, stands R47-J04), is characterized by the presence of aspen and spruce with low coverage of fir. The 21 remaining stands form a cluster characterized by shared dominance of aspen, birch, jack pine, and spruce. All 53 stands are treated as a single community in this discussion because the 2 stands for which quantitative data are available belong to separate subgroups, leaving one subgroup with no quantitative data. Both stands that were sampled quantitatively may differ from the community as a whole because neither was located in the Kawishiwi watershed near the remainder of the stands. Within-group dispersion for the mixed conifer-deciduous community is the highest of any community (96 percent), reflecting the great variablity in canopy composition. Curtis' index of homogeneity (.64) is more similar to that of other upland communities and suggests that the species composition of the subcanopy layers may be less variable than that of the canopy.

Like the black spruce-jack pine community, the mixed conifer-deciduous community is best developed in the Shallow Bedrock Moraine Province. This community represents part of a continuum from deciduous to coniferous natural upland forest types and is not distinguished as a separate community on most forest cover type maps. It appears that the importance of spruce-fir in the Kawishiwi watershed has been reduced by infestations of spruce budworm in the last 30 years (Sloss, 1978).

Like the aspen-birch-fir community, the mixed conifer-deciduous community is difficult to manage and harvest and has been subject to stand conversion in the recent past.

Synecological coordinates lie in the same range as other deciduous uplands, but extend through a broader moisture range than do aspen-birch-fir stands (Figure 15). Almost all the stands fall within the edaphic range of Waring's (1959) Pinetum lycopodiosum type.

As can be seen from Table 2, the mixed conifer-deciduous community is most similar floristically to the red pine, aspen-birch-fir, and mixed black spruce-jack pine communities and least similar to the tamarack and shrub carr communities.

Canopy density (413 trees/ha) and basal area (10.9 m^2/ha) are lower in the mixed conifer-deciduous community than in any other. Aspen and birch are the dominant species, with birch about twice as important as aspen (Figures 8 and 9). Although the density of fir is comparable to that of aspen, the trees are small and the basal area is low.

The frequencies of conifer species in the mixed conifer-deciduous community are generally higher than in the aspen-birch and aspen-birch-fir communities and most nearly approximate those of Ohmann and Ream's (1971) budworm damaged community (Table 16). However, the relative density of black spruce is much lower in the mixed conifer deciduous community of our study area.

With respect to both density and basal area, the tall shrub layer is more important in this community than in any other except shrub carr (Figures 10 and 11). Hazel reaches its highest relative density of 72 percent in this community, followed by juneberry (significantly higher than in the aspen-birch-fir community) and green alder. Although it was not present in the two stands that were sampled quantitatively, mountain ash reaches its highest percent presence in this community and occurs mainly as a subcanopy species.

The low shrub layer is less important than in the jack pine community, but more important than in any other upland type. Average density is 56,700 stems/ha, with hazel, gooseberries, and rose as the dominant species. Raspberry attains lower densities in the mixed conifer-deciduous community than in any other upland type.

Litter accounts for over 50 percent of the groundcover (Figure 14), with 29 percent in forbs, and a higher proportion of deadfall greater than 7 cm in diameter than in any other upland community. Large-leaved aster and wild sarsaparilla share dominance of the herb layer, with coverages of 7 to 9 percent. Bracken fern occurs in proportions about equal to that in the red pine community, lower than in the aspen-birch community (Figure 13). Both bluebead lily (Clintonia borealis) and twinflower (Linnaea borealis) reach their highest percent presence in this community. Although it never accounts for a large proportion of the groundcover, bluebead lily attains an average frequency of 36 percent. Quantitative data for the 31 prevalent species are presented in Table 19.

One hundred and thirty-five species in 41 families were recorded in the mixed conifer-deciduous community. Leading families were the rose, daisy, and honeysuckle (Caprifoliaceae) families. The presence of only five prevalent modal species results in a low index of distinctness (.16), comparable to those of the aspen-birch and aspen-birch-fir communities. These species include: bluebead lily (Clintonia borealis), twinflower (Linnaea borealis), balsam fir (Abies balsamea), mountain ash (Sorbus americana), and undifferentiated mosses. No moss collections were made in stands representative of this community type. One lichen species, Cyphelium lucidum, was restricted in its sole collection to this community.

The mixed conifer-deciduous community may represent the most advanced successional stage of deciduous upland communities in the study area at the present time. Because of the probability of periodic epidemics affecting the supposed "climax" species, it is unlikely that a mixed forest can perpetuate itself in the area even in the absence of management.

The theory of succession from pioneer aspen-birch to shade-tolerant spruce-fir forests predicts that in aspen-birch forests shade-tolerant species should be present only in the youngest age-classes. Because tolerant species such as spruce and fir can reproduce in their own shade, they can be expected to be distributed throughout all age-classes in near-climax forests. Although the ages of stands in all three non-pine upland forest types are variable, the size-class distribution of spruce and fir in aspen-birch, aspen-birch-fir, and mixed conifer-deciduous stands does appear to follow the expected trend (Figure 16).

Relationships Among Structural Layers

Analyses of the same set of 277 releves were performed for each of three subcanopy structural layers in hopes of attaining a better understanding of the relationships among structural components. Because not all stands contain species in each structural layer, the total number of stands included in each of the analyses varied. Analyses were performed using two alternative measures of distance: standard distance, which emphasizes species presence; and absolute distance, which compensates for species dominance. Results of the two analyses varied somewhat, although certain clusters of stands were grouped as recurring units in both analyses. In the following discussion, the results of the most interpretable analyses were used for each structural layer. The number of stands and measure of distance used in each analysis are specified in the discussion of each stratum.

High Shrubs

The high shrub layer (Kuchler classes 3, 4, and 3-4, up to 5 m in height) is represented by 175 releves. Any stand containing shrub species or saplings of tree species in these height classes was included in the analysis. Stands rejected by the analysis because they had no members in these height classes fall mainly into the black spruce and mixed deciduous-coniferous canopy types.

In general, shrub groups identified by the analysis based on absolute distance are more mixed in species composition than those based on standard distance. Groups of stands that remain together in both analyses appear to be more faithful to canopy type as well, suggesting that they represent discrete shrub communities. Eighty-six stands are members of such groups. Unless otherwise stated, the following discussion of high shrub clusters is based on analysis using absolute distance. The use of this measure of distance results in clusters that differ not only in species composition but in shrub density. These differences are illustrated in Figure 17, which presents the average basal area of shrubs in each high shrub cluster, based on the density of shrubs in each of 14 diameter classes in the quantitatively sampled stands. Table 20 includes a complete list of stands and species determining each cluster.

Wetland communities fall into three major tall shrub clusters: HS-I, HS-VI, and HS-VII, distinguished by the presence of either speckled alder or wetland conifers in the shrub layer. Group HS-I is composed of 21 stands whose shrub layer is dominated by speckled alder. Average basal area of alder in stands of this cluster is over twice that of any other species in any other high shrub cluster (Figure 17). Three subgroups can be distinguished. Subgroup A includes both speckled alder and red osier dogwood, whereas species composition of the shrub layer in subgroup B is restricted to speckled alder. The third subgroup is distinguished by the presence of black ash along with alder.

Wetland conifers dominate the tall shrub layer of two groups. Members of the tamarack group (HS-VI) and the wetland black spruce group (HS-VII) exhibit a high fidelity to wetland conifer canopy types. Half the stands characterized by tamarack in the shrub layer are dominated by tamarack in the canopy, with the other half dominated by black spruce. Age relationships between the tamarack and spruce in the two layers were not determined. There is a significant correlation between spruce dominated shrub clusters (HS-VIIA) and the spruce canopy type.

Upland stands fall into eight major clusters. Clusters vary with respect to both species composition and shrub density.

Group HS-II is composed of 16 stands with very low coverage and basal area (Figur 17) and very few species of tall shrubs. Birch, green alder, and Bebb's willow define three subgroups. Stands in group HS-II are significantly related to the black spruce-jack pine cover type. Within this cover type, Ohmann and Ream (1971) also report a sparse shrub layer, but their stands differ from those in the study area because of the dominance of black spruce in their shrub layer.

Group III is characterized by the presence of fir in the tall shrub height classes. There does not appear to be any fidelity to canopy type within the group of stands in this cluster. Fir is the only constant species in the high shrub class of subgroup A, whereas in subgroup B red maple or birch are also present.

The fourth major high-shrub group is characterized by the constant presence of aspen with low coverage. None of the stands dominated by aspen regeneration in this height class is included in this shrub cluster, suggesting that it is the low coverage rather than the species composition that characterizes the group. Half the stands in this high shrub cluster belong to jack pine or red pine canopy types.

Shrub group V is probably the most important shrub group from a management perspective. The 26 stands in this cluster are dominated by hazel in the shrub layer. Subgroup A is characterized by high coverages of hazel (25 to 50 percent) with aspen or arrow-wood. Subgroup B contains alder and subgroup C is characterized by the presence of mountain maple. Quantitative data are available for six stands in shrub group V. Examination of the densiometer data reveals that the subgroup containing alder is significantly related to a more open canopy and the subgroup characterized by mountain maple is significantly related to shadier situations than the hazel cluster as a whole. The data appear to agree with trends in the BWCA, where mountain maple attains its greatest importance in the more shaded fir-birch and white cedar communities (Ohmann and Ream, 1971).

Stands with both black spruce and aspen present in the high shrub layer are clustered in group HS-VIII, which contains two subgroups (with and without fir). Stands in this cluster occur in both aspen-birch and jack pine canopy types but are absent from the mixed black spruce-jack pine type. The presence of spruce in the shrub layer of the jack pine community may represent an earlier phase in succession towards the mixed black spruce-jack pine type. In the absence of disturbance, Grigal and Ohmann (1975) suggest a successional trend from pure pine and deciduous types to forests dominated by spruce and fir. The concentration of stands with subcanopy spruce in the Kawishiwi watershed suggests that this successional trend may be more important there than elsewhere in the study area. The ability of spruce to outcompete deciduous elements on thinner soils may be an important factor controlling this successional trend.

Group HS-IX contains three anomalous stands with affinities for both the preceding and following clusters and no fidelity to any canopy type. The single stand of this cluster that was sampled quantitatively exhibited a high basal area of aspen in the shrub layer (Figure 17).

The remaining major shrub cluster (H-X) is characterized by stands with good coverage of mixed shrubs. Aspen, hazel, and juneberry are constant, with raspberry, Bebb's willow, chokecherry, and rose frequent. The cluster exhibits no fidelity to any given canopy type.

The relationships of the high shrub clusters to those identified in the analyses of the low shrub and herb layers are not as distinct as might be hoped. There is very little relationship between clusters identified on the low shrub and high shrub dendrograms. This situation may be an artifact of the fact that members of the two layers were defined not by species, as is the case in many other studies (Kurmis et al., 1978, 1979), but by height. Distinct relationships between species may, therefore, be obscured by "noise" in the clusters caused by the variability in height attained by individual members of those species. The only clear relationship among clusters in the high shrub and low shrub dendrograms is exhibited by seven of the twelve stands in high shrub group VI, with tamarack in the shrub layer. These stands are members of low shrub group IV, characterized by constant presence of leatherleaf.

There is a better relationship among clusters identified in the high shrub and herb analyses, especially in the case of wetland types. All but one member of the alder-red osier dogwood tall shrub group (HS-IA) are drawn from wetland herb groups H-I and HS-III. In both of these groups sedges (Carex spp.) are constant. All members of HS-IC are drawn from the nutrient-loving wetland herb group (H-I). This relationship between the two dendrograms is not surprising because HS-IC is characterized by the presence of black ash, which has ecological tolerances similar to those of the herbs. Eight of the seventeen spruce-dominated stands in HS-VIIA are drawn from wetland herb groups, whereas all stands in group HS-VI are drawn from herb group III, distinguished by the presence of a suite of acidophilous and ericaceous herb species.

Upland clusters do not relate as well to the herb analysis. Half of the 18 stands in group HS-VIII are drawn from herb group H-IV, located mainly in the northern part of the study area and characterized by low frequencies of spinulose wood fern (Dryopteris spinulosa) and blueberry (Vaccinium angustifolium). The remaining upland shrub groups draw stands from a mixture of herb clusters with no remarkable relationships.

Low Shrubs

Cluster analysis based on standard distance separates 221 releves into 10 major groups on the basis of woody species present in Kuchler height classes 1, 2, 1-2, and 2-3. Three of these groups are wetland clusters, which are clearly distinguished floristically and relate strongly to the black spruce, tamarack, cedar, and ash canopy types. Wetlands dominated by Labrador tea form a cluster (LS-I) of 17 stands clearly distinguished from those dominated by alder (LS-II) and leatherleaf (LS-III). The leatherleaf group contains a distinct subgroup of four stands chracterized by constant presence of Spiraea and located along the banks of streams. The remaining subgroups belong either to the black spruce or tamarack canopy types (subgroups B, D, and E) or could best be described as "low shrub bog" (Jeglum et al., 1974).

Upland low shrub groups are clustered into seven major types, noted in Table 21. Although the low shrub layer of group LS-IV is composed exclusively of black spruce or fir, stands assigned to this cluster are members of a variety of upland canopy types.

Four of the major groups(VI, VII, IX, and XI) are dominated by hazel in the low shrub layer. These groups include a total of 107 stands, 64 of which are classified by the canopy analysis as aspen-birch stands. Hazel appears to be most faithful to the aspen-birch overstory in those stands in which it grows in conjunction with mountain maple. Seventy-one percent of stands dominated by these two species in the low shrub layer are aspen-birch stands. The converse question is whether aspen-birch stands will predictably have hazel in the understory. Of 79 aspen-birch stands containing low shrubs, 63 (or 80 percent) belong to hazel-dominated low shrub clusters. Four of five stands in group LS-VIIA, aspen-birch low shrub layer with high frequencies of hazel and mountain maple, also belong to the aspen-birch canopy type. This group of 15 stands is defined as much by the absence of deciduous elements as by the presence of coniferous species in the low shrub layer. Although group LS-V is the only cluster defined by the exclusive presence of conifers in the low shrub layer, 58 stands contain either spruce or fir in that stratum. Of these stands, 21 are under aspen-birch canopies, 18 in mixed black spruce-jack pine, 5 in jack pine, 4 in red pine, and 2 in black spruce. These figures suggest that although there may be a fair fidelity of exclusively coniferous low shrub layers to conifer canopies, there is no fidelity of the individual species. It is actually more surprising that only 21 stands, or 27 percent, of all aspen-birch stands contain spruce and fir in the low shrub layer.

Comptonia peregrina is another shrub that might be expected to show high fidelity to certain canopy types. Only two of the low-shrub subgroups are distinguished by the constant presence of Comptonia. Five stands in the raspberry hazel group (LSVI-D) form the first group characterized by the presence of this shrub. Three of these five stands are of the mixed spruce-jack pine canopy type. The two stands of the aspen-birch canopy type, J06 and S21, both contain jack pine, white pine, and black spruce in their canopies. A group of eight stands in the aspen-birch low-shrub cluster (LS-VIIC) is distinguished by high frequencies of Comptonia. Comptonia is absent from stands J23 and S40. Stands S16 and C02 are the only stands of the group not belonging to the mixed spruce-jack pine cover type. Although both stands were clustered in the canopy analysis into the aspen-birch group, they both contain black spruce, jack pine, and white pine in the taller layers; it appears that although Comptonia is not faithful to cover type, it does co-occur with jack pine and black spruce. Although it appears at first that there is a strong relationship between the presence of Comptonia and white pine, this is not the case. Only one-third of all stands containing Comptonia contain white pine and less than one-fourth of all stands containing white pine contain Comptonia. Neither group characterized by the presence of Comptonia includes any stands logged since 1960.

Other species whose presence in the low-shrub layer might reflect recent logging are Populus tremuloides and Prunus species. No cluster is defined by the constant presence of Prunus pensylvanica, whereas Prunus virginiana is consistently present in groups VI-B and XI-A (Table 21). Of the 15 stands in which Prunus virginiana occurs consistently, only two have been logged in the last two decades. Quaking aspen occurs consistently in the low shrub layer of two clusters in the aspen-birch group, VI-A and VII-C (Table 21). Two of the five stands in the former group were logged since 1960, but none in the latter group were logged during that era.

Herbs

The cluster analysis accepted all 177 stands for consideration of herb species, defined as any species listed in the 1 and 1-2 Kuchler height classes (.5 m and less), with the addition of the following species from the D2-3 layer: Vaccinium angustifolium, Vaccinium myrtilloides, Gaultheria procumbens, Gaultheria hispidula, and Rubus pubescens. The resulting dendrogram is divided into 11 major groups with within-group dispersions greater than 50 percent. These groups are summarized in Table 22, and the distribution of their stands in the edaphic and climatic synecological fields is illustrated in Figure 18. Upland stands as a whole are separated from wetland stands by high frequencies of Cornus canadensis, Aster macrophyllus, Aralia nudicaulis, and Maianthemum canadense and by absence of high frequencies of Carex spp. and Smilacina trifolia. The four former species attain frequencies greater than 85 percent for upland sites.

Wetland communities exhibit a higher within-group dispersion than upland communities, with some dispersions approaching 100 percent. This high degree of heterogeneity seems remarkable in light of the fact that wetland communities exhibit the least heterogeneity in the canopy layer. The difference in within-group dispersion is undoubtedly accounted for by the higher species diversity of wetland herbs. Although only 8 canopy species are represented in wetland communities, 92 herb species are found in the 82 stands that are members of the wetland herb cluster.

The first major cluster is comprised of stands that may be defined as nutrient rich wetlands (H-I, Table 22). These stands are characterized by the constant presence of sedges (*Carex* spp.), along with high frequencies of species preferring nutrient-rich wetlands or moist forest situations. The first five stands form a subcluster defined by the presence of *Viola* and *Maianthemum canadense* in the herb layer. Stands in this subgroup differ from the remaining stands in the major cluster because they possess conifer canopies. The second and third subgroups are composed mainly of ash stands and alder carrs. The second group (H-IB) differs from the first five stands in the presence of *Lycopus* and absence of *Maianthemum*. The species composition is rich. Although two-thirds of these stands are on poorly drained soils, they are not subject to annual flooding as are the five ash stands in subgroup H-IC. These five stands are characterized by the presence of *Mentha arvensis* and *Aster puniceus*, with high frequencies of *Thalictrum* and lianas of the genera *Parthenocissus*, *Smilax*, and *Clematis*.

The second major herb cluster (H-II) consists mainly of stands that were excluded from the canopy dendrogram because they had no trees of the appropriate size. The group is defined by the consistent presence of *Calamagrostis canadensis* and *Scirpus cyperinus*. Jeglum *et al.* (1974) consider such sites as "meadows." Only four stands of the group are included in the low-shrub dendrogram, where they form a cluster characterized by the presence of *Spiraea alba*.

Fifty-three stands form the third major wetland herb cluster, characterized by the presence of a suite of wetland species tolerant of low-nutrient sites. Stands of this major group fall into nine subgroups. Subgroup III-A is differentiated by the presence of *Lycopus uniflorus, Aster puniceus, Dryopteris cristata,* and *Smilacina trifolia*. Subgroup B is characterized by the presence of *Maianthemum canadense, Cornus canadensis, Clintonia borealis*, and *Vaccinium angustifolium*. Both the preceding subgroups suggest drier conditions than subgroup C, distinguished by the presence of *Sphagnum, Vaccinum oxycoccos,* and *Sarracenia purpurea*. The remaining 39 stands clustered in group III of the herb analysis belong to subgroups D-I. The six subgroups differ in composition with respect to *Vaccinium oxycoccos, Gaultheria hispidula,* and the diversity of woodland species present. These differences may reflect differences in soil types, because all members of subgroup I occur on soil association 7 (Toivola-Cloquet), whereas all members of subgroup H occur on soil association 9 (Conic-Insula). Stands in the third major group exhibit a wider range of moisture coordinates than those in the two previous groups and generally lie lower in the range of nutrient values than stands in groups I and II (Figure 18).

The fourth major cluster, consisting of 54 stands (H-IV) may be thought of as the prototype of upland stands. No species is constantly present in all stands of this major group, but Cornus canadensis, Aster macrophyllus, Aralia nudicaulis, Maianthemum canadense, and Clintonia borealis are all present in 85 percent or more of the stands. The cluster is defined by the lowest frequencies of Vaccinium angustifolium and Dryopteris spinulosa. The influence of the more ubiquitous species in defining the cluster as a whole becomes more apparent when subgroups of the major group are compared. Stands R01-R31 (H-IVA) appear to be a damper facies of the group, with Viola, Streptopus, Anemone quinquefolia, and Coptis occurring more often than in the other subgroups. Petasites palmatus is also more frequent than in other subgroups but attains lower frequencies. Lycopodium annotinum, which prefers damper situations than some of the other lycopods, is more frequent in this group. Indicators of more disturbed or drier sites such as Pteridium, Lathyrus, and Fragaria occur only in low frequencies.

The second subgroup (H-IVB) appears to be a drier facies, with higher frequencies of Vaccinium myrtilloides, Fragaria spp., and Lycopodium clavatum than in the preceding subgroup. Pteridium aquilinum and Lathyrus venosus are most frequent in stands R03-R67. The higher frequencies of plants preferring drier situations in this subgroup is interesting in light of the fact that 8 of the stands belong to the mixed spruce-jack pine canopy type. The first group (H-IVA), with its more mesic species, contains no stands of this cover type (but does contain four spruce stands). Although the mixed coniferous cover type is generally fairly damp in the northeastern part of the study area, where all stands in both groups occur, the canopy analysis placed pine stands in this cover type wherever black spruce was also important in the canopy. The mixed cover type occurs most often in the portion of the study area where soils are thin and bedrock exposures are common. More xeric herbs occurring on convex slopes and edges of bedrock exposures may have an undue influence on the analysis.

A third subgroup of 15 stands (H-IVC) is distinguished from both earlier groups by lower frequencies of *Trientalis borealis*. Low frequencies of *Pteridium* and *Vaccinium myrtilloides* separate it from the second subgroup. *Fragaria* rises in frequency to 93 percent. This group is more similar to the first 14 stands (H-IVA) but differs from them because of its low frequencies of *Viola* species.

The fourth major group as a whole (H-IV) is almost evenly divided between aspen-birch and coniferous stands. Although Grigal (1968) did not find a close relationship between geographical proximity of stands and clusters generated from either soil or vegetation data, this cluster appears to be strongly related to geographical proximity, with all stands located in townships 61 and 62 north, ranges 10 and 11 west, and on soil association 9 (Conic-Insula). The close geographical proximity of stands in this group may account for the concentrated distribution of stands in the edaphic field (Figure 18).

The fifth major group of 10 stands (H-V) is characterized by constant presence of *Cornus canadensis* and the absence of *Aster macrophyllus* in 60 percent of the stands. *Vaccinium angustifolium* and *Dryopteris* spinulosa are both more frequent than in the previous group, whereas Pteridium and Lycopodium obscurum drop to low frequencies. Four species are altogether absent: Galium triflorum, Gaultheria procumbens, Mitella nuda, and Fragaria. All but one of these stands (R05) was classified in the field as either a mixed spruce-jack pine or black spruce canopy type. The general picture is one of a damp, shady, coniferous community. Ninety percent of stands in the group belong to the older logging eras (pre-1940) and all but two are of 41 to 70 percent crown closure. Logging history and crown closure may relate to the complete absence of weed species in all ten stands. This is the only major group that does not include at least a few occurrences of weeds. Stands in this group average the lowest number of species per stand (14).

The next major group of 14 stands (H-VI) appears to represent an herb community found on somewhat drier sites. Grass species and Pteridium are more frequent than in the immediately preceding group, whereas Coptis and Clintonia are less frequent. Maianthemum and Vaccinium angustifolium occur more frequently than Cornus canadensis and Aster macrophyllus. Two subgroups are distinguished: subgroup A by higher frequencies of Pteridium and Fragaria with Linnaea absent; subgroup B by constant presence of Gaultheria procumbens and frequent Apocynum androsaemifolium, Melampyrum lineare, and Habenaria spp. All stands in this group are on soil association 9 (Conic-Insula) and like groups IV and V are in close geographical proximity in the northeastern part of the study area.

The seventh major herb cluster (H-VIII) is distinguished by high frequencies of Linnaea borealis and much higher frequencies of Rubus pubescens than in the previous three groups. Anemone quinquefolia, Lycopodium obscurum, Lycopodium clavatum, Oryzopsis, and fir seedlings all occur more frequently than in the previous clusters. Frequencies of Pteridium are lower than in the previous groups.

Geographically, all stands in this major cluster lie north of the Laurentian Divide and two-thirds of them in the northeastern part of the study area (north of Birch Lake). Two matched pairs of quantitative study sites are members of this cluster. Plots G25 and G26 differ from the group as a whole because of their very high species diversity (53 species and 41 species, respectively). The average number of species per stand for the subgroup in which they occur (H-VIIA) is 26 species. The high species diversity of plots G25 and G26 arises from the extreme patchiness and micro-relief within the plots. Both plots contain some of the driest rock outcrops of the entire sample set. At the same time, presence of ravines and boulders provides habitats for wetland species and ferns. Neither plot would have been releved in its entirety in the 1972 or 1973 sample series because it would have been considered too heterogeneous. Despite the fact that the first is a recent clearcut (occupied by mature pine before the winter of 1972-73) and the other a pine plantation, their similarities in micro-relief and geographical proximity appear to override the treatment effect. Plots G14 and G15, both aspen stands on the north end of White Iron Lake, are clustered together within the second subgroup (A-VIIB).

The eighth major cluster (H-VIII) is characterized by the presence of a high proportion of weedy species. An average of 20 percent of all species are ruderals. The group has lower frequencies of Aralia nudicaulis, Maianthemum canadense, and Clintonia borealis than any other group. Two distinctive subsets contribute to the cluster. The first of these sets (10 stands, N21-N30) has fairly high frequencies of Linnaea borealis and Galium triflorum, with low frequencies of Pteridium and Aralia nudicaulis. Fourteen percent of all species in this set are favored by disturbance, and diversity averages 19 species per stand. The second subset of eight stands (H-VIIIB) exhibits higher presence values for Pteridium, Apocynum, Aster ciliolatus, and Aralia nudicaulis and a lower percentage of stands with Linnaea. An average of 37 percent of all species are weeds and there is an average diversity of 30 species per plot. This subset is composed entirely of recent clearcuts with no canopy development since cutting. The ability of the cluster analysis to identify clearcuts on the basis of the herbaceous layer alone is an interesting finding.

The first subset (H-VIIIA) of the eighth major group appears to represent an older successional stage of previously disturbed stands. The age of disturbance varies. Two of these stands (T04 and T13) originated after the Palo-Markham-Aurora fire. Field notes show that the remaining stands, all in the northeastern part of the study area, range in age from a 6-year-old wildfire and a 7-year-old plantation to two 58-year-old pine stands. Subsets within this subgroup do not relate to age of disturbance.

Stands G10-G36 (11 stands) comprise the ninth major group. A notable attribute of this cluster is the large number of species occurring in over 85 percent of the stands: Aster macrophyllus (100 percent), Aralia nudicaulis, Maianthemum canadense, Gramineae spp., Viola spp., Anemone quinquefolia (100 percent), Galium triflorum (100 percent), Dryopteris spinulosa, and Fragaria spp. (100 percent). The group has the highest average species diversity (40 species per stand), and is probably related to Curtis (1959) "northern mesic forest." Two species cited by Curtis as modal in that community attain their highest percent presence in this cluster (Actaea rubra and Claytonia caroliniana).

All these stands but one (G05) occur in the southern part of the study area in townships 57 and 58 north. Canopy type and cutting history appear to be less well related to the species assemblage than geographic location. Stands vary from mature birch (G42) and pine plantations (G30 and T32) originating after the Palo-Markham-Aurora fire to sapling aspens (G10).

Thirty stands characterized by constant presence of Aster macrophyllus and Aralia nudicaulis form the next major cluster (H-X). Only three species are present in over 85 percent of the stands. Thus, both the average number of species and their distribution throughout the group are reduced. Gaultheria procumbens is absent. High values of Pteridium aquilinum (77 percent) in this and the next group suggest canopy openings or recent logging. However, the greatest proportion of stands in the group are of medium crown closure and were logged before

1948. Ninety percent of these stands are of the aspen canopy type, and all but one (T10) occur in the northern half of the study area. Comparison of this group with the preceding group (H-IX) suggests that aspen-birch stands in the southern part of the study area have a higher species diversity and are more similar to each other in species composition than those in the northern portion. Despite these differences, the range of synecological coordinates of the two groups is similar (Figure 18).

The species composition of the last major cluster (H-XI) is mainly influenced by ubiquitous forest herbs. Only three species exceed 85 percent presence: *Aster macrophyllus*, *Rubus pubescens*, and *Maianthemum canadense*. Forest legumes and *Apocynum androsaemifolium* attain high frequencies along with *Fragaria* species, *Pteridium*, *Anemone quinquefolia*, and *Cornus canadensis*. Species diversity remains high throughout the group, with an average of 30 species per plot. Frequencies of weeds vary between subgroups of the cluster.

Three major subgroups are identified, with the second quite different from the first and third. The first and third subgroups are comprised for the most part of disturbed deciduous stands, with weedy species averaging 7 percent of all species in the first group and 14 percent in the second group. Although these clusters include stands from a wide range of geographic locations, the two clusters account for 4 of the 6 mixed deciduous stands in the central portion of the study area (T59 and T60 N, R12 and R13 W). This part of the study area was logged mainly in the late 1930s and early 1940s. Reforestation was sporadic and plantations were apparently not managed after planting.

The result is an area of highly variable, brushy upland vegetation in the 30 to 40-year age class. Stands N34, G05, G38, N24, T18, and G05 are representatives of this vegetation type. Stands T18 and G05 are clustered with the tenth and ninth major groups, respectively.

Nine stands (H-XIA, G07-T08) form the first subgroup of the last cluster (H-XI, 22 stands, G07-N34). This subset is characterized by higher presence values of Galium triflorum, Anemone quinquefolia, Rubus pubescens (100 percent), and woody seedlings than in the previous subgroup.

Both clearcuts harvested in the winter of 1976-77 (G37 and G40) are included in this group rather than the clearcut subset (8 stands, T20-T31) of cluster 5 (18 stands, N21-T31). A higher proportion of woody sprouts and lower number of disturbance species distinguishes these two most recent clearcuts from those that have had time to establish a weedy flora. Plot G37 is adjacent to G38, an aspen-birch-fir stand that is also a member of this cluster. Both clearcuts were aspen-birch stands before harvest. Only one stand, N39, is not of the aspen-birch canopy type; it is an unsuccessful jack pine plantation where aspen and birch overtop the pine. Only one member of this subgroup (T08) is anomalous, and it was apparently separated from the nearby G42, which is clustered with the ninth major group, because of a higher proportion of woody species in its ground layer. Stands in this group vary in geographic location from the northeast of the study area (T61 N, R9 W) to the extreme southwest (T57 N, R14W), with concomitant variations in soil type.

The third subset (H-XIC, T11-N34) is comprised of five subjectively dissimilar stands united by their common presence of Fragaria, higher proportion of weed species (average 14 percent), and low frequencies of Clintonia borealis, Aralia nudicaulis, and Vaccinium myrtilloides. The group is highly variable in canopy composition and geographic distribution.

The second subset (H-XIB) is a distinctive group of pine stands on well-drained soils. The cluster is characterized by high frequencies of Linnaea borealis, Viola spp., both Vaccinium species, Anemone quinquefolia (100 percent), Cornus canadensis (100 percent), and Rubus pubescens (100 percent). Weedy species are absent from all but one stand.

Pyrola species and Polygala pauciflora are more common than in the other subgroups. Three-fourths of the stands lie in the northern part of the study area, and one-fourth in the southern portion affected by the Palo-Markham-Aurora fire. The two stands whose origin postdates this fire (G24 and T26) are less mesic than the other pine stands in the southern part of the study area (G22, G23, G28, and G30). Three of these remaining pine stands were clustered with the ninth major cluster, and G28 was placed with wetland herbs because of its ericaceous component. Age and crown density vary within this subgroup.

Major clusters of the herb dendrogram appear to be controlled most by the presence or absence of various combinations of ubiquitous species. Only where a whole suite of new species influences the floristic composition are groups defined by less common taxa. An example is the subgroup of eight clearcuts in the "disturbed" cluster (H-VIII). In this case, occurrences of many different weedy species throughout the subgroup appear to separate it from the most similar subgroups.

Wetland stands appear to cluster well into groups related to canopy type. Upland clusters are more influenced by geographic location than canopy type. Only in the case of the tenth major group is the canopy dominated by one type. Here *Aster macrophyllus* and *Aralia nudicaulis* are both present throughout the group, and 90 percent of the sites are aspen stands. The opposite extreme is demonstrated by the fifth herb group where *Aster macrophyllus* frequencies are low and 80 percent of the stands are coniferous.

The best correspondences between crown density and herb clusters are found in those clusters defined by herb species related to open canopies. Herbs of wet meadows (H-II) and upland clearcuts (H-VIIIB) relate well to low crown densities. In the case of group II, this relationship is reflected by the higher light coordinates (Figure 18).

Relationships between the low-shrub dendrogram and herb dendrogram are better for wetland stands than for upland stands. There is a good relationship between large clusters of wetland herbs and wetland low shrub clusters. Although stands are not arranged in the same order, whole clusters of wetland low shrubs are composed of stands that fall mainly within the same herb cluster. Stands G48, G03, G43, and G46 remain together in both dendrograms. This is the largest set of stands that remain intact as a group in both dendrograms. Six of 17 stands in the Labrador tea-dominated shrub group (LS-I) are members of the first subgroup of "conifer bog" herbs (H-IIIA)(Table 22). All but one of the members of the "wet meadow" herb group (H-II) are either absent from the low-shrub dendrogram or occur in group III, Spiraea-dominated, comprised entirely of stands belonging to this herb group. Eighty-three percent of the stands in the ericaceous low shrub group (LS-IV) are members of the third major wetland group (H-III).

In the case of upland stands, major low-shrub groups mix stands from many herb clusters even within small clusters. Five of the 11 "mesic" herb stands (H-IX) contribute to the same subgroup (LS-VIB), of the low-shrub dendrogram. The eleventh herb group (Table 22) contributes 53 percent of the stands in this same low-shrub cluster, which is not surprising in the light of the high frequency of woody seedlings in the ground layer of this herb group. Stands contributing to low-shrub groups (LS-VIB)(Table 21) are derived from both deciduous and pine members of this last herb cluster. Five stands belonging to the dry facies of the fourth herb cluster contribute 31 percent of the stands in the low-shrub cluster (LS-VIII). Four of these five are coniferous stands. Five deciduous and two mixed coniferous stands from the herb group IV-B comprise one-third of the stands in low-shrub group LS-IX, the largest number of stands of any single herb group contributing to this cluster.

The highest proportion of stands of one herb type contributing to the hazel-mountain maple shrub group (LS-X) comes from herb group H-X. Along with the dry facies of herb group IV this herb cluster is an important component of the alder-hazel shrub cluster (LS-XI). All four members of the last herb type contributing to this shrub community are members of the pine subset.

Comparison With Communities in the Boundary Waters Canoe Area

Sixty-two stands for which quantitative data were available were compared with communities in the BWCA, using the methods of Grigal and Ohmann (1975). These methods use the frequency of selected species from all structural layers to generate discriminant functions that determine the assignment of each stand to a given community type. Analysis of the Regional Copper-Nickel Study data set required the deletion of 5 moss and lichen species from the list of 53 species used by Grigal and Ohmann (1975), because moss and lichen species were not consistently identified in the Regional Study's data set. The remaining set of 48 species, listed in Table 23, was used to recalculate discriminant functions for the BWCA.

Application of the corrected discriminant functions to the 62 study area stands assigns them to 9 of the original 13 upland forest communities recognized in the BWCA (Table 24). This assignment of stands based on discriminant analysis of species from all structural layers relates closely to the groups defined by the Regional Study's cluster analysis of the same 62 stands based on frequency of canopy species alone. Communities to which study area stands were assigned include the jack pine-fir, jack pine-oak, jack pine-black spruce, aspen-birch, maple-aspen-birch-fir, aspen-birch-white pine, black spruce-feathermoss, fir-birch, and white cedar communities. Communities identified by Grigal and Ohmann in the BWCA but missing from the study area sample include the lichen, red pine, maple-oak, and maple-aspen-birch communities. Within the study area, examples of the maple-aspen-birch community may be present along the crest of the Giant's Range, where the high proportion of maple in the canopy is noticeable in the autumn, but no stands of this type were sampled as part of this study.

Subsequent canonical analysis produces a series of ordinations of BWCA and study area stands along six abstract axes. The first two axes divide the canonical space into four quadrants. The upper right quadrant represents shade-tolerant conifers, the lower right quadrant pioneer (sunloving) conifers, the upper left quadrant pioneer broadleaf, and the lower left quadrant rock communities. Removal of the five moss and lichen species shifts the position of the BWCA communities as compared with the original analysis (Grigal and Ohmann, 1975). Broadleaf communities are shifted nearer the needleleaf end of the first axis and open communities nearer the shade-tolerant end of the second axis.

The positions of the BWCA and copper-nickel stands with respect to the first and second canonical axes are illustrated in Figures 19 and 20, respectively. Because the 48 species used in the analysis are upland species that are generally unimportant in wetlands, the assignment of study area wetland stands to BWCA upland community types was based on consideration of a small number of species such as violets, blueberries, cedar, black spruce, and willow. The picture of the distribution of upland forest communities in canonical space is only clouded by the inclusion of these wetland stands. For this reason, wetland stands other than cedar have been omitted from Figure 20. The upland types to which these stands were assigned by the discriminant analysis are included in Table 23.

Study area white cedar stands assigned to the upland white cedar type fall in the same quadrant as BWCA upland white cedar stands, but lie farther in the upper right hand corner. Had other wetland stands been included in Figure 20, they would fall at the extreme right hand end of the first axis, suggesting that the abstract axis might be related to the moisture gradient. If this relationship is the case, it is not reflected by the relationship of community centroids on the first axis to average community synecological coordinates (Table 25).

On the other hand, communities as distinguished by the Regional Study's cluster analysis do appear to represent a continuum of positions along a moisture gradient. The matrix of similarity coefficients (Table 2) reveals that the most dissimilar communities are the wettest (shrub carr and tamarack) and driest (jack pine and red pine) as shown by the distribution of these communities in the edaphic field. Shrub carr and tamarack communities, which have the highest synecological coordinates for moisture, are most dissimilar floristically from jack pine stands which have the lowest moisture coordinates. The ash, cedar, and spruce communities lie nearest tamarack and shrub carr in the edaphic field and appear to be most floristically similar to those communities. Aspen-birch and aspen-birch-fir have ranges of moisture coordinates that overlap the red pine community and are more floristically similar to red pine stands (Figure 15, Table 2).

These relationships are in general agreement with the results of ordinations of upland coniferous stands by Maycock and Curtis (1960), who used 72 species to ordinate stands along 3 axes on the basis of similarities and differences in species composition. They found that their primary axis was related to a moisture gradient and their secondary axis to a gradient in the coniferous or deciduous life form of the dominant tree species. They noted that their most floristically dissimilar stands were those at opposite ends of the moisture gradient.

Apparently, the use of frequency in the canonical analysis integrates a complex of variables resulting in axes that do not relate to single environmental factors, whereas the use of presence-absence data more clearly reflects single limiting variables. Because the vegetation of the community responds to a complex of variables, the canonical analysis using frequency may clarify similarities between communities that are not revealed by analyses that depend solely on floristic data (such as coefficients of similarity and synecological coordinates).

Although Regional Copper-Nickel Study stands that are assigned to each of the nine communities lie in roughly the same quadrants as Boundary Waters stands of the same communities, they are more widely scattered in canonical space (Figures 19 and 20). This pattern of scatter suggests that upland communities in the Copper-Nickel Study Area are more heterogeneous than those within the BWCA.

Discriminant analysis assigns 17 Copper-Nickel Study stands to an aspen-birch group that is scattered throughout and beyond the canonical space occupied by five separate BWCA communities (aspen-birch, aspen-birch-white pine, maple-aspen-birch, maple-aspen-birch-fir, and maple-oak). Stands included by the discriminant analysis in the aspen-birch group are drawn from both our mature aspen-birch and aspen-birch-fir communities. It appears that these two Copper-Nickel Study communities encompass the ecological range of five BWCA communities.

Grigal and Ohmann (1975) recognize three communities in which jack pine is a major component, the jack pine-oak, jack pine-fir, and jack pine-black spruce communities, whereas the Copper-Nickel Study recognizes only two (jack pine and black spruce-jack pine). The jack pine-black spruce community described by Grigal and Ohmann is very similar to the black spruce-jack pine community found on slopes in the Shallow Moraine Bedrock Province of the study area.

Stands that are classified by the Copper-Nickel Study analysis as jack pine stands are assigned by the discriminant analysis to BWCA jack pine communities. Three of the more open stands (G13, G25, and G28) are classified as members of the more open jack pine-oak community. Assignment of stand G26 to the jack pine-black spruce community is reasonable considering the inclusion of a pocket of spruce wetland within this predominantly rocky, dry jack pine plantation. The Regional study's cluster analysis based on canopy species also assigns this stand to the black spruce-jack pine community.

Comparison of the communities suggests that, of the upland community types recognized in both studies, the red pine community is the least similar. Discriminant analysis failed to assign any of the Copper-Nickel Study red pine stands to the BWCA red pine community. This failure to assign red pine stands the red pine community does not arise merely because the deletion of mosses and lichens from the diagnostic species list, because although mosses and lichens accounted for 35 percent of the groundcover in Grigal and Ohmann's original red pine community (Grigal and Ohmann, 1975), they average less than 3 percent in the Copper-Nickel Study red pine community. Species important in deciduous forests, such as aspen and large-leaved aster, are more important in Copper-Nickel Study red pine stands than in those of the BWCA.

Six of 8 young plantations (5-18 years old) were misclassified by the discriminant analysis. Such stands are difficult to classify by multivariate techniques that use canopy data because they have not yet developed a canopy of the species for which they are being managed. Uncut trees of the previous canopy type seriously affect the analysis. It is interesting that the disciminant analysis based on frequency of species from all structural layers found these stands as difficult to classify as did the cluster analysis based only on canopy species. Clearcuts and young plantations generally lie parallel and close to the first canonical axis.

Concluding statement

The purpose of this study was the characterization of vegetation communities within an area likely to bear the impact of mining for heavy metals. Potential impacts of such mining were not considered in the sample design and cannot be assessed directly from the data collected.

It is the author's opinion that the greater variability of communities in the vegetation study area, contrasted with the neighboring BWCA, reflects in greatest part the variable treatment history of the former area. The secondary impacts of a mining industry, such as development of power line and road rights of way and complete clearing of forested lands, have already been experienced within the study area. Although the vegetation cannot be considered "virgin", it exhibits a resilience in recovering from such disturbance because of the longstanding presence of pioneer species adapted to natural disturbances.

The options available for rejecting, accepting, or directing the development of a heavy-metal mining industry need to be considered more in the light of vegetational responses to direct impacts of the heavy metals themselves than in the light of secondary impacts similar to disturbances previously experienced in the area. These responses could best be understood by pursuing studies of community function in test areas where heavy metals are presently entering the ecosystem, rather than by a structural and floristic study such as the one reported here.

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Table 1. Locations of all releves used in the vegetation analysis.

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1972 Series	R01	SW1/4 S33,	T62N, R11W
	R02	NE1/4 SW/4 S33,	T62N, R11W
	R03	SW1/4 S34,	T62N, R11W
	R04	NE1/4 SW1/4 S34,	T62N, R11W
	R05	NE1/4 SW1/4 S34,	T62N, R11W
	R06	NE1/4 SW1/4 S31,	T62N, R11W
	R07	SW1/4 NW1/4 S34,	T62N, R11W
	R08	S34	T62N, R11W
	R09	S37,	T62N, R11W
	R10	border SS27 and 34,	T62N, R11W
	R11	NW1/4 NW1/4 S34,	T62N, R11W
	R12	NW1/4 S34,	T62N, R11W
	R13	border SS27 and 26,	T62N, R11W
	R14	SE1/4 S27,	T62N, R11W
	R15	NW1/4 NE1/4 S34,	T62N, R11W
	R16	NW1/4 NE1/4 S34,	T62N, R11W
	R17	NE1/4 SW1/4 S26,	T62N, R11W
	R18	SW1/4 NE1/4 S26,	T62N, R11W
	R19	SW1/4 NE1/4 S26,	T62N, R11W
	R20	center NE1/4 S26,	T62N, R11W
	R21	center W1/2 S26,	T62N, R11W
	R22	border SS26 and 27,	T62N, R11W
	R23	NW1/4 S25,	T62N, R11W
	R24	border SS24 and 25,	T62N, R11W

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1972 Series	R25	SE1/4,SW1/4 S24,	T62N, R11W
	R26	SE1/4 SW1/4 S24,	T62N, R11W
	R27	NW1/4 SE1/4 S24,	T62N, R11W
	R28	center E1/2 S24,	T62N, R11W
	R29	S1/2 NE1/4 S24,	T62N, R11W
	R30	border SS24 and 19,	T62N, RR11 and 10W
	R31	border SS24 and 19,	T62N, RR11 and 10W
	R32	center S19,	T62N, R10W
	R33	SE1/4 SE1/4 S19,	T62N, R10W
	R34	border SS19 and 20,	T62N, R10W
	R35	NW1/4 NW1/4 S29,	T62N, R10W
	R36	NW1/4 S29,	T62N, R10W
	R37	NW1/4 S29,	T62N, R10W
	R38	SE1/4 NW1/4 S29,	T62N, R10W
	R39	center NW1/4 S33,	T62N, R11W
	R40	NW1/4 NW1/4 S33,	T62N, R11W
	R41	NW1/4 SW1/4 S28,	T62N, R11W
	R42	SE1/4 SW1/4 S21,	T62N, R11W
	R43	SW1/4 NE1/4 S33,	T62N, R11W
	R44	NE1/4 NE1/4 S33,	T62N, R11W
	R45	NE1/4 NE1/4 S33,	T62N, R11W
	R46	border SS27 and 34,.	T62N, R11W
	R47	NW1/4 NE1/4 S34,	T62N, R11W
	R48	NE1/4 SE1/4 S33,	T62N, R11W

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1972 Series	R49	SW1/4 SW1/4 S20,	T62N, R10W
	R50	S20,	T62N, R10W
	R51	SW1/4 SW1/4 S17,	T62N, R10W
	R52	NE1/4 NE1/4 S19,	T62N, R10W
	R53	SE1/4 NW1/4 S26,	T62N, R11W
	R54	SW1/4 SW1/4 S23,	T62N, R11W
	R55	SW1/4 SW1/4 S23,	T62N, R11W
	R56	SE1/4 S33,	T62N, R11W
	R57	S34,	T62N, R11W
	R58	S27,	T62N, R11W
	R59	SE1/4 SW1/4 S24,	T62N, R11W
	R60	SE1/4 SW1/4 S24,	T62N, R11W
	R61	SE1/4 NE1/4 S24,	T62N, R11W
	R62	SE1/4 NE1/4 S19,	T62N, R11W
	R63	SW1/4 SE1/4 S33,	T62N, R11W
	R64	SE1/4 SW1/4 S33,	T62N, R11W
	R65	SE1/4 SE1/4 SW1/4 S33,	T62N, R11W
	R66	NE1/4 NE1/4 NW1/4 S04,	T62N, R11W
	R67	SW1/4 SW1/4 S33,	T62N, R11W
	R68	SE1/4 SE1/4 SE1/4 S32,	T62N, R11W
	R69	SE1/4 SE1/4 S32,	T62N, R11W
	R70	NW1/4 NE1/4 S04,	T62N, R11W
	R71	S04,	T62N, R11W
	R72	SE1/4 SE1/4 S33,	T62N, R11W

Table 1, continued

RELEVE NUMBER	TECHNICAL DESCRIPTION	
1972 Series R73	SE1/4 SE1/4 S33,	T62N, R11W
R74	S33,	T62N, R11W
R75	S04,	T62N, R11W
R76	SE1/4 SW1/4 S04,	T62N, R11W
R77	NW1/4 S09,	T62N, R11W
R78	NW1/4 S09,	T62N, R11W
R79	NW1/4 NW1/4 S09,	T62N, R11W
R80	SW1/4 NW1/4 S09,	T62N, R11W
R81	SE1/4 S32,	T61N, R11W
R82	S07,	T61N, R11W
R83	NE1/4 NE1/4 S07,	T61N, R11W
R84	SE1/4 S07,	T61N, R11W
R85	SE1/4 S07,	T61N, R11W
1972 Series S01	NE1/4 SW1/4 S18,	T61N, R10W
S02	N1/2. SW1/4 S18,	T61N, R10W
S03	NE1/4 SW1/4 SW1/4 S18,	T61N, R10W
S04	S1/2 NE1/4 SW1/4 S18,	T61N, R10W
S05	SW1/4 NE1/4 S19,	T61N, R10W
S06	W1/2 S08,	T61N, R10W
S07	NW1/4 NE1/4 NW1/4 S17,	T61N, R10W
S08	NE1/4 NW1/4 NW1/4 S17,	T61N, R10W
S09	N1/2 NW1/4 SW1/4 S08,	T61N, R10W
S10	NE1/4 NE1/4 S07,	T61N, R10W
S11	NE1/4 NE1/4 SW1/4 S07,	T61N, R10W

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1972 Series	S12	SE1/4 NW1/4 S18,	T61N, R10W
	S13	SE1/4 SW1/4 S12,	T61N, R11W
	S14	NW1/4 NW1/4 S13,	T61N, R11W
	S15	SE1/4 NE1/4 S13,	T61N, R11W
	S16	SE1/4 SE1/4 NE1/4 S13,	T61N, R11W
	S17	NW1/4 SE1/4 S01,	T61N, R11W
	S18	NW1/4 NE1/4 S01,	T61N, R11W
	S19	NW1/4 NE1/4 S01,	T61N, R11W
	S20	NW1/4 SE1/4 S01,	T61N, R11W
	S21	S1/2 SW1/4 SE1/4 S01,	T61N, R11W
	S22	W1/2 SW1/4 NW1/4 S07,	T61N, R10W
	S23	SW1/4 NW1/4 S07,	T61N, R10W
	S24	SW1/4 SW1/4 S07,	T61N, R10W
	S25	NE1/4 NW1/4 S13,	T61N, R10W
	S26	SE1/4 NW1/4 S14,	T61N, R11W
	S27	NE1/4 NW1/4 S14,	T61N, R11W
	S28	SW1/4 NW1/4 S14,	T61N, R11W
	S29	SE1/4 NW1/4 S14,	T61N, R11W
	S30	SW1/4 NW1/4 S14,	T61N, R11W
	S31	SW1/4 NW1/4 S14,	T61N, R11W
	S32	SW1/4 NW1/4 S14,	T61N, R11W
	S33	SW1/4 NW1/4 S14,	T61N, R11W
	S34	NE1/4 SW1/4 S14,	T61N, R11W
	S35	no releve	

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1972 Series	S36	NE1/4 NW1/4 S14,	T61N, R11W
	S37	center SW1/4 S23,	T62N, R11W
	S38	SW1/4 S23,	T62N, R11W
	S39	SE1/4 NW1/4 S23,	T62N, R11W
	S40	SE1/4 NW1/4 S23,	T62N, R11W
	S41	NW1/4 NE1/4 S23,	T62N, R11W
	S42	W1/2 NW1/4 S32,	T62N, R11W
	S43	NE1/4 NE1/4 S31,	T62N, R11W
	S44	NW1/4 NE1/4 S31,	T62N, R11W
	S45	NW1/4 S07,	T61N, R11W
	S46	N1/2 NW1/4 NW1/4 S07,	T61N, R11W
	S47	SW1/4 SW1/4 S06,	T61N, R11W
	S48	NW1/4 NW1/4 S18,	T61N, R11W
	S49	SE1/4 SW1/4 S30,	T61N, R11W
	S50	SW1/4 SE1/4 S11,	T60N, R12W
1972 Series	J01	SE1/4 NW1/4 S29,	T62N, R10W
	J02	center S03,	T61N, R11W
	J03	NE1/4 SE1/4 S03,	T61N, R11W
	J04	NW1/4 NE1/4 S10,	T61N, R11W
	J05	SE1/4 SE1/4 S3,	T61N, R11W
	J06	NE1/4 NW1/4 S11,	T61N, R11W
	J07	NE1/4 SE1/4 S11,	T61N, R11W
	J08	NW1/4 SE1/4 S11,	T61N, R11W
	J09	NE1/4 NW1/4 S14,	T61N, R11W

Table 1, continued

RELEVE NUMBER	TECHNICAL DESCRIPTION	
1972 Series J10	SW1/4 SW1/4 S11,	T61N, R11W
J11	SW1/4 NW1/4 S11,	T61N, R11W
J12	NW1/4 SW1/4 S12,	T61N, R11W
J13	NW1/4 NW1/4 S11,	T61N, R11W
J14	NE1/4 SE1/4 S03,	T61N, R11W
J15	SE1/4 NE1/4 S03,	T61N, R11W
J16	SE1/4 NW1/4 S14,	T61N, R11W
J17	SE1/4 NW1/4 S14,	T61N, R11W
J18	NE1/4 S27,	T62N, R11W
J19	SE1/4 NW1/4 S23,	T62N, R11W
J20	SW1/4 NE1/4 S23,	T62N, R11W
J21	SE1/4 NE1/4 S23,	T62N, R11W
J22	NW1/4 NW1/4 S19,	T61N, R11W
J23	NW1/4 NW1/4 S19,	T61N, R11W
1972 Series C01	NE1/4 NW1/4 S14,	T61N, R11W
C02	SE1/4 SE1/4 S03,	T61N, R12W
C03	SE1/4 SE1/4 S03,	T61N, R12W
C04	SE1/4 SE1/4 S03,	T61N, R12W
C05	SE1/4 SE1/4 S10,	T61N, R12W
C06	SE1/4 NE1/4 S24,	T62N, R11W
C07	SE1/4 NE1/4 S10,	T61N, R12W
C08	NW1/4 SE1/4 S13,	T61N, R12W
C09	NW1/4 SE1/4 S13,	T61N, R12W

Table 1, continued

RELEVE NUMBER	TECHNICAL DESCRIPTION	
1973 Series N01	NE1/4 SW1/4 S11,	T60N, R12W
N02	NE1/4 SW1/4 S11,	T60N, R12W
N03	SE1/4 NW1/4 S18,	T60N, R12W
N04	SW1/4 NE1/4 S01,	T59N, R12W
N05	SW1/4 NE1/4 S01,	T59N, R12W
N06	SW1/4 SW1/4 S10,	T59N, R12W
N07	NW1/4 NW1/4 S2,	T59N, R12W
N08	SW1/4 SE1/4 SW1/4 S36,	T60N, R12W
N09	SW1/4 SE1/4 SW1/4 S36,	T60N, R12W
N10	SW1/4 SE1/4 SW1/4 S36,	T60N, R12W
N11	E1/2 SE1/4 NE1/4 S26,	T60N, R12W
N12	NE1/4 SE1/4 NE1/4 S26,	T60N, R12W
N13	SW1/4 NE1/4 NE1/4 S26,	T60N, R12W
N14	NW1/4 NE1/4 NW1/4 S26,	T60N, R12W
N15	NE1/4 NE1/4 SW1/4 S25,	T60N, R12W
N16	W1/2 NW1/4 SE1/4 S25,	T60N, R12W
N17	SE1/4 SE1/4 NW1/4 S26,	T60N, R12W
N18	NW1/4 NE1/4 NE1/4 S26,	T60N, R12W
N19	no releve completed	
N20	NE1/4 SW1/4 NW1/4 S23,	T60N, R12W
N21	SW1/4 NE1/4 NE1/4 S22,	T60N, R12W
N22	E1/2 E1/2 SW1/4 SW1/4 S25,	T60N, R12W
N23	SW1/4 SW1/4 S25,	T60N, R12W

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1973 Series	N24	S1/2 NW1/4 SW1/4 S25,	T60N, R12W
	N25	SE1/4 NE1/4 SE1/4 S23,	T60N, R12W
	N26	NE1/4 SE1/4 SE1/4 S23,	T60N, R12W
	N27	W1/2 NW1/4 NE1/4 SE1/4 S23,	T60N, R12W
	N28	SW1/4 NE1/4 NE1/4 S26,	T60N, R12W
	N29	SE1/4 SW1/4 NW1/4 S23,	T60N, R12W
	N30	SE1/4 NE1/4 SE1/4 S24,	T60N, R12W
	N31	SE1/4 NW1/4 S24,	T60N, R12W
	N32	SE1/4 NW1/4 S25,	T60N, R12W
	N33	S26	T60N, R12W
	N34	W1/2 SW1/4 S10,	T59N, R12W
	N35	SW1/4 SW1/4 S14,	T60N, R12W
	N36	NE1/4 SE1/4 S14,	T60N, R12W
	N37	NW1/4 SE1/4 S18,	T59N, R12W
	N38	NE1/4 SW1/4 S12,	T58N, R13W
1975 Series	D01	SE1/4 S36,	T61N, R11W
	T01 (=G17)	NE1/4 SE1/4 S15,	T60N, R12W
	T02 (=G30)	SE1/4 NE1/4 S07,	T57N, R14W
	T03	NW1/4 SE1/4 S23,	T60N, R12W
	T04	NW1/4 SE1/4 S18,	T57N, R14W
	T05	SE1/4 NE1/4 S26,	T61N, R10W
	T06 (=G06)	SW1/4 SE1/4 S15,	T58N, R14W
	T07 (=G39)	NE1/4 NW1/4 S09,	T60N, R11W
	T08 (=G42)	SE1/4 SW1/4 S08,	T57N, R13W

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1975 Series	T09 (=G32,G47)	E1/2 SE1/4 S32,	T61N, R10W
	T10	SE1/4 SW1/4 S01,	T59N, R11W
	T11	SE1/4 SE1/4 S07,	T60N, R11W
	T12	NW1/4 SW1/4 S05,	T57N, R13W
	T13	SW1/4 NW1/4 S33,	T58N, R14W
	T14	SW1/4 SE1/4 S31,	T61N, R10W
	T15 (=G31)	NW1/4 SW1/4 S18,	T60N, R11W
	T16	NE1/4 NW1/4 S13,	T60N, R12W
	T17	SE1/4 NW1/4 S18,	T60N, R11W
	T18	NE1/4 SE1/4 S18,	T59N, R12W
	T19	SE1/4 SW1/4 S25,	T60N, R12W
	T20	SE1/4 NW1/4 S26,	T62N, R11W
	T21	NW1/4 SW1/4 NW1/4 S36,	T58N, R13W
	T22	SE1/4 SW1/4 SW1/4 S05,	T57N, R13W
	T23	no releve	
	T24 (=G18)	NE1/4 NW1/4 SW1/4 S08,	T57N, R13W
	T25	S1/2 SE1/4 NW1/4 S18,	T60N, R11W
	T26	S1/2 NW1/4 SW1/4 S33,	T58N, R14W
	T27	SW1/4 NE1/4 S12	T60N, R11W
	T28	N1/2 SE1/4 NE1/4 S31,	T61N, R10W
	T29	SW1/4 NE1/4 S29,	T61N, R10W
	T30	SW1/4 SE1/4 S10,	T58N, R13W
	T31	NE1/4 NE1/4 S17,	T61N, R09W
	T32	NW1/4 NW1/4 S05,	T57N, R14W

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1975 Series	T33	NW1/4 NW1/4 S06,	T59N, R10W
	T34	SE1/4 NW1/4 S17,	T60N, R11W
1976 Series	G01	SE1/4 NE1/4 S14,	T60N, R11W
	G02	NW1/4 SW1/4 S34,	T62N, R11W
	G03 (=T28)	NE1/4 NE1/4 S31,	T61N, R10W
	G04	NW1/4 SE1/4 S24,	T59N, R13W
	G05	SW1/4 SE1/4 S36,	T60N, R12W
	G06 (=T06)	NE1/4 SW1/4 S15,	T58N, R14W
	G07	NW1/4 S24,	T61N, R12W
	G08	SW1/4 NW1/4 S1,	T60N, R11W
	G09	SE1/4 NW1/4 S7,	T61N, R11W
	G10	NE1/4 NW1/4 S32,	T57N, R14W
	G11	NW1/4 NE1/4 S2,	T59N, R13W
	G12	SW1/4 SW1/4 S28,	T57N, R12W
	G13	NE1/4 SE1/4 S15,	T60N, R12W
	G14	NE1/4 SE1/4 S3,	T62N, R11W
	G15	SE1/4 S5,	T62N, R11W
	G16	SE1/4 SW1/4 S8,	T60N, R11W
	G17 (=T01)	NE1/4 NE1/4 S15,	T60N, R12W
	G18 (=T24)	NW1/4 NW1/4 S8,	T57N, R13W
	G19	SW1/4 NE1/4 S2,	T60N, R10W
	G20	SW1/4 NE1/4 S35,	T61N, R10W
	G21	SE1/4 SE1/4 S4,	T60N, R12W

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1976 Series	G22	SW1/4 SW1/4 S22,	T58N, R14W
	G23	SW1/4 NE1/4 S30,	T57N, R14W
	G24	NE1/4 NW1/4 S20,	T57N, R14W
	G25	S1/2 NE1/4 S13,	T61N, R11W
	G26	SE1/4 SW1/4 S7,	T61N, R10W
	G27	NW1/4 NW1/4 S20,	T60N, R11W
	G28	SW1/4 NW1/4 S27,	T58N, R13W
	G29	SW1/4 NW1/4 S36,	T58N, R13W
	G30 (=T02)	SE1/4 NE1/4 S7,	T57N, R14W
	G31 (=T15)	SE1/4 SW1/4 S12,	T60N, R12W
	G32 (=T09)	SE1/4 NE1/4 S32,	T61N, R10W
	G33	SE1/4 NE1/4 S32,	T61N, R10W
	G34	SE1/4 S19,	T57N, R14W
	G35	SW1/4 S18,	T57N, R12W
	G36	SE1/4 NE1/4 S32,	T58N, R14W
	G37	NE1/4 NE1/4 S16,	T59N, R12W
	G38	NW1/4 NW1/4 S15,	T59N, R12W
	G39 (=T07)	NE1/4 NW1/4 S09,	T60N, R11W
	G40	SW1/4 SE1/4 S29,	T57N, R14W
	G41	NW1/4 SW1/4 S20,	T57N, R14W
	G42 (=T08)	NE1/4 NW1/4 S17,	T57N, R13W
	G43	SE1/4 SW1/4 S2,	T60N, R12W
	G44	SE1/4 SE1/4 S29,	T60N, R12W

Table 1, continued

RELEVE NUMBER		TECHNICAL DESCRIPTION	
1976 Series	G45	NW1/4 SW1/4 S18,	T60N, R11W
	G46 (=T09)	E1/2 SE1/4 S3,	T60N, R12W
	G47	SE1/4 NE1/4 S32,	T61N, R10W
	G48	SE1/4 SE1/4 S31,	T57N, R13W

Table 2. Jaccard's coefficient of community between communities.

	Spruce	Tamarack	Cedar	Mixed Spruce Jack Pine	Jack Pine	Red Pine	Ash	Aspen-Birch	Aspen-Birch-Fir	Mixed Conifer-Deciduous	Shrub Carr
Spruce	1.000	.406	.418	.506	.356	.267	.328	.427	.454	.476	.311
Tamarack		1.000	.335	.243	.171	.222	.336	.227	.213	.229	.323
Cedar			1.000	.370	.255	.387	.373	.356	.404	.392	.344
Mixed Spruce Jack Pine				1.000	.307	.533	.314	.473	.494	.563	.320
Jack Pine					1.000	.407	.157	.371	.378	.352	.139
Red Pine						1.000	.318	.607	.635	.575	.306
Ash							1.000	.275	.281	.343	.437
Aspen-Birch								1.000	.590	.528	.220
Aspen-Birch-Fir									1.000	.569	.219
Mixed Conifer-Deciduous										1.000	.264
Shrub Carr											1.000

Table 3. Final community assignment of stands.

Stand Number	Community Type
R01	mixed conifer-deciduous
R02	mixed conifer-deciduous
R03	mixed conifer-deciduous
R04	jack pine
R05	aspen-birch-fir
R06	red pine
Ro7	black spruce-jack pine
R08	mixed conifer-deciduous
R09	black spruce
R10	omitted from analysis
R11	mixed conifer-deciduous
R12	black spruce
R13	aspen-birch
R14	aspen-birch
R15	aspen-birch
R16	jack pine
R17	mixed conifer-deciduous
R18	mixed conifer-deciduous
R19	black spruce
R20	black spruce
R21	aspen-birch
R22	aspen-birch
R23	aspen-birch
R24	jack pine
R25	black spruce-jackpine
R26	black spruce
R27	aspen-birch
R28	aspen-birch
R29	mixed conifer-deciduous
R30	mixed conifer-deciduous
R31	aspen-birch-fir
R32	jack pine
R33	black spruce
R34	aspen-birch
R35	mixed conifer-deciduous
R36	aspen-birch
R37	black spruce-jack pine
R38	mixed conifer-deciduous
R39	mixed conifer-deciduous
R40	aspen-birch

Table 3 -- continued

Stand Number	Community Type
R41	black spruce
R42	mixed conifer-deciduous
R43	mixed conifer-deciduous
R44	black spruce
R45	mixed conifer-deciduous
R46	aspen-birch
R47	mixed conifer-deciduous
R48	mixed conifer-deciduous
R49	black spruce
R50	black spruce
R51	black spruce-jack pine
R52	no relevé
R53	aspen-birch
R54	mixed conifer-deciduous
R55	ash
R56	black spruce
R57	black spruce
R58	shrub carr
R59	shrub carr
R60	black spruce
R61	shrub carr
R62	shrub carr
R63	mixed conifer-deciduous
R64	black spruce-jack pine
R65	mixed conifer-deciduous
R66	aspen-birch
R67	jack pine
R68	aspen-birch-fir
R69	ash
R70	mixed conifer-deciduous
R71	black spruce
R72	jack pine
R73	black spruce
R74	black spruce
R75	aspen-birch-fir
R76	black spruce
R77	mixed conifer-deciduous
R78	mixed conifer-deciduous
R79	mixed conifer-deciduous
R80	black spruce

Table 3 -- continued

Stand Number	Community Type
R81	ash
R82	aspen-birch-fir
R83	aspen-birch
R84	black spruce
R85	aspen-birch
J01	mixed conifer-deciduous
J02	mixed conifer-deciduous
J03	mixed conifer-deciduous
J04	mixed conifer-deciduous
J05	mixed conifer-deciduous
J06	mixed conifer-deciduous
J07	red pine
J08	mixed conifer-deciduous
J09	mixed conifer-deciduous
J10	mixed conifer-deciduous
J11	mixed conifer-deciduous
J12	shrub carr
J13	tamarack
J14	tamarack
J15	black spruce
J16	mixed conifer-deciduous
J17	mixed conifer-deciduous
J18	ash
J19	black spruce-jack pine
J20	ash
J21	ash
J22	aspen-birch-fir
J23	black spruce-jack pine
C01	mixed conifer-deciduous
C02	mixed conifer-deciduous
C03	jack pine
C04	black spruce
C05	black spruce
C06	mixed conifer-deciduous
C07	black spruce-jack pine
C08	aspen-birch
C09	aspen-birch
S01	mixed conifer-deciduous
S02	mixed conifer-deciduous
S03	mixed conifer-deciduous

Table 3 -- continued

Stand Number	Community Type
S04	black spruce
S05	mixed conifer-deciduous
S06	red pine
S07	black spruce
S08	aspen-birch
S09	aspen-birch
S10	mixed conifer-deciduous
S11	red pine
S12	tamarack
S13	black spruce
S14	jack pine
S15	black spruce-jack pine
S16	jack pine
S17	tamarack
S18	black spruce
S19	aspen-birch
S20	black spruce-jack pine
S21	mixed conifer-deciduous
S22	black spruce
S23	tamarack
S24	red pine
S25	jack pine
S26	black spruce
S27	shrub carr
S28	black spruce
S29	black spruce
S30	mixed conifer-deciduous
S31	mixed conifer-deciduous
S32	black spruce
S33	mixed conifer-deciduous
S34	black spruce-jack pine
S35	no relevé
S36	shrub carr
S37	aspen-birch
S38	mixed conifer-deciduous
S39	shrub carr
S40	black spruce-jack pine
S41	ash
S42	black spruce
S43	mixed conifer-deciduous

Table 3 -- continued

Stand Number	Community Type
S44	black spruce-jack pine
S45	aspen-birch
S46	black spruce
S47	aspen-birch
S48	mixed conifer-deciduous
S49	ash
S50	red pine
N01	black spruce-jack pine
N02	red pine
N03	ash
N04	red pine
N05	jack pine
N06	ash
N07	mixed conifer-deciduous
N08	aspen-birch-fir
N09	black spruce
N10	black spruce
N11	aspen-birch-fir
N12	jack pine
N13	black spruce
N14	black spruce-jack pine
N15	black spruce-jack pine
N16	black spruce-jack pine
N17	black spruce-jack pine
N18	red pine
N19	no relevé
N20	black spruce
N21	black spruce-jack pine
N22	black spruce
N23	black spruce-jack pine
N24	black spruce
N25	black spruce
N26	black spruce
N27	red pine
N28	black spruce
N29	black spruce
N30	red pine
N31	jack pine
N32	black spruce
N33	jack pine

Table 3 -- continued

Stand Number	Community Type
N34	aspen-birch-fir
N35	black spruce-jack pine
N36	jack pine
N37	aspen-birch
N38	aspen-birch
N39	aspen-birch-fir
N40	aspen-birch-fir
T01 = G17	no relevé (see G17)
D01	black spruce
T02 = G30	no relevé (see G30)
T03	red pine
T04	red pine
T05	black spruce
T06 = G06	no relevé (see G06)
T07 = G39	no relevé (see G39)
T08 = G42	no relevé (see G42)
T09 = G32, G47	no relevé (see G32 and G47)
T10	aspen-birch-fir
T11	aspen-birch
T12	aspen-birch
T13	aspen-birch
T14	tamarack
T15 = G31	no relevé (see G31)
T16	tamarack
T17	cedar
T18	aspen-birch-fir
T19	jack pine
T20	jack pine
T21	no relevé
T22	shrub carr
T23	no relevé
D24	shrub carr (omitted from analysis)
T24 = G24	shrub carr
T25	ash
T26	red pine
T27	aspen-birch
T28 = G03	black spruce
T29	aspen-birch
T30	black spruce
T31	omitted from analysis
T32	red pine

Table 3 -- continued

Stand Number	Community Type
T33	aspen-birch-fir
T34	red pine
G01	black spruce
G02	black spruce
G03 = T28	black spruce
G04	mixed conifer-deciduous
G05	aspen-birch-fir
G06 = T06	black spruce
G07	aspen-birch
G08	aspen-birch
G09	aspen-birch
G10	aspen-birch
G11	jack pine
G12	aspen-birch-fir
G13	jack pine
G14	aspen-birch-fir
G15	aspen-birch-fir
G16	jack pine
G17 = T01	jack pine
G18 = T24	shrub carr
G19	red pine
G20	red pine
G21	red pine
G22	red pine
G23	red pine
G24	red pine
G25	jack pine
G26	jack pine
G27	jack pine
G28	jack pine
G29	grassland
G30 = T02	jack pine
G31 = T15	tamarack
G32 = T09 (in part)	aspen-birch
G33	aspen-birch
G34	white spruce
G35	white spruce
G36	white spruce
G37	aspen-birch-fir

Table 3 -- continued

Stand Number	Community Type
G38	aspen-birch-fir
G39 = T07	aspen-birch
G40	aspen-birch
G41	aspen-birch-fir
G42 = T08	aspen-birch-fir
G43	cedar
G44	black spruce
G45	tamarack
G46	cedar
G47 = T09 (in part)	mixed conifer-deciduous
G48	shrub carr

Table 4. Timber information for mature and pole stands.

PLOT	COMMUNITY TYPE	AGE OF STAND (1977)	HEIGHT (m)	SITE INDEX	B.A. m^2/ha	VOLUME m^3/ha
G02	Black spruce	N.D.	8.9	N.D.	2.71	9.9
G03	Black spruce	85	12.0	28	22.8	112.7
G06	Black spruce	145	10.0	23	12.3	50.5
G44	Black spruce	55	9.9	29	19.7	80.3
T05	Black spruce	N.D.	10.4	N.D.	42.6	182.9
T30	Black spruce	N.D.	20.9	N.D.	40.0	342.9
G31	Tamarack	60	10.2	26	10.7	44.4
G45	Tamarack	N.D.	2.0	N.D.	N.D.	N.D.
G43	Cedar	75	12.2	29	33.6	168.7
G46	Cedar	N.D.	10.9	N.D.	36.9	165.9
G16	Jack pine	18	6.4	49	7.7	20.5
G17	Jack pine	62	15.3	43	33.8	212.0
G26	Jack pine	27	6.1	39	6.8	17.1
G27	Jack pine	91	22.6	64	28.9	450.9
G28	Jack pine	N.D.	3.0	N.D.	.09	.14
G30	Jack pine	40	15.7	60	35.5	228.6
G20	Red pine	29	10.6	51	21.3	92.7
G21	Red pine	58	22.0	63	38.0	342.2
G22	Red pine	N.D.	3.9	N.D.	.7	1.1
G23	Red pine	37	14.8	62	44.3	269.2
G24	Red pine	39	16.1	64	48.8	322.7
T03	Red pine	N.D.	19.9	N.D.	46.0	375.4
G08	Aspen-birch	N.D.	5.0	N.D.	N.D.	N.D.
G09	Aspen-birch	40	19.6	73	20.0	160.7
G32	Aspen-birch	29	14.2	67	17.6	102.8
G33	Aspen-birch	90	23.4	63	51.8	496.4
G39	Aspen-birch	65	15.7	45	20.6	132.5
T11	Aspen-birch	N.D.	20.8	N.D.	25.0	214.3
T13	Aspen-birch	N.D.	15.9	N.D.	14.0	91.4
T27	Aspen-birch	N.D.	17.4	N.D.	28.9	206.4
T29	Aspen-birch	N.D.	15.9	N.D.	15.1	99.65

Table 4 continued.

PLOT	COMMUNITY TYPE	AGE OF STAND (1977)	HEIGHT (m)	SITE INDEX	B.A. m^2/ha	VOLUME m^3/ha
G05	Aspen-birch-fir	N.D.	13.9	N.D.	7.2	41.1
G12	Aspen-birch-fir	55	14.5	46	15.4	91.5
G14	Aspen-birch-fir	60	17.2	52	13.5	95.3
G15	Aspen-birch-fir	55	19.8	62	29.0	235.2
G38	Aspen-birch-fir	50	22.2	70	29.6	269.3
G41	Aspen-birch-fir	39	12.2	57	19.2	96.4
G42	Aspen-birch-fir	34	14.6	60	20.2	120.9
T10	Aspen-birch-fir	N.D.	14.9	N.D.	24.1	147.8
T33	Aspen-birch-fir	N.D.	16.9	N.D.	27.6	191.6
G04	Mixed conifer-deciduous	N.D.	5.0	N.D.	8.5	17.4
G47	Mixed conifer-deciduous	28	11.4	52	13.3	62.5

Table 5. Leading families in community types, number of species represented.

FAMILY	COMMON NAME	BLACK SPRUCE BOG	TAMARACK BOG	CEDAR BOG	MIXED BLACK SPRUCE-JACK PINE	JACK PINE	RED PINE	ASH	MATURE ASPEN-BIRCH	ASPEN-BIRCH-FIR	MIXED CONIFER DECID-UOUS	SHRUB CARR
Aceraceae	Maple	2		1	2	3	2	3	2	2	3	
Apocynaceae	Dogbane	1			1	1	1		1	1	1	
Aquifoliaceae	Holly	1	1	2		1	1			1		1
Araceae	Arum		1	1				1				1
Araliaceae	Ginseng	2		2	2	2	2		2	2	3	
Aristolochiaceae	Wild Ginger									1		
Asclepiadaceae	Milkweed											
Balsaminaceae	Touch-me-not		1					1	1	1		
Betulaceae	Birch	5	3	4	5	7	4	4	4	4	4	3
Boraginaceae	Borage					3	2		2	2	2	
Campanulaceae	Bluebell	1	1	2					1			
Caprifoliaceae	Honeysuckle	5	3	6	7	8	10	2	7	9	9	3
Caryophyllaceae	Pink	2	1			2				2		2

Table 5, continued

FAMILY	COMMON NAME	BLACK SPRUCE BOG	TAMARACK BOG	CEDAR BOG	MIXED BLACK SPRUCE-JACK PINE	JACK PINE	RED PINE	ASH	MATURE ASPEN-BIRCH	ASPEN-BIRCH-FIR	MIXED CONIFER DECID-UOUS	SHRUB CARR
Chenopodiaceae	Lamb's Quarters								1	1		
Compositae	Daisy/Aster	14	5	11	9	25	24	7	11	17	10	9
Cornaceae	Dogwood	3	3	3	3	3	3	5	3	3	4	4
Cruciferae	Mustard											
Cyperaceae	Sedge	5	3	3	2	4	2	2	1	2	1	2
Droseraceae	Sundew	1		1								
Equisetaceae	Horsetail	4	1	2	1	1	1	3	1	2	1	1
Ericaceae	Heath	10	7	7	6	10	5	3	4	5	6	3
Fabaceae	Pea	4			3	6	5		5	4	2	
Fagaceae	Beech/Oak				1					2		
Fumariaceae	Fumitory				1	2			1	1	1	
Gentianaceae	Gentian	1	1			1			1		1	
Geraniaceae	Geranium					1	1		1	1		

Table 5, continued

FAMILY	COMMON NAME	BLACK SPRUCE BOG	TAMARACK BOG	CEDAR BOG	MIXED BLACK SPRUCE-JACK PINE	JACK PINE	RED PINE	ASH	MATURE ASPEN-BIRCH	ASPEN-BIRCH-FIR	MIXED CONIFER DECID-UOUS	SHRUB CARR
Grossulariaceae	Gooseberry	4	2	5	3	4	4	6	5	4	3	5
Guttiferae	St. Johnswort		1	1				1				2
Iridaceae	Iris	1	1	1				1		1	1	1
Juncaceae	Rush					2				1	1	
Labiatae	Mint	2		2	1	2	2	4	2	4		2
Liliaceae	Lily	5	3	4	4	5	6	6	7	6	6	2
Lycopodiaceae	Clubmoss	5	2	4	4	6	4	1	4	5	4	3
Myricaceae	Bayberry	1			1	1	1		1		1	1
Oleaceae	Olive			1	1			1		1	1	1
Onagraceae	Evening primrose	3	2	1	1	2	1		1	3	3	2
Ophioglossaceae	Adder's tongue			1			1			2		
Orchidaceae	Orchid	5		4	4	5	3		3	2	5	1
Osmundaceae	Royal fern	1	1	3		1	1	2	2	1	1	1

Table 5, continued

FAMILY	COMMON NAME	BLACK SPRUCE BOG	TAMARACK BOG	CEDAR BOG	MIXED BLACK SPRUCE-JACK PINE	JACK PINE	RED PINE	ASH	MATURE ASPEN-BIRCH	ASPEN-BIRCH-FIR	MIXED CONIFER DECID-UOUS	SHRUB CARR
Oxalidaceae	Sorrel					1						
Pinaceae	Pine	7	4	4	6	7	6	3	4	7	1	2
Plantaginaceae	Plantain						1			1		
Poaceae (Gramineae)	Grass	6		1	5	8	5	4	10	5	8	4
Polygalaceae	Milkwort				1	1	1		1	1	1	
Polygonaceae	Buckwheat	2			1	3	1		1	1	1	4
Polypodiaceae	Polypody fern	7	2	6	5	7	5	6	6	9	7	3
Portulacaceae	Purslane									1		
Primulaceae	Primrose	1	2	1	1	3	2	1	2	1	1	3
Pyrolaceae	Wintergreen	7	4	3	3	8	9		8	8	6	
Ranunculaceae	Buttercup	3	2	4	6	6	6	6	7	10	6	2
Rosaceae	Rose	13	8	8	11	18	14	10	12	11	13	5
Rubiaceae	Madder	3	2	4	1	3	2	3	3	3	1	4

Table 5, continued

FAMILY	COMMON NAME	BLACK SPRUCE BOG	TAMARACK BOG	CEDAR BOG	MIXED BLACK SPRUCE-JACK PINE	JACK PINE	JACK PINE	ASH	ASPEN-BIRCH	ASPEN-BIRCH-FIR	MIXED CONIFER DECID-UOUS	SHRUB CARR
Salicaceae	Willow	9	5	3	4	6	4	7	6	5	4	7
Santalaceae	Sandalwood	1				1					1	
Sarraceniaceae	Pitcher Plant	1	1									
Saxifragaceae	Saxifrage	1	1	1		1	1		1	1	1	
Scrophulariaceae	Figwort	2		2	1	3	2		1	2	1	
Solanaceae	Night shade						1					
Sphagnaceae	Sphagnum moss	1	1	1								
Taxaceae	Yew											
Tiliaceae	Basswood								1			
Typhaceae	Cattail							1			1	
Umbelliferae	Parsley					1	1	1	1	3	1	
Urticaceae	Nettle											
Verbenaceae	Vervain											

Table 5, continued

FAMILY	COMMON NAME	BLACK SPRUCE BOG	TAMARACK BOG	CEDAR BOG	MIXED BLACK SPRUCE-JACK PINE	JACK PINE	JACK PINE	ASH	MATURE ASPEN-BIRCH	ASPEN-BIRCH-FIR	MIXED CONIFER DECID-UOUS	SHRUB CARR
Vitaceae	Grape							1				
Violaceae	Violet	1	1	2	1	2	1	1	1	2	1	1
TOTAL NUMBER OF FAMILIES REPRESENTED IN COMMUNITY		41	32	37	34	44	37	29	43	48	41	35

Table 6. Community summary, black spruce

Number of releves: 53
Number of quantitative sample sites: 7
Species density: 19
Curtis Index of Homogeneity: .495
Number of prevalent modal species (*): 2
Average site index: 26

		HERB			LOW SHRUBS			HIGH SHRUBS				TREES			
Prevalent Species	Percent presence in releves	Percent presence	Average frequency	Average percent cover	Percent presence	Average frequency	Average density stems/ha	Percent presence	Average frequency	Average density stems/ha	Basal area m /ha	Percent presence	Average frequency	Average density stems/ha	Basal area m /ha
Picea mariana *	100.00				57.14	8.6	1700	100.00	32.1	175	1.77	100.00	88.5	3177	19.61
Ledum groenlandicum	79.25	85.71	26.6	.56	100.00	67.6	113100								
Carex spp.	73.58	100.00	58.0	9.46											
Gaultheria hispidula *	58.49	71.43	32.4	1.76											
Smilacina trifolia	54.72	100.00	44.7	2.11											
Chamaedaphne calyculata	52.83	28.57	9.6	.13	71.43	34.3	98400	14.29	.7	25					
Alnus rugosa	49.06				42.86	8.7	2300	57.14	19.3	2325	.530				
Cornus canadensis	47.17	71.43	31.57	2.01											
Sphagnum spp.	45.28	100.00	40.0	27.53											
Betula papyrifera	41.51											14.29	2.9	1.33	
Undifferentiated mosses	37.74	100.00	43.7	31.36											
Vaccinium oxycoccos	37.37	85.71	31.4	.79											
Vaccinium angustifolium	35.85	57.14	31.3	1.11	28.57	6.7	1.04								
Abies balsamea	32.08							28.57	2.1	50	.013	14.29	5.7	7.56	
Coptis trifolia	32.08	57.14	15.4	.46											
Kalmia polifolia	32.08	57.14	13.3	.04	57.14	23.7	2.99								
Vaccinium myrtilloides	30.19	71.43	12.29	.46	14.29	1.0	.03								
Larix laricina	30.19				14.29	1.0	.01	28.57	4.3	125	.02				
Clintonia borealis	30.19	14.29	3.9	.07											

Table 7. Percent of possible occurrences of indicator species (Heinselman, 1970) in each wetland community.

COMMUNITY	NUMBER OF STANDS IN SAMPLE	PERCENT OF POSSIBLE OMBROTROPHIC INDICATORS	PERCENT OF POSSIBLE WEAKLY MINEROTROPHIC INDICATORS	PERCENT OF POSSIBLE MINEROTROPHIC INDICATORS
Black spruce	54	47.64	11.81	19.50
Tamarack	11	58.33	44.44	13.76
Cedar	3	33.00	14.29	80.95
Ash	11	2.27	6.49	30.74
Shrub carr	13	7.14	5.95	17.06

Table 8. Community summary, Tamarack

Number of releves: 11
Number of quantitative sample sites: 5
Species density: 22
Curtis Index of Homogeneity: .633
Number of prevalent modal species (*): 17
Average site index: 26.6

Prevalent Species	Percent presence in releves	HERB Percent presence	HERB Average frequency	HERB Average percent cover	LOW SHRUBS Percent presence	LOW SHRUBS Average frequency	LOW SHRUBS Average density stems/ha	HIGH SHRUBS Percent presence	HIGH SHRUBS Average frequency	HIGH SHRUBS Average density stems/ha	HIGH SHRUBS Basal area m /ha	TREES Percent presence	TREES Average frequency	TREES Average density stems/ha	TREES Basal area m /ha
Carex spp. *	100.00	100.00	47.0	2.9											
Larix laricina *	100.00							100.00	35.0	1500	1.945	50.00	40.0	93	.64
Chamaedaphne calyculata *	88.89	100.00	50.0	2.8	100.00	93.5	363000								
Andromeda glaucophylla *	88.89				100.00	63.0	50000								
Ledum groenlandicum *	88.89	100.00	30.0	.5	100.00	56.5	127500								
Vaccinium oxycoccos *	88.89	100.00	67.0	.5											
Sphagnum spp. *	77.78		33.5	.3											
Betula pumila *	77.78	100.00	23.5	.4	100.00	93.5	66000	100.00	70.0	15825	.740				
Picea mariana	77.78				50.00	10.0	1500	50.00	5.0	325	.308				
Smilacina trifolia *	66.67	100.00	33.5	.7											
Salix pedicellaris *	66.67	50.00	3.5		50.00	10.0	9500	50.00	2.5	.75					
Sarracenia purpurea *	66.67	100.00	20.0	.6											
Kalmia polifolia *	66.67	50.00	6.5		50.00	3.5	500								
Alnus rugosa	55.56	50.00	10.0	.1	50.00	13.5	600	50.00	30.0	4000	.395				
Equisetum fluviatile *	55.56	100.00	53.5	2.4											
Salix spp. *	44.44				50.00	10.0	1500	50.00	2.5	75					
Potentilla palustris	44.44	100.00	10.0	.3											
Coptis trifolia **	33.33	50.00	20.0	1.5											
Rubus pubescens	22.22	50.00	20.0	.3											
Pleurozium schreberi *	22.22	Not differentiated													
Dryopteris cristata	22.22	50.00	3.5												
Rubus acaulis *	22.22	50.00	10.0	.3											

Table 9. Community summary, Cedar

Number of releves: 3
Number of quantitative sample sites: 3
Species density: 67
Curtis Index of Homogeneity: .743
Number of prevalent modal species: not calculated

Prevalent Species	Percent presence in releves	HERB			LOW SHRUBS			HIGH SHRUBS				TREES			
		Percent presence	Average frequency	Average percent cover	Percent presence	Average frequency	Average density stems/ha	Percent presence	Average frequency	Average density stems/ha	Basal area m /ha	Percent presence	Average frequency	Average density stems/ha	Basal area m /ha
Thuja occidentalis	100.00				66.7	15.7	4700	66.7	5.0	250	.03	100.00	100.0	1134.67	26.46
Abies balsamea	100.00				66.7	18.0	2000	100.00	18.3	1050	.67	100.00	80.0	160	1.65
Ledum groenlandicum	100.00	100.00	31.0	0.97	100.00	58.0	51700	33.3	1.7	50	0.00				
Alnus rugosa	100.00				66.67	26.7	4700	66.7	46.7	8175	1.62				
Carex spp.	100.00	100.00	69.9	19.7											
Gymnocarpium dryopteris	100.00														
Picea mariana	100.00											100.00	66.7	156.89	3.50
Ribes glandulosum	100.00														
Rubus pubescens	100.00	100.00	71.3	3.13											
Fraxinus nigra	100.00							66.7	5.0	200	.04	66.7	40.0	23.56	.063
Lycopus uniflorus	100.00	66.7	17.7	.17											
Linnaea borealis	100.00	100.00	42.0	.43											
Clintonia borealis	100.00	66.67	15.7	.57											
Coptis trifolia	100.00	100.00	29.0	.33											
Mitella nuda	100.00	66.67	26.7	.07											
Sorbus americana	100.00														
Cornus canadensis	100.00	100.00	57.7	1.40											
Vaccinium angustifolium	100.00	66.67	9.0	.10											
Trientalis borealis	100.00	100.00	42.3	.27											
Lonicera canadensis	100.00														
Maianthemum canadense	100.00	100.00	22.33	.07											
Cornus stolonifera	100.00				66.7	4.7	1000	33.3	6.70	375	.01				
Gaultheria hispidula	100.00	33.3	9.0	.03											
Galium triflorum	100.00	100.00	18.0	.07											
Amelanchier spp.	100.00														
Sphagnum spp.	66.67	100.00	27.0	7.43											
Smilacina trifolia	66.67	100.00	40.0	1.23											
Lonicera villosa	66.67				66.67	4.7	700								
Dryopteris cristata	66.67	66.67	15.7	.20											
Viola spp.	66.67	100.00	40.0	.23											
Undifferentiated mosses	66.67	100.00	51.0	16.10											
Athyrium Filix-femina	66.67														
Anemone quinquefolia	66.67	66.67	6.7	0.00											
Vaccinium myrtilloides	66.67	66.67	9.0	.07											
Vaccinium oxycoccos	66.67	66.67	22.0	.03											
Lonicera hirsuta	66.67														
Dicranum spp.	66.67														
Lycopodium annotinum	66.67	66.67	4.7	1.37											
Equisetum sylvaticum	66.67														
Habenaria hyperborea	66.67														
Salix bebbiana	66.67														
Caltha palustris	66.67														
Ribes triste	66.67														
Rosa acicularis	66.67														
Rubus idaeus	66.67														
Spiraea alba	66.67														
Ilex verticellata	66.67							66.7	3.3	125	0.00				
Acer spicatum	66.67														
Aralia nudicaulis	66.67	66.7	13.3	.13											
Cornus rugosa	66.67														
Aster puniceus	66.67														
Aster umbellatus	66.67														
Eupatorium maculatum	66.67														
Pleurozium schreberi	66.67														
Dryopteris spinulosa	66.67	66.67	4.7	.13											

Table 10. Community summary, Black ash

Number of releves: 11
Number of quantitative study sites: 0
Species density: 24
Curtis Index of Homogeneity: .50
Number of prevalent modal species (*): 5

Prevalent Species	Percent presence in releves	Average cover abundance	Structural layers in which the species is present			
			groundlayer	low shrub	high shrub-sapling	canopy
Fraxinus nigra *	100.00	6-25				
Alnus rugosa *	90.91	6-25	+	+	+	+
Carex spp.	81.82	6-25	+	+	+	
Aster puniceus *	63.64	6-25	+			
Rubus pubescens	54.55	6-25	+			
Viola spp. *	54.55	6-25	+			
Abies balsamea	54.55	1-5	+	+		+
Calamagrostis sp.	45.45	6-25	+			
Mentha arvensis *	45.45	6-25	+			
Thuja occidentalis *	45.45	1-5	+	+	+	+
Lycopus uniflorus	45.45	25-50	+			
Thalictrum dioicum *	45.45	6-25	+			
Maianthemum canadense	45.45	1-5	+			
Acer saccharinum *	36.36	6-25	+	+	+	+
Onoclea sensibilis *	36.36	6-25	+			
Galium triflorum	36.36	6-25	+			
Dryopteris cristata	36.36	1-5	+			
Caltha palustris *	36.36	6-25	+			
Iris versicolor *	36.36	6-25	+			
Rubus idaeus	27.27	6-25	+	+		
Gymnocarpium dryopteris	27.27	6-25	+			
Spiraea alba	27.27	6-25	+	+		

Table 11. Community summary, Alder carr

Number of releves: 12
Number of quantitative sample sites: 2
Species density: 20
Curtis Index of Homogeneity: .466
Number of prevalent modal species (*): 11

Prevalent Species	Percent presence in releves	HERB Percent presence	HERB Average frequency	HERB Average percent cover	LOW SHRUBS Percent presence	LOW SHRUBS Average frequency	LOW SHRUBS Average density stems/ha	HIGH SHRUBS Percent presence	HIGH SHRUBS Average frequency	HIGH SHRUBS Average density stems/ha	HIGH SHRUBS Basal area m /ha	TREES Percent presence	TREES Average frequency	TREES Average density stems/ha	TREES Basal area m /ha
Carex app.	91.67	50.00	26.5	2.65											
Hypericum spp.	75.00 *	50.00	3.5	.10											
Calamagrostis spp.	66.67 *														
Alnus rugosa	58.33	50.00	16.5	.95				100.00	100.0	6612.5	9.315				
Spiraea alba	58.33 *														
Lycopus uniflorus	58.33 *	100.00	66.5	2.2											
Potentella palustris	50.00 *														
Scirpus spp.	50.00 *														
Galium triflorum	50.00	50.00	16.5	0.00											
Rubus idaeus v. strigosus	41.67	50.00	6.5	.35	100.00	26.5	.90								
Dryopteris cristata	41.67 *	100.00	36.5	.65											
Chamaedaphne calyculata	33.33														
Cornus stolonifera	33.33 *				100.00	7.0	.3	100.00	12.5	57.5	.038				
Viola spp.	33.33	100.00	83.5	1.35											
Campanula aparinoides	33.33 *														
Dryopteris spinulosa	33.33	50.00	13.5	.20											
Iris versicolor	33.33	50.00	6.5	.50											
Rumex crispus	33.33 *	50.00	3.5	.10											
Ilex verticillata	25.00														
Salix discolor	25.00 *														

Table 12. Community summary, Black spruce - jack pine

Number of releves: 21
Number of quantitative study sites: 0
Species density: 26
Curtis Index of Homogeneity: .61
Number of prevalent modal species (*): 4

Prevalent Species	Percent presence in releves	Average cover abundance	Structural layers in which the species is present: groundlayer	low shrub	high shrub-sapling	canopy
Picea mariana	95.24	6-25	+	+	+	+
Pinus banksiana *	95.24	1-5	+	+	+	+
Vaccinium angustifolium *	90.48	6-25	+	+		
Cornus canadensis	80.95	6-25	+			
Aster macrophyllus	76.19	1-5	+			
Aralia nudicaulis	76.19	1-5	+			
Maianthemum canadense	76.19	1-5	+			
Abies balsamea	66.67	1-5	+	+	+	+
Linnaea borealis	66.67	6-25	+			
Amelanchier spp.	66.67	1-5	+	+	+	
Clintonia borealis	66.67	1-5	+			
Betula papyrifera	61.90	6-25	+	+	+	+
Rosa acicularis	61.90	1-5	+	+	+	
Fragaria spp.	57.14	1-5	+			
Ledum groenlandicum	57.14	6-25	+	+		
Diervilla lonicera	57.14	1-5	+	+		
Gramineae	52.38	1-5	+			
Moss	47.62	26-50	+			
Corylus cornuta	47.62	6-25	+	+	+	
Oryzopsis asperifolia	47.62	1-5	+	+	+	
Sorbus americana	47.62	1-5	+	+	+	
Lycopodium annotinum *	38.10	6-25	+			
Lycopodium obscurum	38.10	6-25	+			
Trientalis borealis	38.10	1-5	+			
Coptis groenlandica **	33.33	1-5	+			
Salix bebbiana	33.33	6-25	+	+	+	

Table 13. Community summary, Jack pine

Number of releves: 21
Number of quantitative sample sites: 9
Species density: 37
Curtis Index of Homogeneity: .608
Number of prevalent modal species (*): 8
Average site index: 61

		HERB			LOW SHRUBS			HIGH SHRUBS				TREES			
Prevalent Species	Percent presence in releves	Percent presence	Average frequency	Average percent cover	Percent presence	Average frequency	Average density stems/ha	Percent presence	Average frequency	Average density stems/ha	Basal area m /ha	Percent presence	Average frequency	Average density stems/ha	Basal area m /ha
Aster macrophyllus	96.53	88.93	60.0	13.18											
Cornus canadensis	93.10	100.00	47.6	1.52											
Vaccinium angustifolium	86.21	77.80	33.4	3.64	11.10	.80	.16								
Fragaria virginiana *	86.21	100.00	49.7	1.94											
Pinus banksiana	82.76				22.2	2.2	.03	44.4	15.6	1050.0	.905	77.8	60.0	626.7	21.15
Maianthemum canadense	79.21	100.00	48.8	.82											
Corylus cornuta	75.86				77.80	23.8	1.34	77.8	27.8	6100.0	.420				
Amelanchier spp. *	75.86	11.10	1.4	.09	66.70	9.6	.39	55.6	6.7	950.0	.145				
Aralia nudicaulis	75.86	100.00	23.8	1.17											
Vaccinium myrtilloides	72.41	77.80	24.4	2.06											
Diervilla lonicera	72.41	44.40	.9	.50	88.90	30.4	.06								
Rubus pubescens	68.97	100.00	43.8	3.38											
Populus tremuloides	68.97				22.22	3.8	.06	44.4	11.1	1525.0	.098	33.3	6.7	4.0	.072
Clintonia borealis	65.52	66.70	12.7	.30											
Anemone quinquefolia	65.52	100.00	40.7	.58											
Oryzopsis spp.	62.07	66.70	19.3	.83											
Rosa acicularis	62.07	44.40	6.0	.08	88.90	16.4	.34	44.4	2.2	500.0					
Gramineae	58.62	100.00	55.4	4.79											
Salix bebbiana *	58.62				33.30	4.4	.07	44.4	8.9	550.0	.088				
Picea mariana	55.17				11.10	2.2	.02	55.6	2.8	100.0	.055	22.2	8.9	9.3	.335
Betula papyrifera	55.17				11.10	1.4	.10					44.4	17.8	13.8	3.5
Pteridium aquilinum	55.12	33.30	5.9	.04											
Apocynum androsaemifolium *	55.12	55.60	9.8	.78											
Linnaea borealis	51.72	55.60	14.8	.51											
Alnus crispa *	51.72	11.10	.80	.03	22.20	2.2	.23	55.6	11.7	2650.0	.010				
Viola spp.	48.28	77.80	20.8	.18											
Trientalis borealis	48.28	55.60	8.9	.06											
Sorbus americana	48.28	11.10	.80	.00	22.20	2.2	.16	11.1	1.1	125.0	.010				
Ledum groenlandicum	44.83	33.30	3.8	.22	44.40	9.7	1.28								
Anaphalis margaritacea *	44.83	55.60	3.9	.03											
Lycopodium obscurum	44.83	55.60	8.2	.51											
Rubus idaeus	41.38	55.60	14.0	.30	88.90	18.7	.67								
Moss	41.38	100.00	29.0	6.28											
Carex spp.	37.93	55.60	8.8	.20											
Aster ciliolatus	37.93	66.70	17.7	.34											
Comptonia peregrina *	37.93	11.10	.8	.07	11.10	1.4	.04								
Dryopteris spinulosa *	37.93	33.30	3.0	.06											
Prunus virginiana	34.48				44.40	3.8	.08	33.3	2.8	275	.040				

Table 14. Community summary, Red pine

Number of releves: 22
Number of quantitative sample sites: 11
Species density: 38
Curtis Index of Homogeneity: .64
Number of prevalent modal species (*): 17
Average site index: 63

Prevalent Species	Percent presence in releves	HERB Percent presence	HERB Average frequency	HERB Average percent cover	LOW SHRUBS Percent presence	LOW SHRUBS Average frequency	LOW SHRUBS Average density stems/ha	HIGH SHRUBS Percent presence	HIGH SHRUBS Average frequency	HIGH SHRUBS Average density stems/ha	HIGH SHRUBS Basal area m /ha	TREES Percent presence	TREES Average frequency	TREES Average density stems/ha	TREES Basal area m /ha
Cornus canadensis *	100.00	100.00	40.7	.83											
Aster macrophyllus	95.45	100.00	91.0	22.52											
Pinus resinosa *	90.91							36.36	3.6	75.0	.073	90.90	78.2	1212.0	33.2
Malanthemum canadense *	90.91	100.00	52.2	1.03											
Rosa acicularis *	86.36	75.45	4.9	.09	72.73	23.8	.43	27.27	2.7	75.0	.003				
Fragaria virginiana	81.82	100.00	51.0	1.54											
Corylus cornuta	77.27	18.18	1.3	.01	45.45	14.6	.35	72.73	21.8	392.5	.253				
Diervilla lonicera *	77.27	63.64	10.8	.06	81.82	40.7	2.13								
Rubus pubescens *	77.27	100.00	37.5	2.05											
Aralia nudicaulis	77.27	63.64	21.9	2.28											
Betula papyrifera	72.73							18.18	2.3	75.0	.113	45.45	25.45	24.89	.18
Vaccinium myrtilloides *	72.73	54.55	5.5	.13	27.27	1.9	.12								
Vaccinium angustifolium	72.73	72.73	10.9	.27	9.09	1.2	.15								
Anemone quinquefolia *	72.73	81.82	25.6	.31											
Linnaea borealis	72.73	45.45	9.6	.15											
Populus tremuloides	68.18				36.36	6.1	.09	54.55	11.8	725.0	.385	72.73	45.45	166.67	1.5
Amelanchier spp.	68.18	9.09	.60	0.00	45.45	6.7	.15	36.36	9.1	725.0	.045				
Oryzopsis spp. *	68.18	36.36	13.4	1.05											
Rubus idaeus v. strigosus *	63.64	54.55	9.1	.17	63.64	22.4	.92								
Trientalis borealis	63.64	100.00	9.9	.05											
Picea mariana	59.09														
Abies balsamea	59.09				18.18	2.45	.03	18.18	2.3	100.0	.048				.4
Salix bebbiana	54.55				9.09	.06	.01	36.36	4.1	225.0	.030				
Galium triflorum	54.55	54.55	6.2	.02											
Viola spp. *	54.55	54.55	9.1	.05											
Pinus banksiana	50.00	18.18	3.1	.04	9.09	.60	.01	9.09	1.4	25.0	.060	18.18	9.1	33.33	.6
Pteridium aquilinum	50.00	63.64	24.3	2.54											
Lycopodium obscurum	50.00	27.27	5.5	.05											
Epilobium angustifolium *	45.45	18.18	1.3	.02											
Vicia americana *	45.45	45.45	9.2	.07											
Apocynum androsaemifolium	45.45	36.36	9.2	.23											
Aster ciliolatus *	45.45	72.73	21.8	.41											
Prunus virginiana *	45.45				45.45	4.3	.15	36.36	4.5	500.0	.063				
Clintonia borealis	40.91	45.45	5.5	.08											
Melampyrum lineare *	40.91	27.27	3.6	.02											
Streptopus roseus	36.36	45.45	6.1	.09											
Lonicera canadensis	36.36	9.09	.60	0.00	45.45	5.5	.19	36.36	2.3	125.0	.003				
Viburnum rafinesquianum *	36.36				18.18	1.3	.02								

Table 15. Reassignment of anomalous stands to appropriate communities.

STAND NUMBER	ASSIGNED COMMUNITY TYPE
G01	Black spruce
N05	Jack pine
G13	Jack pine
G08	Aspen-birch
T19	Jack pine
G29	Grassland
N37	Aspen-birch
T11	Aspen-birch
T18	Aspen-birch-fir
S06	Red pine
G18	Shrub carr
T20	Jack pine
S16	Jack pine
G40	Aspen-birch
S37	Aspen-birch
G35	White spruce

Table 16. Importance of conifer species.

SPECIES	ASPEN-BIRCH % Presence	ASPEN-BIRCH Basal Area	ASPEN-BIRCH Relative Density	ASPEN-BIRCH-FIR % Presence	ASPEN-BIRCH-FIR Basal Area	ASPEN-BIRCH-FIR Relative Density
Balsam fir	42.31	.019	.1	95.45	1.22	11.9
Black spruce	26.92	.034	.1	27.27	.015	.3
Jack pine	19.23	.277	1.4	18.18	.361	3.6
Red pine	3.8	.123	.1	9.06	.300	.7
White pine	3.8	.214	.5	18.18	NO QUANTITATIVE DATA	
White spruce	7.69	.013	.1	27.27	.028	.4

SPECIES	MIXED CONIFER-DECIDUOUS % Presence	MIXED CONIFER-DECIDUOUS Basal Area	MIXED CONIFER-DECIDUOUS Relative Density	BWCA ASPEN-BIRCH % Presence	BWCA ASPEN-BIRCH Basal Area	BWCA ASPEN-BIRCH Relative Density
Balsam fir	81.43	.153	20.2	69.2	1.24	11.5
Black spruce	94.44	.565	3.1	69.2	.71	4.7
Jack pine	62.96	NO QUANTITATIVE DATA		53.8	2.16	4.8
Red pine	16.66			23.1	.36	.2
White pine	26.63			30.8	1.40	3.0
White spruce	5.55			61.5	.76	3.4

SPECIES	BWCA FIR-BIRCH % Presence	BWCA FIR-BIRCH Basal Area	BWCA FIR-BIRCH Relative Density	BWCA BUDWORM-DAMAGED % Presence	BWCA BUDWORM-DAMAGED Basal Area	BWCA BUDWORM-DAMAGED Relative Density
Balsam fir	100.0	5.98	43.8	90.0	1.38	20.7
Black spruce	87.5	2.13	8.6	80.0	4.05	21.6
Jack pine	12.5	.09	.1	60	2.99	7.4
Red pine				10.0	.23	.1
White pine	12.5	.14	.5	20.0	.16	.3
White spruce	87.5	1.04	2.9	80.0	1.29	4.6

Basal area is expressed in m^2/ha. Data for the BWCA (Ohmann and Ream, 1971) have been converted from ft^2/acre.

Table 17. Community summary, Aspen-birch

Number of releves: 26
Number of quantitative sample sites: 11
Species density: 34
Curtis Index of Homogeneity: .643
Number of prevalent modal species (*): 5

		HERB			LOW SHRUBS			HIGH SHRUBS				TREES			
Prevalent Species	Percent presence in releves	Percent presence	Average frequency	Average percent cover	Percent presence	Average frequency	Average density stems/ha	Percent presence	Average frequency	Average density stems/ha	Basal area m /ha	Percent presence	Average frequency	Average density stems/ha	Basal area m /ha
Populus tremuloides *	100.00	100.00	84.2	27.15				63.64	34.1	6250.0	1.68	66.64	58.2	413.78	14.93
Aster macrophyllus *	100.00	90.91	70.4	9.19											
Aralia nudicaulis *	96.15	36.36	3.6	.03											
Corylus cornuta	92.31				100.00	50.7	2.3	100.00	64.1	18175.0	1.103				
Betula papyrifera	84.62				27.27	3.1	.08	27.27	3.2	150.0	.030	54.55	32.7	174.67	7.09
Maianthemum canadense	84.62	100.00	64.8	.97											
Pteridium aquilinum *	80.77	90.91	29.1	5.13											
Cornus canadensis	80.77	72.73	17.0	.25											
Diervilla lonicera	76.92	36.36	5.5	.05	100.00	42.5	2.4	9.09	.90	50.0	0.00				
Galium triflorum *	76.92	63.64	12.7	.07											
Amelanchier spp.	73.08	18.18	1.3	.01	36.36	4.9	.10	81.82	8.2	4250.0	.40				
Clintonia borealis	73.08	45.45	12.0	.17											
Streptopus roseus	69.23	81.82	23.1	.42											
Fragaria virginiana	65.38	81.82	29.7	1.2											
Rosa acicularis	65.38	18.18	1.8	.05	54.55	8.5	.16								
Apocynum androsaemifolium	65.38	45.45	6.0	.32											
Alnus crispa	61.54				27.27	1.9	.13	54.55	16.4	2775.0	.223				
Rubus pubescens	61.54	90.91	40.7	2.56											
Trientalis borealis	61.54	63.64	16.4	.09											
Lycopodium obscurum	61.54	45.45	11.5	.36											
Salix bebbiana	53.85				18.18	1.3	.02	36.36	3.60	250.0	.053				
Rubus idaeus	53.85	72.73	8.0	.15	81.82	22.4	.64								
Anemone quinquefolia	53.85	100.00	26.7	.15											
Viola spp.	53.85	54.55	8.5	.04											
Gramineae	50.00	100.00	46.1	2.09											
Oryzopsis spp.	50.00	54.55	12.2	.26											
Vaccinium angustifolium	50.00	36.36	6.6	.10	9.09	.60	.04								
Vaccinium myrtilloides	46.12	27.27	3.0	.07											
Acer spicatum	42.31	27.27	3.1	.03	36.36	11.5	.48	54.55	15.9	1900.0	.143				
Abies balsamea	42.31											18.18	3.6	3.11	
Moss	34.62	81.82	15.4	.72											
Prunus virginiana	38.46	9.09	1.20	0.00	45.45	4.4	.12	45.45	4.1	200.0	.025				
Vicea americana	38.46	45.45	9.1	.18											
Dryopteris spinulosa	38.46	18.18	1.3	.04											

Table 18. Community summary, Aspen-Birch-Fir

Number of releves: 24
Number of quantitative sample sites: 10
Species density: 41
Curtis Index of Homogeneity: .628
Number of prevalent modal species (*): 7

Prevalent Species	Percent presence in releves	HERB Percent presence	HERB Average frequency	HERB Average percent cover	LOW SHRUBS Percent presence	LOW SHRUBS Average frequency	LOW SHRUBS Average density stems/ha	HIGH SHRUBS Percent presence	HIGH SHRUBS Average frequency	HIGH SHRUBS Average density stems/ha	HIGH SHRUBS Basal area m^2/ha	TREES Percent presence	TREES Average frequency	TREES Average density stems/ha	TREES Basal area m^2/ha
Corylus cornuta *	100.00	20.00	2.6	.01				100.00	36.5	7000.0	.653				
Betula papyrifera *	95.45							40.00	9.0	350.0	.488	90.00	72.0	589.78	7.83
Abies balsamea	95.45							60.0	8.0	425.0	.365	90.00	50.0	133.73	1.22
Aster macrophyllus	95.45	100.00	82.1	19.12											
Aralia nudicaulis	90.91	100.00	53.3	4.63											
Populus tremuloides	86.36							90.0	11.0	375.0	.180	90.00	72.0	409.33	10.26
Maianthemum canadense	81.82	100.00	54.0	.93											
Streptopus roseus *	81.82	100.00	30.0	.73											
Trientalis borealis *	81.82	80.00	21.5	.16											
Cornus canadensis	77.27	90.00	32.1	1.3											
Acer spicatum *	77.27	20.00	3.3	.05				80.0	20.5	1975	.213				
Lycopodium obscurum	77.27	50.00	16.6	.73											
Clintoria borealis	77.27	70.00	26.8	.82											
Galium triflorum	72.73	70.00	13.9	.08											
Diervilla lonicera	68.18	60.00	10.1	.20											
Fragaria spp.	68.18	40.00	25.9	.81											
Lonicera canadensis *	68.18							30.0	2.0	125	0.00				
Rosa acicularis	68.18	30.00	4.6	.07											
Anemone quinquefolia	68.18	70.00	16.0	.08											
Pteridium aquilinum	63.64	60.0	8.1	.85											
Gramineae	63.64	100.00	53.9	2.61											
Amelanchier spp.	59.09							60.00	6.0	275	.06				
Rubus idaeus v. strigosus	54.55	20.00	1.4	.02											
Rubus pubescens	54.55	100.00	53.3	2.35											
Sorbus americana	54.55	10.00	0.7	0.00											
Vaccinium angustifolium	50.00	30.00	4.7	.04											
Apocynum androsaemifolium	50.00	40.00	5.3	.60											
Acer rubrum *	45.45							50.00	4.0	175	.038	60.00	16.0	8.0	.09
Alnus crispa	45.45							50.00	9.0	1325	.253				
Viola spp.	45.45	70.00	12.0	.07											
Moss	45.45	100.00	31.4	1.77											
Athyrium Filix-femina	45.45	40.00	60.0	.58											
Carex spp.	45.45	50.00	8.0	1.42											
Oryzopsis	45.45	50.00	9.3	.40											
Petasites palmatus	40.91	30.00	12.7	.47											
Linnaea borealis	40.91	20.00	5.4	.04											
Coptis groenlandica	40.91	20.00	2.0	0.00											
Vaccinium myrtilloides	40.91	30.00	2.7	.06											
Dryopteris spinulosa	40.91	50.00	3.5	.05											
Vicia americana	40.91	20.00	4.6	.03											
Lonicera hirsuta	40.91														

Table 19. Community summary, Mixed Conifer-Deciduous

Number of releves: 54
Number of quantitative sample sites: 2
Species density: 31
Curtis Index of Homogeneity: .658
Number of prevalent modal species (*): 5

Prevalent Species	Percent presence in releves	HERB Percent presence	HERB Average frequency	HERB Average percent cover	LOW SHRUBS Percent presence	LOW SHRUBS Average frequency	LOW SHRUBS Average density stems/ha	HIGH SHRUBS Percent presence	HIGH SHRUBS Average frequency	HIGH SHRUBS Average density stems/ha	HIGH SHRUBS Basal area m /ha	TREES Percent presence	TREES Average frequency	TREES Average density stems/ha	TREES Basal area m /ha
Cornus canadensis	98.15	100.00	30.0	.3											
Populus tremuloides	93.30				50.00	3.5	.05	100.00	7.5	200.0	.225	100.00	70.0	191.1	19.72
Picea mariana	94.44											50.00	20.0	26.7	7.67
Aralia nudicaulis	94.44	100.00	63.5	8.1											
Aster macrophyllus	90.74	100.00	53.0	9.85											
Maianthemum canadense	90.75	100.00	80.0	1.05											
Clintonia borealis *	85.19	100.00	36.5	.90											
Abies balsamea *	81.48				50.00	13.0	.1	50.0	7.5	250.0	.227	50.00	20.0	173.3	6.87
Linnaea borealis *	77.78	50.00	3.5	.10											
Betula papyrifera	72.22				50.00	3.5	.05	50.00	17.5	950.0	.790	50.00	50.0	453.3	5.13
Diervilla lonicera	72.22				50.00	13.5	.30								
Corylus cornuta	72.22				100.00	90.0	4.30								
Amelanchier spp.	66.67				100.00	16.5	1.95								
Trientalis borealis	64.81	100.00	13.5	.05											
Pinus banksiana	62.96														
Rosa acicularis	62.96	50.00	3.5	.10	50.00	20.00	.35	50.0	2.5	75.0	.001				
Vaccinium angustifolium	61.11														
Lycopodium obscurum	61.11	100.00	13.5	.90											
Vaccinium myrtilloides	59.26	50.00	16.5	.15	50.0	3.5	.05								
Sorbus americana *	57.41														
Moss *	55.56	50.00	10.0	.65											
Gramineae	53.70	100.00	23.0	1.10											
Fragaria spp.	51.85														
Rubus idaeus v. strigosus	50.00				100.00	36.5	1.2								
Pteridium aquilinum	50.00	50.00	13.5	3.25											
Alnus crispa	46.30							100.00	22.5	.363	.745				
Anemone quinquefolia	46.30	100.00	26.5	.05											
Streptopus roseus	46.30	100.00	40.0	.60											
Rubus pubescens	42.59	100.00	53.5	.85											
Salix bebbiana	38.89														

Table 20. Groups of stands clustered in the high shrub dendrogram.

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
GROUP I	21	D24,G48,T22,T25,G18, G46,G31,R01,R75,R68, R67,R69,R81,N03,R55, R40,J18,J20,J21,N06,S41	*Alnus rugosa* constantly present with matrix values higher than 3
Subgroup A	6	D24,G48,T22,T25,G18, G46	*Alnus rugosa* with *Cornus stolonifera*
Subgroup B	10	G31,R01,R75,R68,R67, R69,R81,N03,R55,R40	Almost pure *Alnus rugosa*
Subgroup C	5	J18,J20,J21,N06,S41	*Alnus rugosa* with *Fraxinus nigra*
GROUP II	16	N14,N22,R24,R76,R37, R51,G43,S15,R56,R57, R47,R64,G05,R59,G03, S13	Very few high shrub species and those that are present have low coverage, mixture of upland types
Subgroup A	8	N14,N22,R24,R76,R37, R51,G43,S15	*Betula papyrifera* constantly present in low coverages
Subgroup B	2	R56,R57	These stands contain only Typha in this height class and should be deleted from the analysis
Subgroup C	3	R47,R64,G05	*Salix bebbiana* with cover less than 5%
Subgroup D	3	R59,G03,S13	*Alnus crispa* with cover less than 5%
GROUP III	12	N13,T18,N23,T33,G24, R07,R15,S50,R53,G37, N12,G15	*Abies balsamea* constant in 80% of stands with varying coverages generally less than 50%
Subgroup A	7	N13,T18,N23,T33,G24, R07,R15	*Abies balsamea* the only species in the shrub height class
Subgroup B	5	S50,R53,G37,N12,G15	*Abies balsamea* and/or *Acer rubrum* present in all stands, coverages less than 5%

Table 20 continued.

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
GROUP IV	19	G35,J23,G30,T27,G17, T03,T26,S02,S45,G23, R54,S39,N38,T11,T32, S47,G26,G29,T19	Populus tremuloides present in all stands with coverage less than 5%
Subgroup A	7	G35,J23,G30,T27,G17, T03,T26	Populus tremuloides, Amelanchier, and Corylus constantly present in coverages of less than 5%
Subgroup B	12	S02,S45,G23,R54,S39, N38,T11,T32,S47,G26, G29,T19	Populus tremuloides at values of "plentiful" to 5% cover with other species scattered in presence
GROUP V	26	C01,N37,J16,G09,G32, J17,N15,G12,C08,N39, R85,T12,G16,C03,C02, N08,N02,N07,N04,G33, T07,T08,R46,G27,N33,N11	Corylus cornuta constantly present throughout
Subgroup A	8	C01,N37,J16,G09,G32, J17,N15,G12	Corylus cornuta coverages average 25-50%. Amelanchier present in 5/8 of stands with coverage less than 5%
Subgroup B	9	C08,N39,R85,T12,G16, C03,C01,N08,N02	Corylus cornuta and Alnus crispa each present in all stands at coverage values averaging 2-5%. Amelanchier present in all stands with coverage less than 5%
Subgroup C	9	N07,N04,G33,T07,T08, R46,G27,N33,N11	Corylus present in all but one stand at coverages averaging less than 5% with Acer spicatum present in all stands, usually with equal or higher coverage
GROUP VI	12	J13,S12,J15,S46,T16, S17,G02,G45,S04,N10, D01,J14	Larix present throughout in coverages of less than 5%, spruce present in all stands but J13 and S12 with comparable coverages

Table 20 continued.

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
GROUP VII	31	R60,R49,R41,S16,S18, R35,R27,G25,G06,G44, T05,N09,N20,N29,S22, R19,S14,G01,S29,R18, R05,R17,C06,R36,N21, R70,N01,S40,G11,R04,R06	Picea mariana present throughout, aspen not consistently present
Subgroup A	17	R60,R49,R41,S16,S18, R35,R27,G25,G06,G44, T05,N09,N20,N29,S22, R19,S14	Picea mariana constantly present without Abies balsamea
Subgroup B	14	G01,S29,R18,R05,R17, C06,R36,N21,R70,N01, S40,G11,R04,R06	Picea mariana and Abies balsamea constantly present with coverages less than 5%
GROUP VIII	18	R03,R72,S25,R21,R28,R34, R66,R16,S48,G28,R11,R22, R10,R32,R30,R23,S05,G22	Picea mariana and Populus tremuloides generally present throughout
Subgroup A	10	R03,R72,S25,R21,R28,R34, R66,R16,S48,G28	Picea mariana and Populus tremuloides without fir
Subgroup B	8	R11,R22,R10,R32,R30, R23,S05,G22	Picea mariana, Populus tremuloides, and Abies balsamea
GROUP IX	3	J09,G34,C09	Anomalous stands with a combination of species from the previous group (Picea mariana, Abies balsamea, and Populus tremuloides) and of the following group (Amelanchier, Alnus crispa) and (Rubus idaeus)
GROUP X	17	J11,N34,N24,T29,G21, J19,T34,N16,G04,G36, N05,G07,G08,G38,J22, G14,G20	Populus tremuloides, Corylus cornuta, Amelanchier constant with Rubus idaeus, Salix bebbiana, Prunus virginiana, and Alnus crispa frequent throughout

Table 20 continued.

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
GROUP X (contd.)			
Subgroup A	3	J11,N34,N24	Rosa acicularis absent in N34 and N24, Rubus idaeus consistently present, Salix bebbiana consistently present
Subgroup B	10	T29,G21,J19,T34,N16, G04,G36,N05,G07,G08, G38	Rosa acicularis present throughout. High frequency of Salix bebbiana and Rubus idaeus
Subgroup C	3	J22,G14,G20	Rosa acicularis and Rubus idaeus absent Abies balsamea present in all three stands

Table 21. Groups of stands clustered in the low shrub dendrogram.

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
GROUP I	17	G48,G03,G43,G46,G01,G28, G25,G26,N09,S20,N13,R33, T14,N10,R56,R20,N18	*Ledum groenlandicum* constantly present
Subgroup A	13	G48,G03,G43,G46,G01,G28, G25,G26,N09,S20,N13,R33, T14	*Ledum groenlandicum* and *Alnus rugosa* constant, *Sorbus americana* frequent
Subgroup B	4	N10,R56,R20,N18	*Ledum* constant, but *Alnus* and *Sorbus* absent
GROUP II	12	S04,T05,S43,S08,R65,R15, R41,R43,N03,N06,S41,S49	*Alnus rugosa* present in almost all stands
Subgroup A	8	S04,T05,S43,S08,R65,R15, R41,R43	*Alnus rugosa* constant with *Populus tremuloides* frequent
Subgroup B	4	N03,N06,S41,S49	Few low shrub species, *Populus tremuloides* absent
GROUP III	4	J12,S36,S38,R62	*Spiraea alba* constant
GROUP IV	23	J13,S17,S18,S32,S22,S07, G31,S23,S12,S26,G45,T16, D01,G02,G44,G06,C04,C05, N22,R73,R09,N32,S46	*Chamaedaphne calyculata* constantly present, other ericaceous shrubs vary
Subgroup A	8	J13,S17,S18,S32,S22,S07, G31,S23	*Chamaedaphne*, *Betula pumila*, *Salix pedicellaris*, and *Alnus rugosa* present, but *Andromeda* absent
Subgroup B	4	S12,S26,G45,T16	*Andromeda* and *Chamaedaphne* present, both other species above, *Ledum* and *Kalmia* absent
Subgroup C	4	D01,G02,G44,G06	*Chamaedaphne*, *Ledum*, *Kalmia* and *Andromeda* present
Subgroup D	7	C04,C05,N22,R73,R09,N32, S46	*Chamaedaphne* and *Ledum* present, other species listed above absent

Table 21 continued.

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
GROUP V	15	N20,R26,S42,J01,R04,S14, R06,R81,N17,J22,G24,R03, R19,T34	Low shrub layer exclusively *Picea mariana* and/or *Abies balsamea* and other coniferous elements
Subgroup A	7	N20,R26,S42,J01,R04,S14, R06	*Picea mariana* only
Subgroup B	7	R81,N17,J22,G24,R03,R19, T34	*Abies balsamea* constant
GROUP VI	43	N28,T12,T31,N21,S50,N31, G19,G22,T30,C09,N40,T20, N34,N30,J07,N24,G35,G07, G10,G05,G12,T32,G41,G47, G32,J05,J06,J08,J10,S21, G09,G13,G17,T06,C07,G04, G30,G29,T19,T11,T04,G11, G34	*Rubus idaeus* constant; high frequencies of *Corylus cornuta*
Subgroup A	8	N28,T12,T31,N21,S50,N31, G19,G22	Coniferous elements present with *Corylus cornuta* absent
Subgroup B	9	T30,C09,N40,T20,N34,N30, J07,N24,G35	*Corylus cornuta* present with coniferous elements absent; *Salix bebbiana* and *Alnus crispa* frequent
Subgroup C	8	G07,G10,G05,G12,T32,G41, G47,G32	*Diervilla* constant, *Salix bebbiana*, *Cornus rugosa*, *Acer rubrum*, and *Lonicera canadensis* frequent, *Comptonia* absent
Subgroup D	5	J05,J06,J08,J10,S21	*Comptonia peregrina* and *Salix bebbiana* constant, *Viburnum rafinesquianum* frequent, *Acer rubrum* and *Cornus rugosa* absent
Subgroup E	9	G09,G13,G17,T06,C07,G04, G30,G29,T19	*Salix bebbiana* frequent, lower *Viburnum*, *Alnus crispa* & *Comptonia peregrina* absent
Subgroup F	4	T11,T04,G11,G34	*Corylus cornuta*, *Populus tremuloides*, and *Cornus stolinifera* constant

Table 21 continued.

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
GROUP VII	19	R01,G37,R30,R31,G40,S29, C03,S34,S28,S19,S11,J02, J03,R51,J23,S16,S44,C02	High frequencies of *Populus tremuloides* and *Betula papyrifera*
Subgroup A	5	R01,G37,R30,R31,G40	*Populus tremuloides* and *Betula papyrifera* constant, high frequencies of *Corylus cornuta* and *Acer spicatum*
Subgroup B	6	S29,C03,S34,S28,S19,S11	High frequencies of *Amelanchier* and *Sorbus*, low frequencies of *Populus tremuloides* and *Betula papyrifera*
Subgroup C	8	J02,J03,R51,J23,G40,S16, S44,C02	High frequencies of *Populus tremuloides*, *Betula papyrifera*, and *Comptonia peregrina*, *Diervilla* constant
GROUP VIII	16	R47,N28,R48,R67,R25,R45, R42,R55,R69,R64,N36,R85, R78,R16,S10,S06	*Rubus* sp. constant (although this taxon is probably *Rubus idaeus* v. *strigosus*, it was counted as a separate entity in these stands)
Subgroup A	9	R47,N28,R48,R67,R25,R45, R42,R55,R69	*Rubus* constant with high frequencies of *Amelanchier* and *Rosa*, low frequencies of *Salix bebbiana*
Subgroup B	7	R64,N36,R85,R78,R16,S10, S06	*Salix bebbiana* and *Rubus* constant, high frequencies of *Rosa acicularis* and *Populus tremuloides*
GROUP IX	21	C01,S02,N12,C06,J04,R19, R35,N37,S31,R13,R66,R22, R53,T13,R36,R75,R17,R82, R34,R40,G24	*Corylus cornuta* constant in subgroups A and C, with high frequency in B
Subgroup A	7	C01,S02,N12,C06,J04,R19, R35	*Corylus cornuta* and *Abies balsamea* constant

Table 21 continued.

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
Subgroup B	7	N37,S31,R13,R66,R22,R53, T13	High frequencies of *Rubus*, *Amelanchier*, and *Corylus cornuta*, *Abies balsamea* absent
Subgroup C	7	R36,R75,R17,R82,R34,R40, G24	*Corylus cornuta* and *Rubus* sp. constant, high frequencies of *Diervilla*, *Populus tremuloides*, and *Rosa acicularis*
GROUP X	24	R74,S09,R46,R54,N27,S33, R68,S39,C08,N33,N11,G08, G23,G14,G15,T10,T33,T18, G27,G33,S05,T08,G42,G38	*Corylus cornuta* and *Acer spicatum* in high frequencies
Subgroup A	11	R74,S09,R46,R54,N27,S33, R68,S39,C08,N33,N11	*Lonicera canadensis*, *Cornus rugosa*, and *Viburnum rafinesquianum* absent
Subgroup B	8	G23,G14,G15,T10,T33,T18, G27,G08	*Lonicera canadensis* constant
Subgroup C	5	G33,S05,T08,G42,G38	*Cornus rugosa* and *Lonicera canadensis* constant, *Viburnum rafinesquianum* present in low frequencies
GROUP XI	27	R24,G16,S37,S01,G21,G20, T03,R21,S47,R28,N35,R23, R27,N23,N39,R77,R83,S45, R39,S48,R32,R37,R18,R38, R70,R02,R63	*Alnus crispa* and *Corylus cornuta* constant
Subgroup A	7	R24,G16,S37,S01,G21,G20, T03	*Amelanchier* constant, *Prunus virginiana* frequent
Subgroup B	6	R21,S47,R28,N35,R23,R27	no additional constant species
Subgroup C	3	N23,N39,R77	*Amelanchier* present, *Prunus virginiana* absent, *Salix bebbiana* absent
Subgroup D	5	R83,S45,R39,S48,R32	*Rubus* sp., *Diervilla*, and *Salix bebbiana* constant
Subgroup E	6	R37,R18,R38,R70,R02,R63	*Picea mariana* constant

Table 22. Summary of clusters in the herb dendrogram

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
Group I	19	D24, T14, N09, N13, N28, T22, G18, S20, S19, N03, R81, T25, N06, R69, J18, S41, J20, J21, R55	*Carex* spp., species of nutrient-rich wetlands and moist woodlands
Group II	10	J12, S36, R62, S27, R58, R61, R64, R59, R60	*Calamagrostis canadensis*, *Scirpus cyperinus*, no *Viola* spp.
Group III	53	G48, G03, G46, G43, N14, T30, G01, G28, T17, G06, G44, G45, G31, T16, R56, S43, R76, R84, S42, R33, R50, S17, R20, N22, G02, R09, R26, R12, J13, J14, S46, S12, S26, J15, N30, C05, D01, S23, R77, N10, R51, S18, S04, S07, S32, S29, C04, N26, N25, N29, N32, T05	*Carex* spp. Ericaceous wetland species and species tolerant of lower nutrient status
Group IV	54	R01, R71, R80, R46, J17, R63, R11, R85, R81, R48, R74, J16, R30, R31, J02, J04, R05, R25, R45, R15, R36, R54, R70, R38, R18, R16, R77, R02, S44, R21, R17, R23, R82, R13, R22, R27, R42, R28, J05, R67, N27, R40, J19, R43, R68, J06, J07, J08, J10, N16, N05, R10, R04, R14, R34	High frequences of *Cornus canadensis*, *Aster macrophyllus*, *Aralia nudicaulis*, *Clintonia borealis*, and *Malanthermum canadense*. Low frequences of *Dryopteris spinulosa* and *Vaccinium angustifolium*.
Group V	10	R44, S13, R29, S18, R47, R65, R49, N17, R51, R05	*Cornus canadensis* constant, *Vaccinium angustifolium* and *Dryopteris spinulosa* higher than Group IV. Low *Aster macrophyllus* and *Pteridium*. *Fragaria* and *Gaultheria procumben* absent.

Table 22 -- continued

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
Group VI	14	N01, S11, S05, S21, S48, R37, R39, R78, S40, R32, R19, R24, S34, R06	Maianthemum canadense and Vaccinium angustifolium more frequent than Cornus canadensis and Aster macrophyllus. Gaultheria procumbens, Melampyrum lineare and Lathyrus venosus frequent.
Group VII	36	C01, C06, N11, J23, N25, C03, C02, C07, N40, G25, G26, J01, J09, J11, S02, S03, S15, G14, G15, R07, R72, S25, N12, S14, S08, N07, N04, N15, S30, S50, N27, S33, N02, R35, R79, N33	Cornus canadensis constant. High frequencies of Linnaea borealis, Anemone quinquefolia, Lycopodium obscurum, and Abies balsamea. Low frequencies of Pteridium.
Group VIII	18	N21, N18, S16, S24, T13, N36, R04, S09, S10, N30, T20, T19, S19, S06, G13, G11, N31, T31	Mainly disturbed sites with lower frequences of Clintonia borealis, Maianthemum canadense, and Aralia nudicaulis.
Group IX	11	G10, G23, G12, G42, G05, G22, G35, G41, T32, G30, G36	Highest frequences of Actaea spp. and Mitella nuda. High species diversity. High Aster macrophyllus, Aralia nudicaulis, Graimineae, Viola, Anemone quinquefolia, Fragaria, and Dryopteris spinulosa
Group X	30	C08, C09, R02, T29, T34, G19, G09, N08, T33, S39, G47, G32, T27, S31, T07, S01, T12, T10, T18, N38, J22, S45, S47, J03, R53, R66, S37, N23, R75, R83.	Constant presence of Aster macrophyllus and Aralia nudicaulis. High frequency of Pteridium.

Table 22 -- continued

COMMUNITY TYPE	NUMBER OF STANDS	STAND NUMBERS IN GROUP	CHARACTERISTIC SPECIES
Group XI	22	G07, G37, G40, G04, G08, G38, G33, N39, T08, G16, G20, G21, G17, T03, G27, G24, T26, T11, N24, G29, G34, N34.	Higher frequences of Lathyrus spp., Vicia and Apocynum. Many woody species in herb layer.

Table 23. Species used in discriminant analysis for comparison of study area communities with BWCA communities.

Abies balsamea (trees and seedlings)
Acer rubrum (trees and seedlings)
Acer spicatum
Alnus crispa
Amelanchler spp.

Aralia nudicaulis
Aster macrophyllus
Betula papyrifera (trees and seedlings)
Clintonia borealis
Cornus canadensis

Cornus rugosa
Corylus cornuta
Diervilla lonicera
Fragaria vesca
Galium triflorum

Gaultheria procumbens
Linnaea borealis
Lonicera canadensis
Lycopodium clavatum
Lycopodium obscurum

Maianthemum canadense
Melampyrum lineare
Mitella nuda
Picea glauca (trees and seedlings)
Picea mariana (trees and seedlings)

Pinus banksiana
Pinus resinosa
Pinus strobus (trees and seedlings)
Populus tremuloides (trees and seedlings)
Pteridium aquilinum

Quercus rubra
Rubus pubescens
Rubus strigosus
Salix spp.
Streptopus roseus

Thuja occidentalis (trees and seedlings)
Trientalis borealis
Vaccinium angustifolium
Vaccinium myrtilloides
Viola spp.

Table 24. Community designation of 62 regional copper-nickel study stands.

Stand	Assigned BWCA Community	Quadrant in Canonical Space	Assigned Copper-Nickel Study Community
G01	JP-F	PC	BS
G02	JP-BS	PC	BS
G03	JP-BS	PC	BS
G04	JP-O	PC	MIX C-D
G05	AB	PB	ABF
G06	JP-BS	PC	BS
G07	AB	RO	AB
G08	JP-F	PC	AB
G09	AB	PB	AB
G10	JP-F	TC	AB
G11	JP-F	TC	JP
G12	AB	PB	ABF
G13	JP-O	PC	JP
G14	MABF	PB	ABF
G15	MABF	PB	ABF
G16	JP-F	PC	JP
G17	JP-F	TC	JP
G18	JP-O	PC	Carr
G19	JP-F	TC	RP
G20	JP-O	PC	RP
G21	AB	PB	RP
G22	AB	PC	RP
G23	JP-F	PC	RP
G24	JP-F	PC	RP
G25	JP-O	PC	BS-JP
G26	JP-BS	PC	BS-JP
G27	JP-F	PB	JP
G28	JP-O	PC	JP
G29	JP-F	PC	Grass
G30	JP-F	PC	JP
G31	JP-O	PC	Tam
G32	AB	PB	AB
G33	MABF	RO	AB
G34	AB-WP	PC	WS
G35	BS-FM	PC	WS

Table 24 -- continued

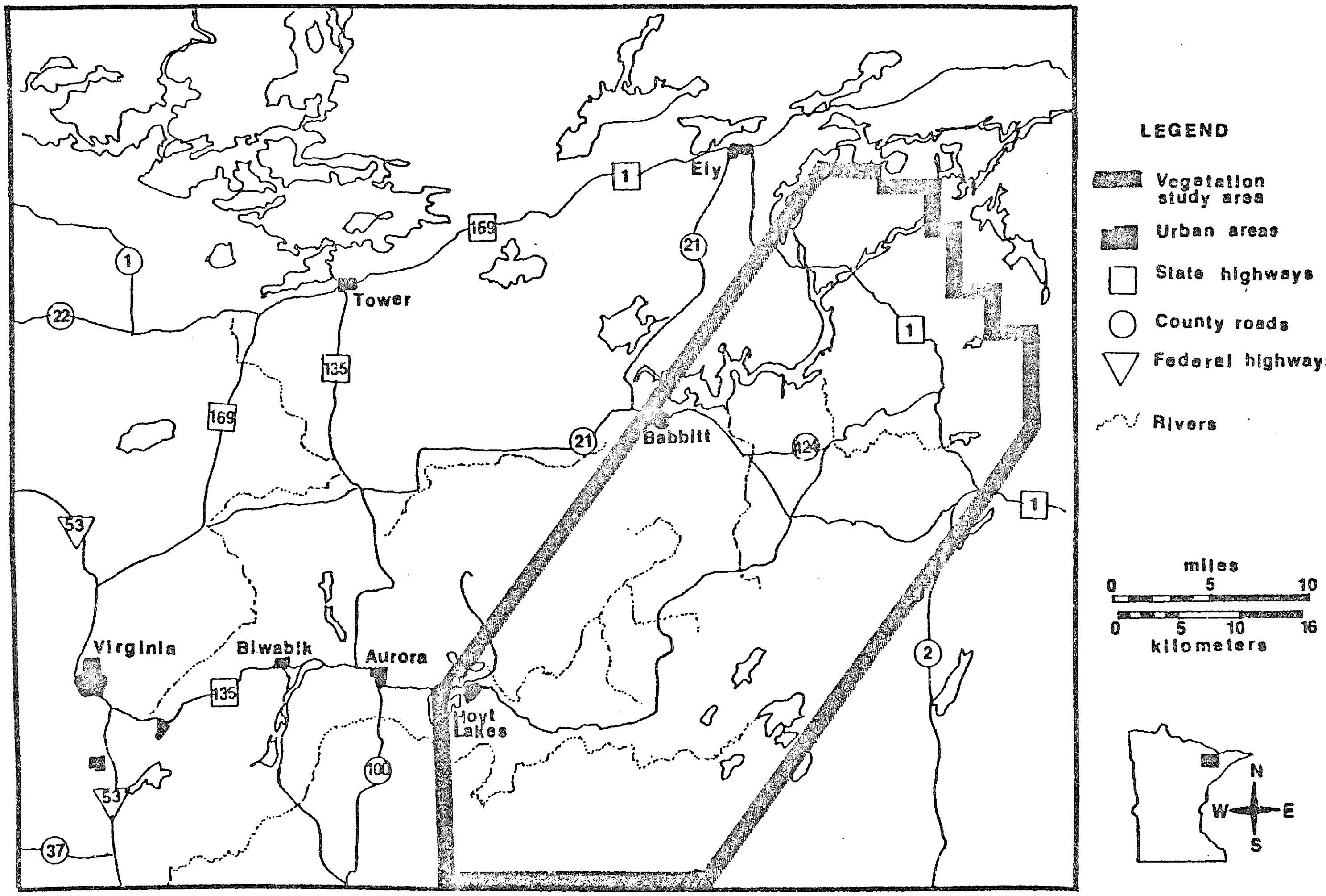
Stand	Assigned BWCA Community	Quadrant in Canonical Space	Assigned Copper-Nickel Study Community
G36	AB	TC	WS
G37	FB	TC	ABF
G38	AB	PB	ABF
G39	AB	PB	AB
G40	JP-F	TC	AB
G41	AB	PB	ABF
G42	AB	PB	ABF
G43	WC	TC	WC
G44	JP-O	PC	BS
G45	JP-O	PC	Tam
G46	WC	TC	WC
G47	FB	PB	MIX C-D
G48	JP-O	PC	Carr
T03	ABWP	TC	RP
T04	AB	PB	RP
T05	JP-O	PC	BS
T10	AB	PB	ABF
T11	AB	PB	AB
T13	AB	RO	AB
T17	WC	TC	WC
T26	JP-O	PC	RP
T27	AB	PB	AB
T29	AB-WP	RO	AB
T30	JP-BS	PC	BS
T32	JP-O	PC	RP
T33	AB	PB	ABF
T34	AB	PB	RP

Table 25. Centroids of communities along the first canonical axis, compared with average synecological coordinates for moisture.

BWCA community types	BWCA stands, centroid on 1st axis	BWCA stands, average synecological coordinates	RCNSA stands assigned to BWCA groups centroid on 1st axis	RCNSA stands assigned to BWCA grouping synecological coordinates
Maple-aspen-birch	-10.1	2.2	---	---
Aspen-birch	- 8.5	2.3	- 7.13	2.44
Aspen-birch-white pine	- 7.2	2.3	- 2.32	2.37
Maple-aspen-fir-birch	- 5.8	2.7	- 3.07	2.58
Maple-oak	- 3.2	2.1	---	---
Red pine	- .1	2.0	---	---
Fir-birch	3.1	2.8	.93	2.57
Jack pine-fir	4.9	2.3	5.05	2.45
Black spruce-feathermoss	6.5	2.6	6.78	2.89
White cedar	7.7	3.1	17.64	3.43
Jack pine-black spruce	8.0	2.2	11.95	3.50
Lichen	9.0	---	---	---
Jack pine-oak	10.0	2.0	10.35	3.18

RCNS community types	Average of these stands projected on canonical axis	Average synecological coordinates for moisture
Cedar	17.64	3.43
Alder	16.93	4.09
Spruce and tamarack	12.57	3.78
Jack pine	8.58	2.49
Mixed conifer-deciduous	1.52	2.61
Red pine	- 1.84	2.33
Aspen-birch	- 4.39	2.40
Aspen-birch-fir	- 6.40	2.62

FIGURE 1 LOCATION OF VEGETATION STUDY AREA WITHIN REGIONAL COPPER-NICKEL STUDY AREA



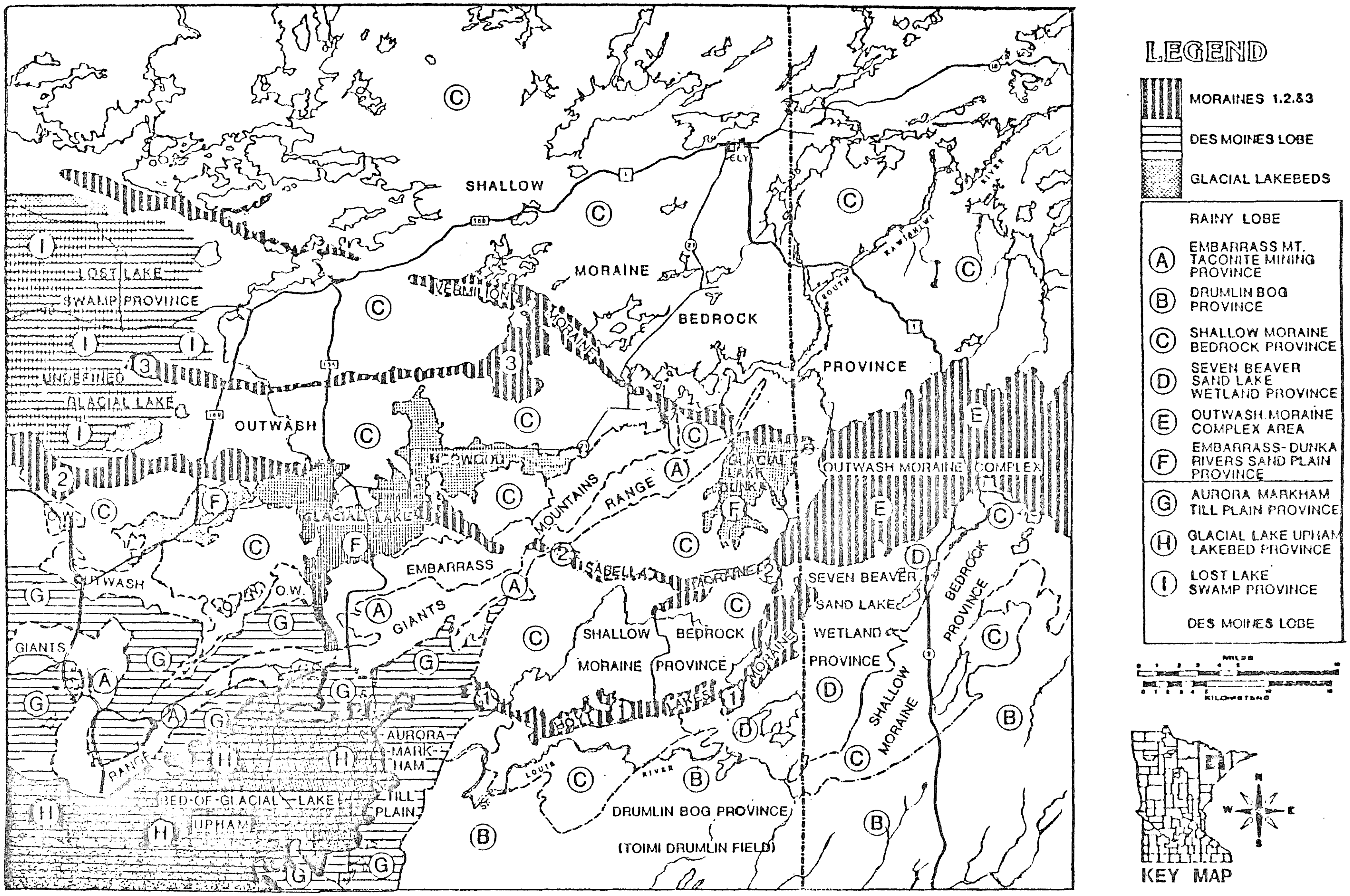
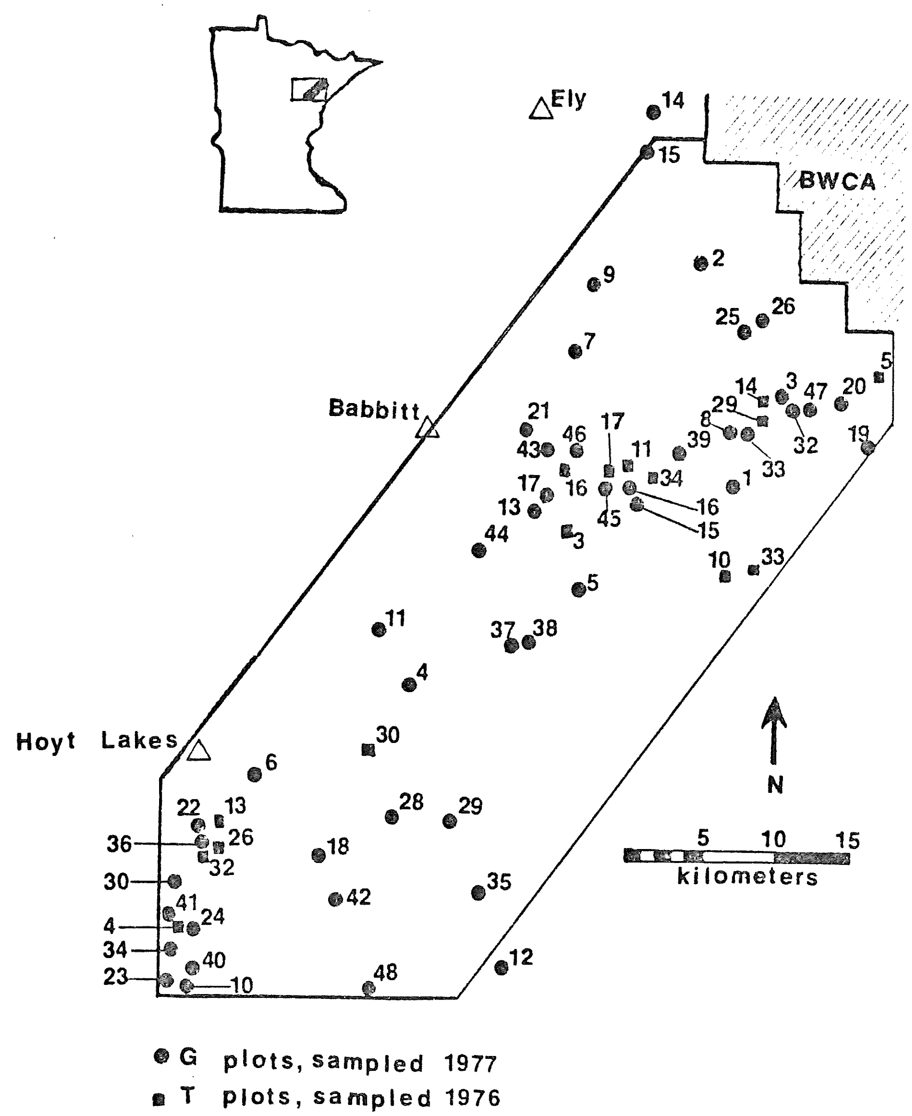


FIGURE 2 PHYSIOGRAPHIC PROVINCES & GLACIAL FEATURES

FIGURE 4 LOCATION OF QUANTITATIVE STUDY PLOTS

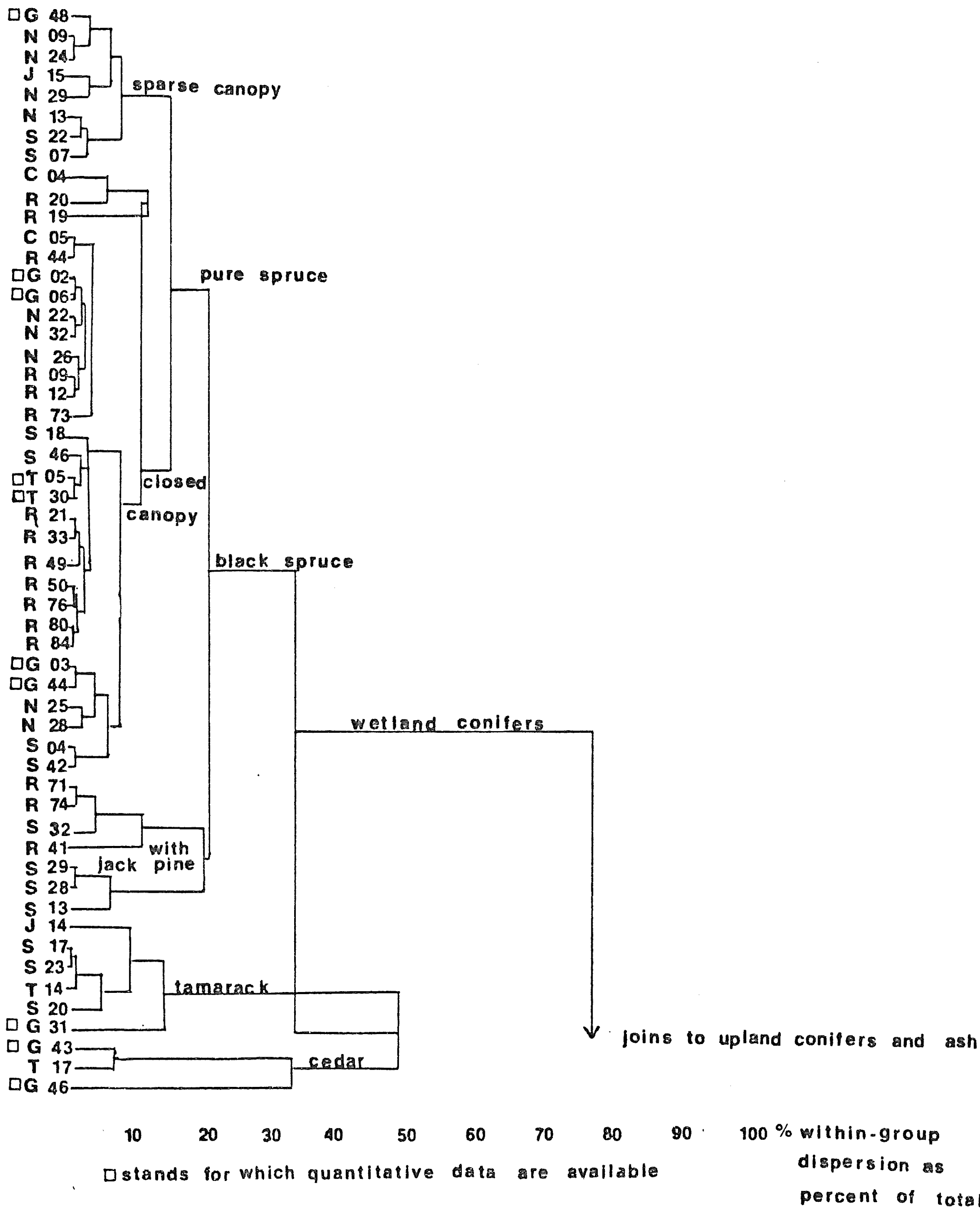


MEQB REGIONAL COPPER-NICKEL STUDY

ORIGINAL VEGETATION OF THE STUDY AREA
ACCORDING TO MARSHNER (1930)

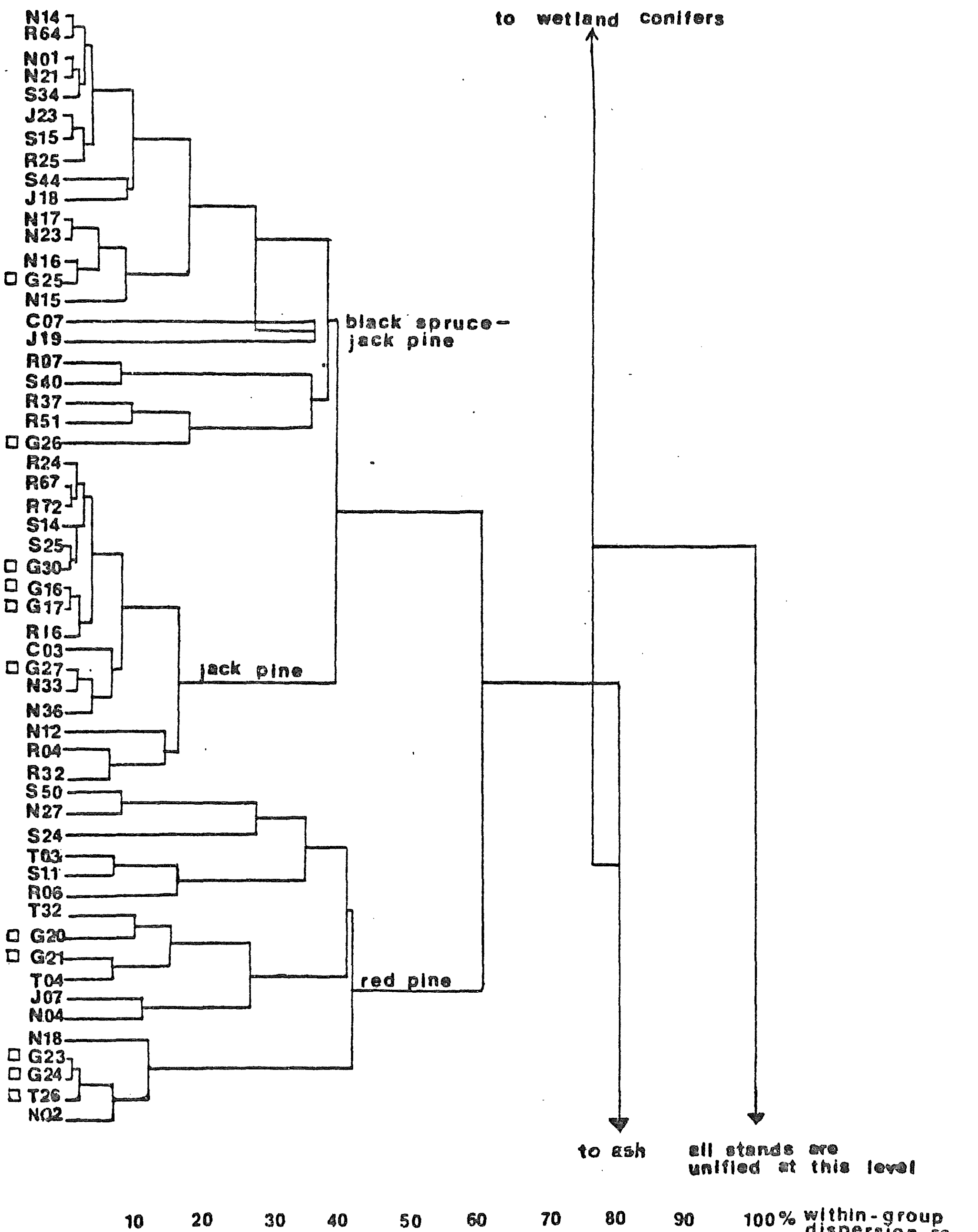
FIGURE 5 DENDROGRAM PRODUCED BY CLUSTER ANALYSIS OF RELEVES

A. Conifer wetlands



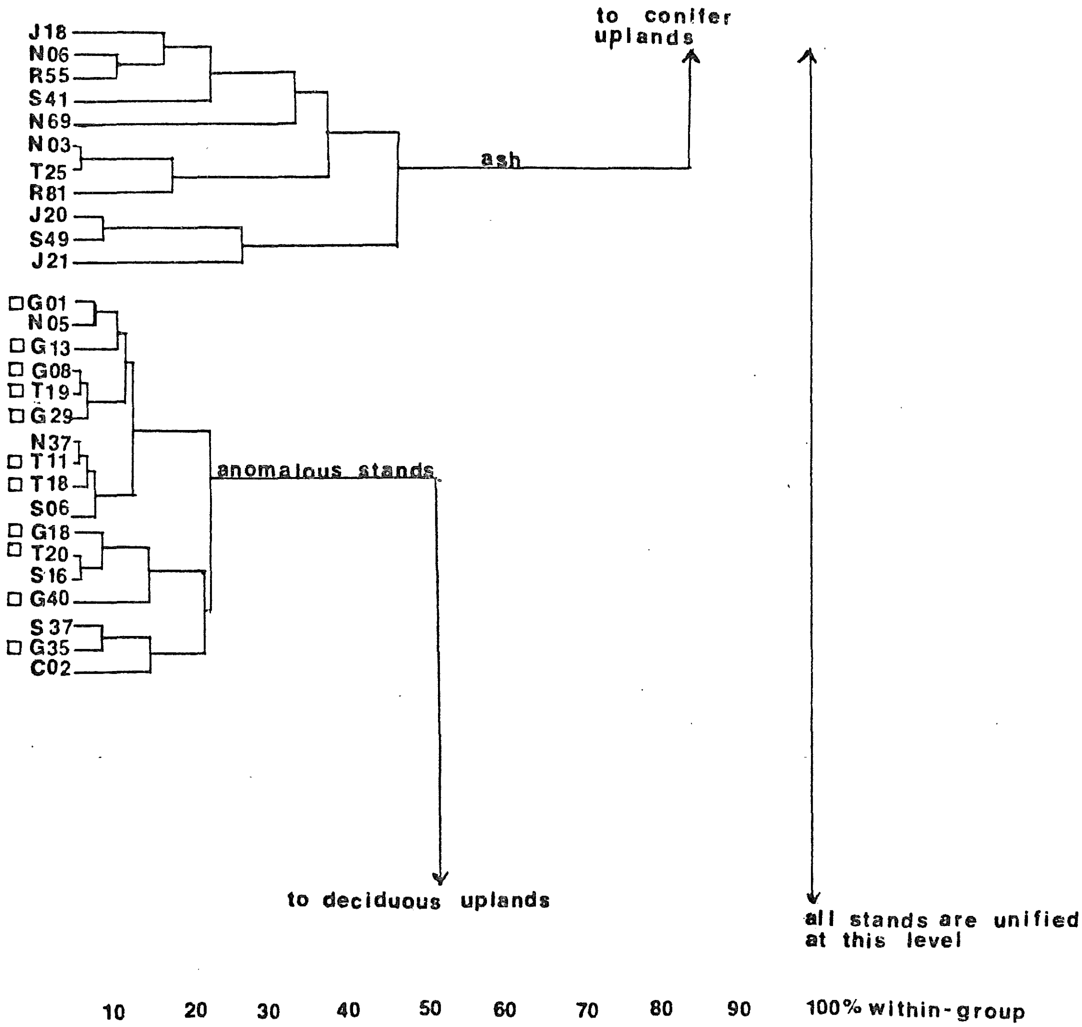
□ stands for which quantitative data are available

FIGURE 5
B. Upland coniferous



□ stands for which quantitative data are available

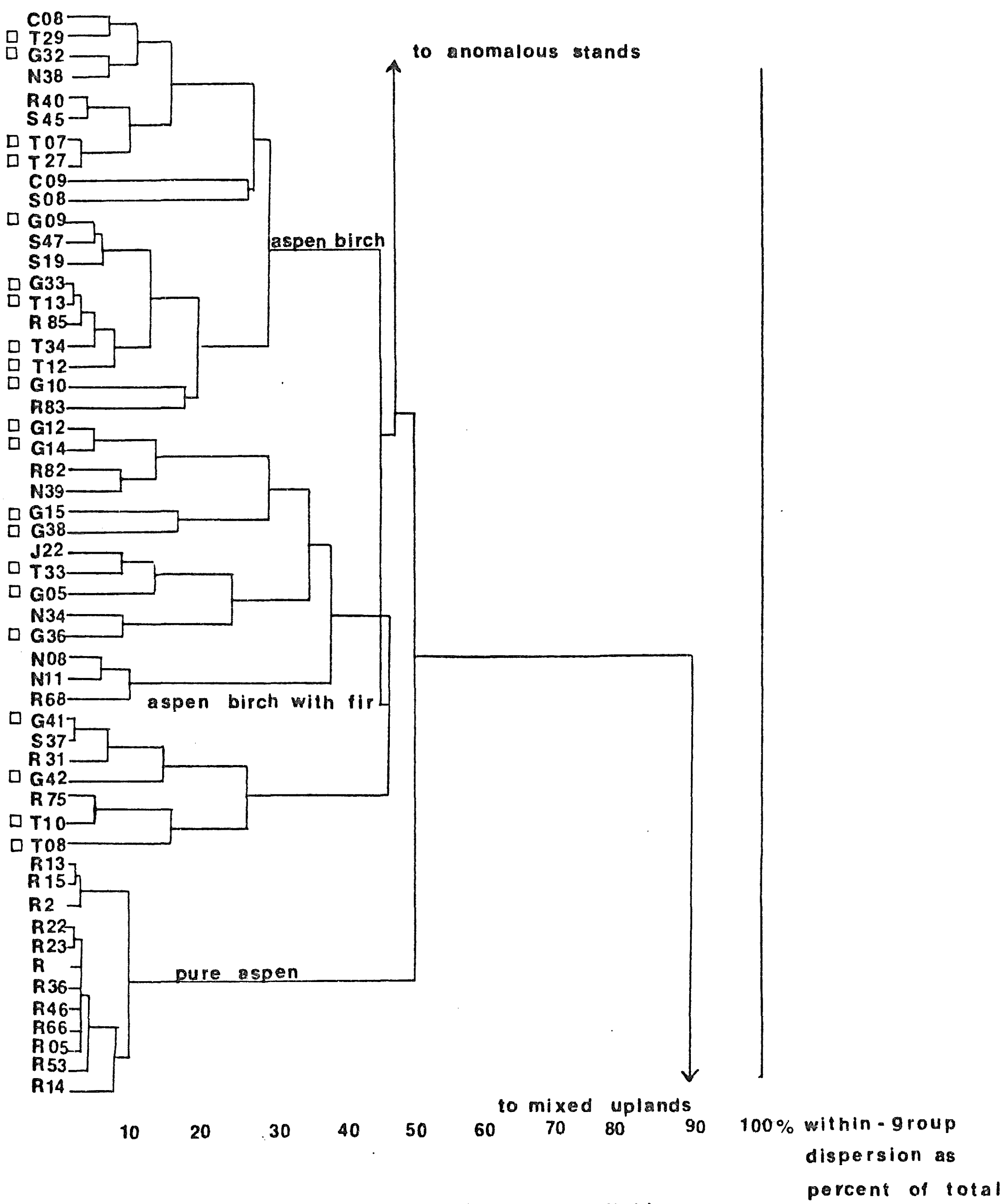
FIGURE 5
C. Ash and anomalous stands



□ stands for which quantitative data are available

FIGURE 5

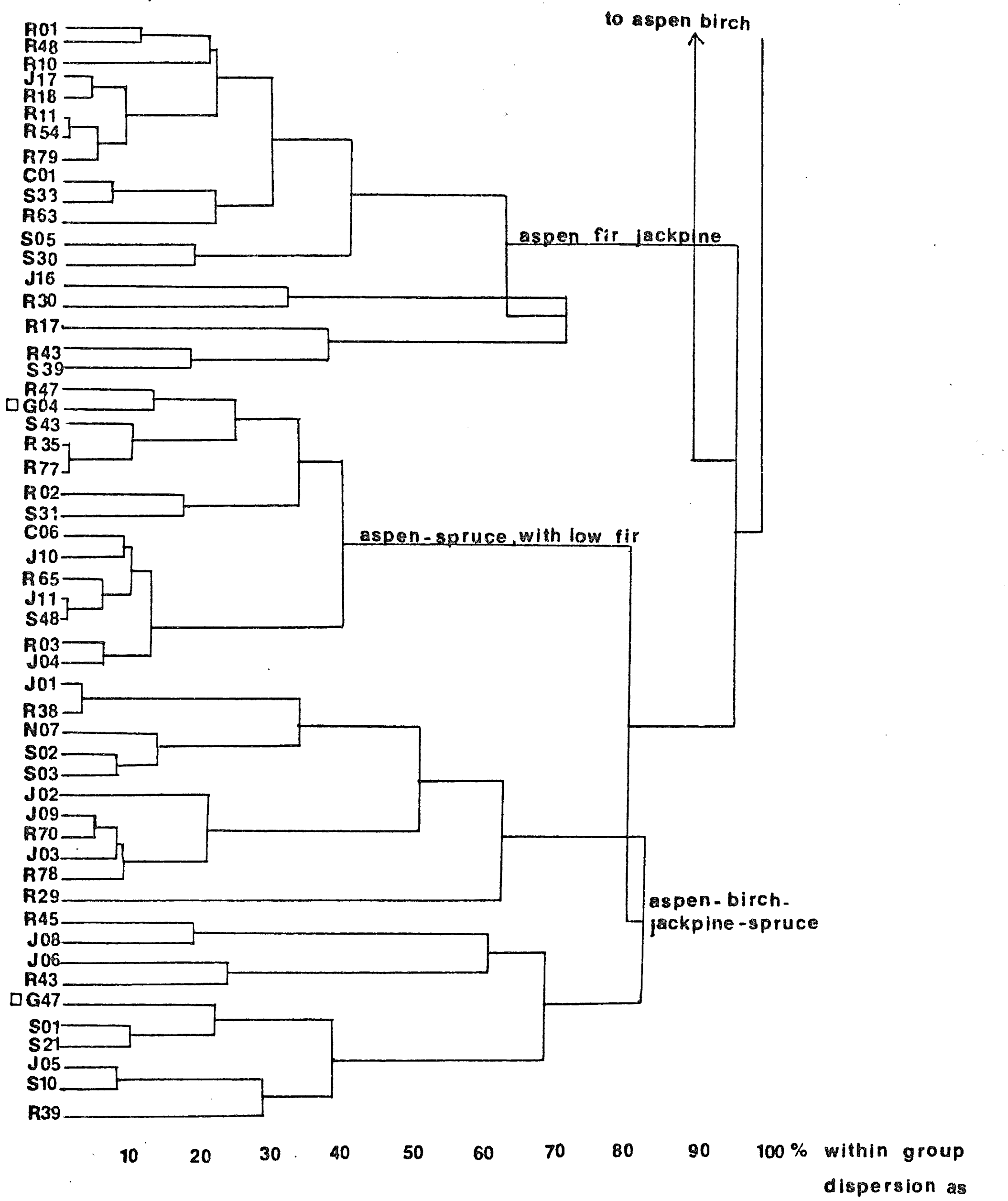
D. Deciduous uplands



□ stands for which quantitative data are available

FIGURE 5

E. Mixed uplands



□ stands for which quantitative data are available

FIGURE 6a DENDROGRAM PRODUCED BY CLUSTER ANALYSIS OF 53 STANDS BASED ON FREQUENCY OF CANOPY SPECIES

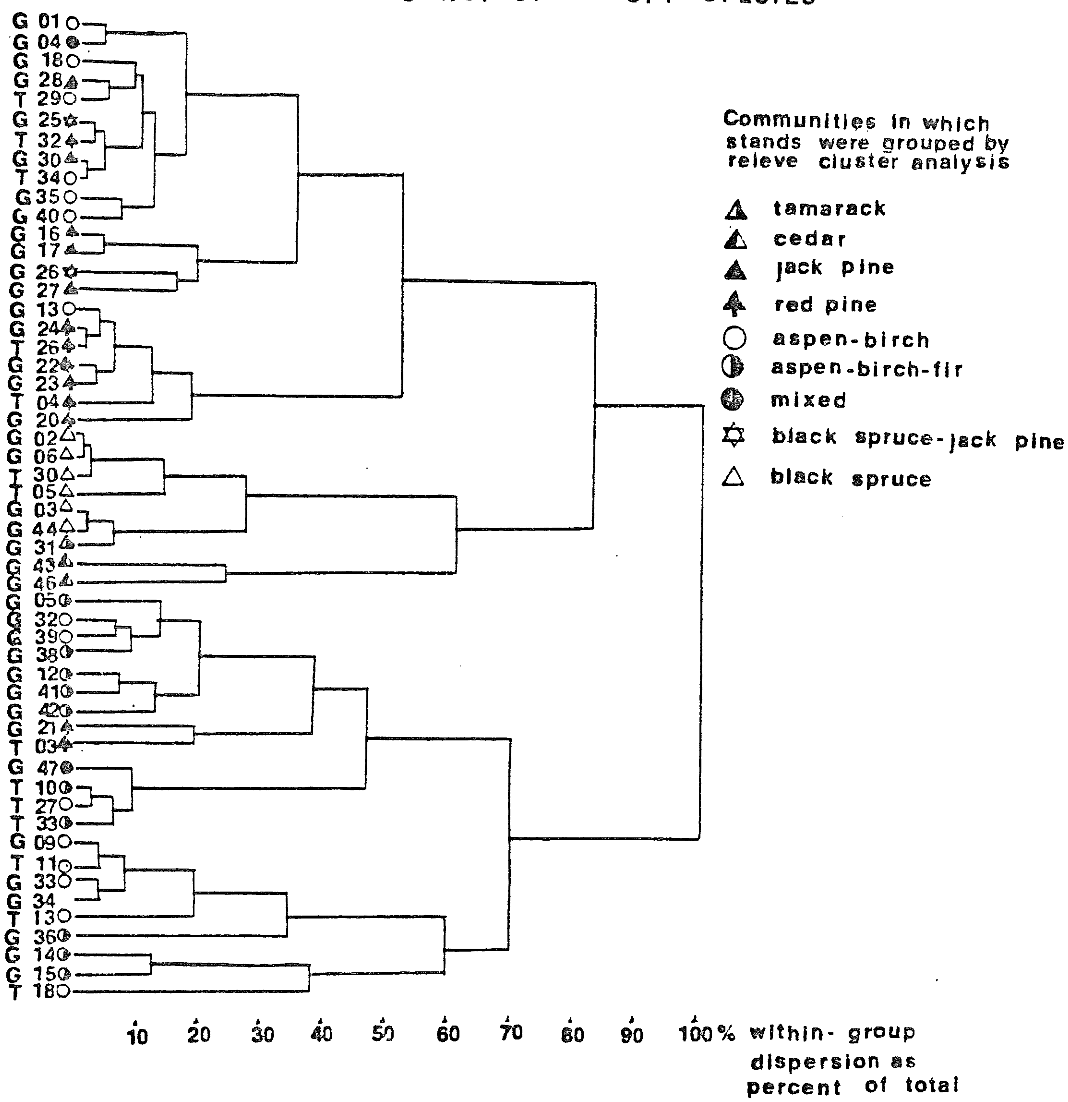
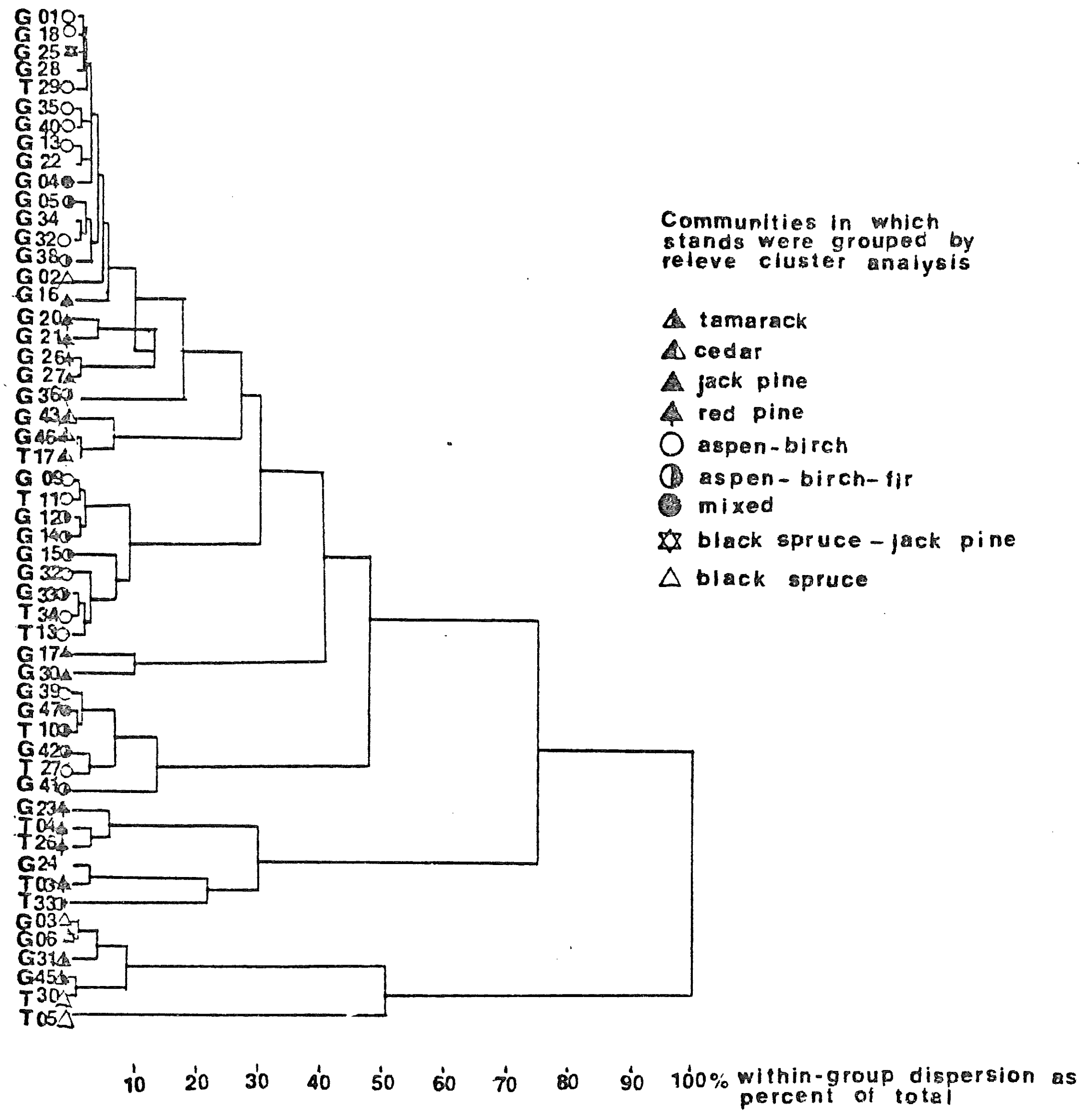


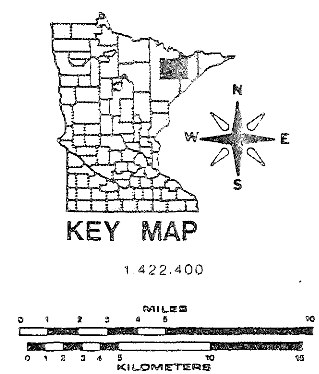
FIGURE 6b DENDROGRAM PRODUCED BY CLUSTER ANALYSIS OF 53 STANDS BASED ON DENSITY OF CANOPY SPECIES



LEGEND

- PINE
- UPLAND SPRUCE (FIR)
- CONIFER BOG
- ASPEN-BIRCH & MIXED DECIDUOUS
- SHRUB CARR & OPEN TAMARACK BOG
- FEN
- UNPRODUCTIVE UPLANDS
- NON-FORESTED
- WATER

SOURCE: REGIONAL COPPER-NICKEL STUDY (MLMIS VARIABLE V45-FILE 0)

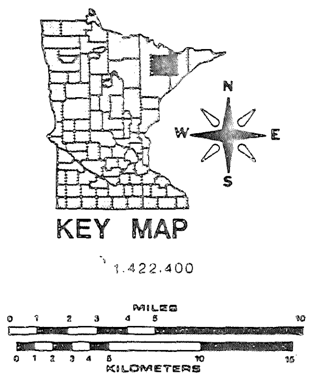


MEQB REGIONAL COPPER-NICKEL STUDY

FOREST COVER

DETAILED CONIFEROUS

SOURCE: REGIONAL COPPER-NICKEL STUDY (MLMIS VARIABLE V45-FILE 0)



MEQB REGIONAL COPPER-NICKEL STUDY

FOREST COVER

DETAILED DECIDUOUS

FIGURE 8 AVERAGE RELATIVE DENSITY OF TREE SPECIES IN EACH COMMUNITY

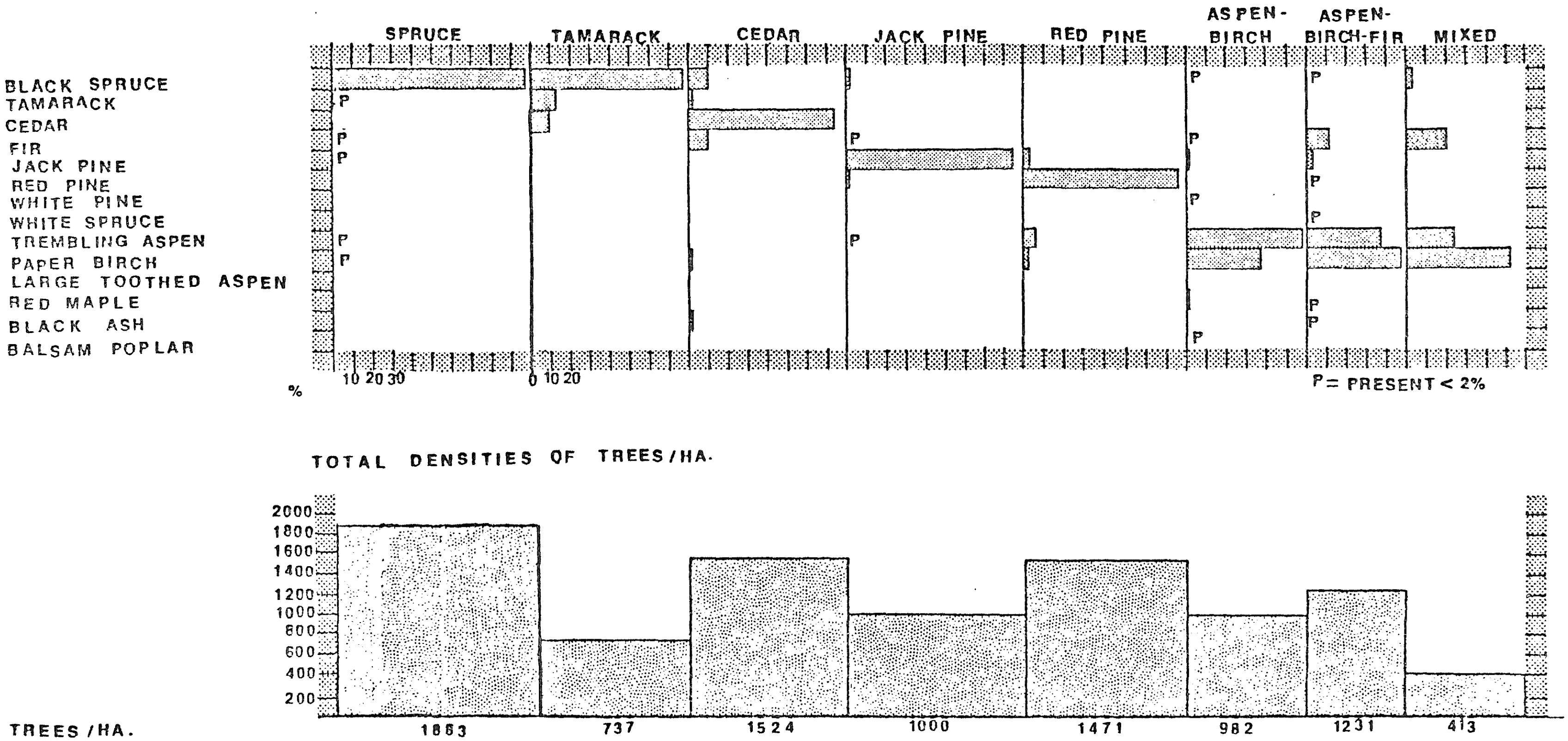


FIGURE 9 AVERAGE BASAL AREA OF TREE SPECIES IN EACH COMMUNITY

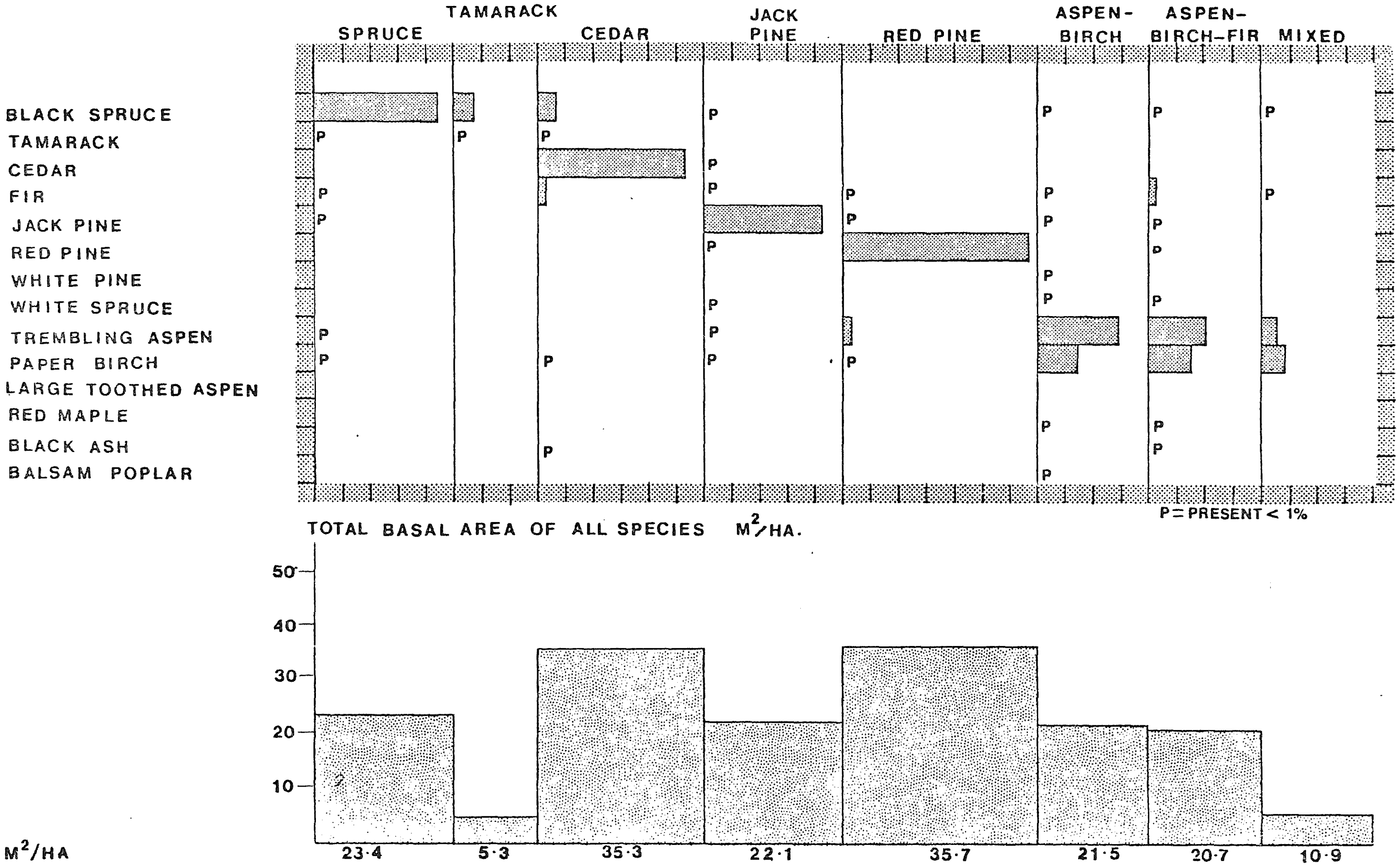


FIGURE 10 AVERAGE DENSITY OF HIGH SHRUB SPECIES IN EACH COMMUNITY

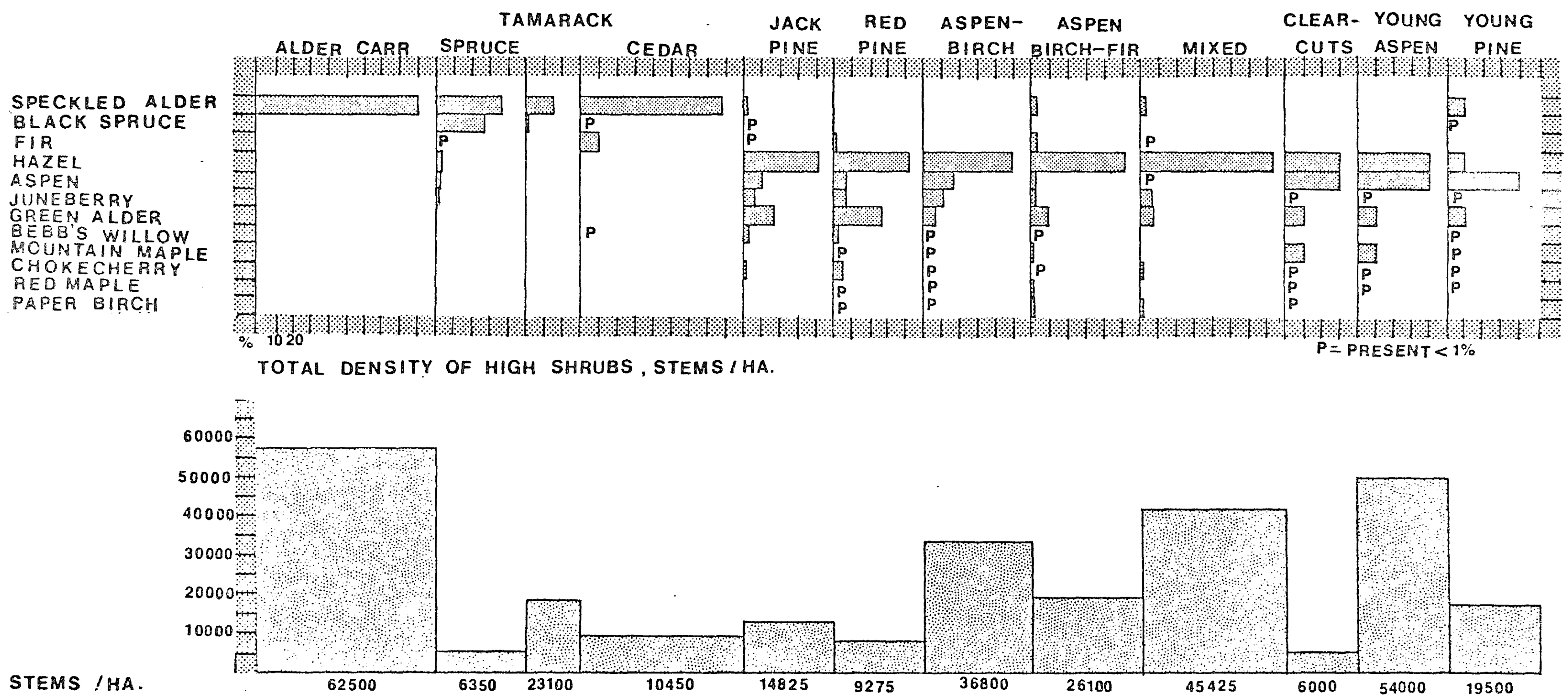


FIGURE 11 AVERAGE BASAL AREA OF HIGH SHRUB SPECIES IN EACH COMMUNITY

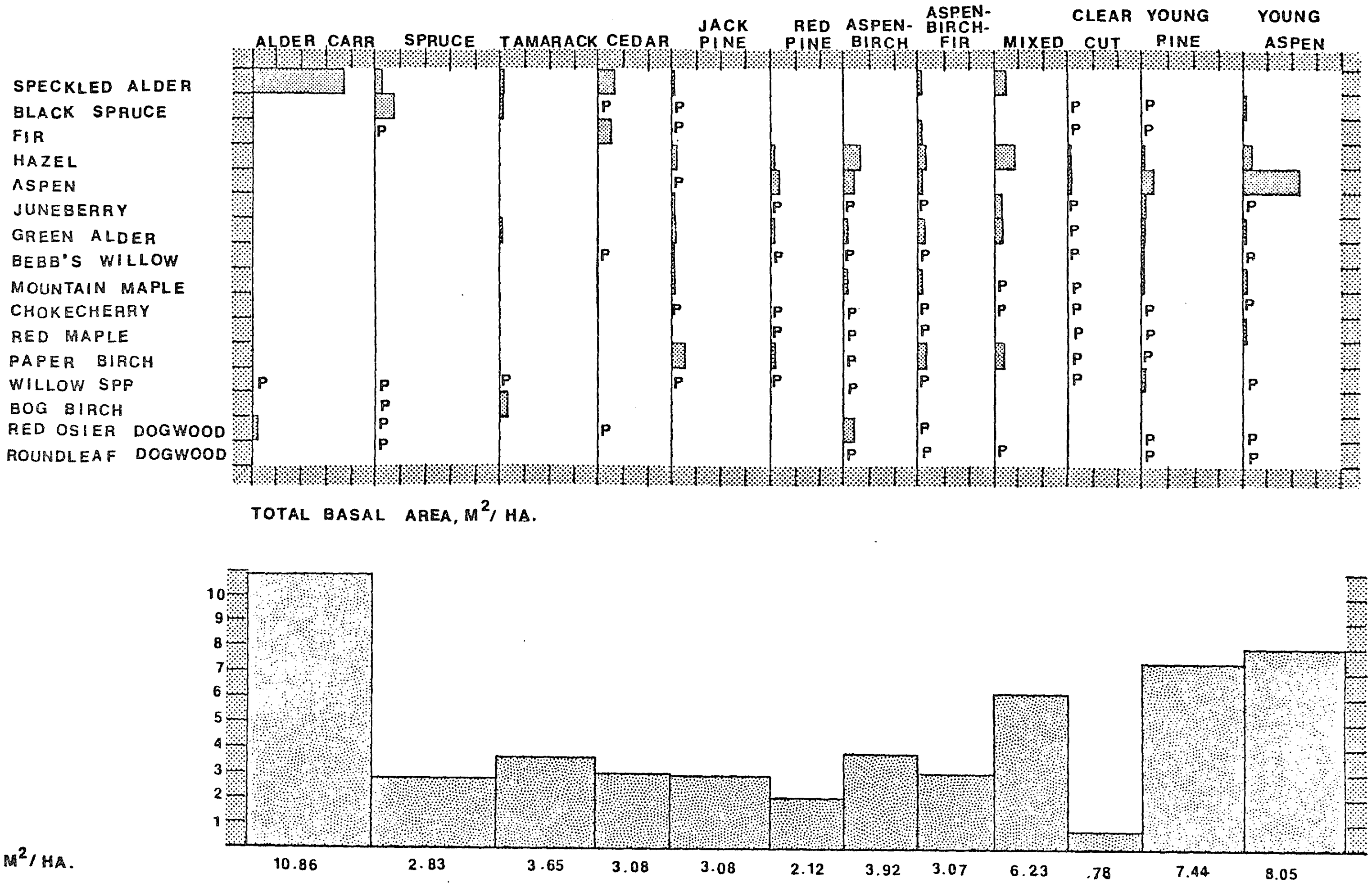


FIGURE 12 AVERAGE RELATIVE DENSITY OF LOW SHRUBS IN EACH COMMUNITY

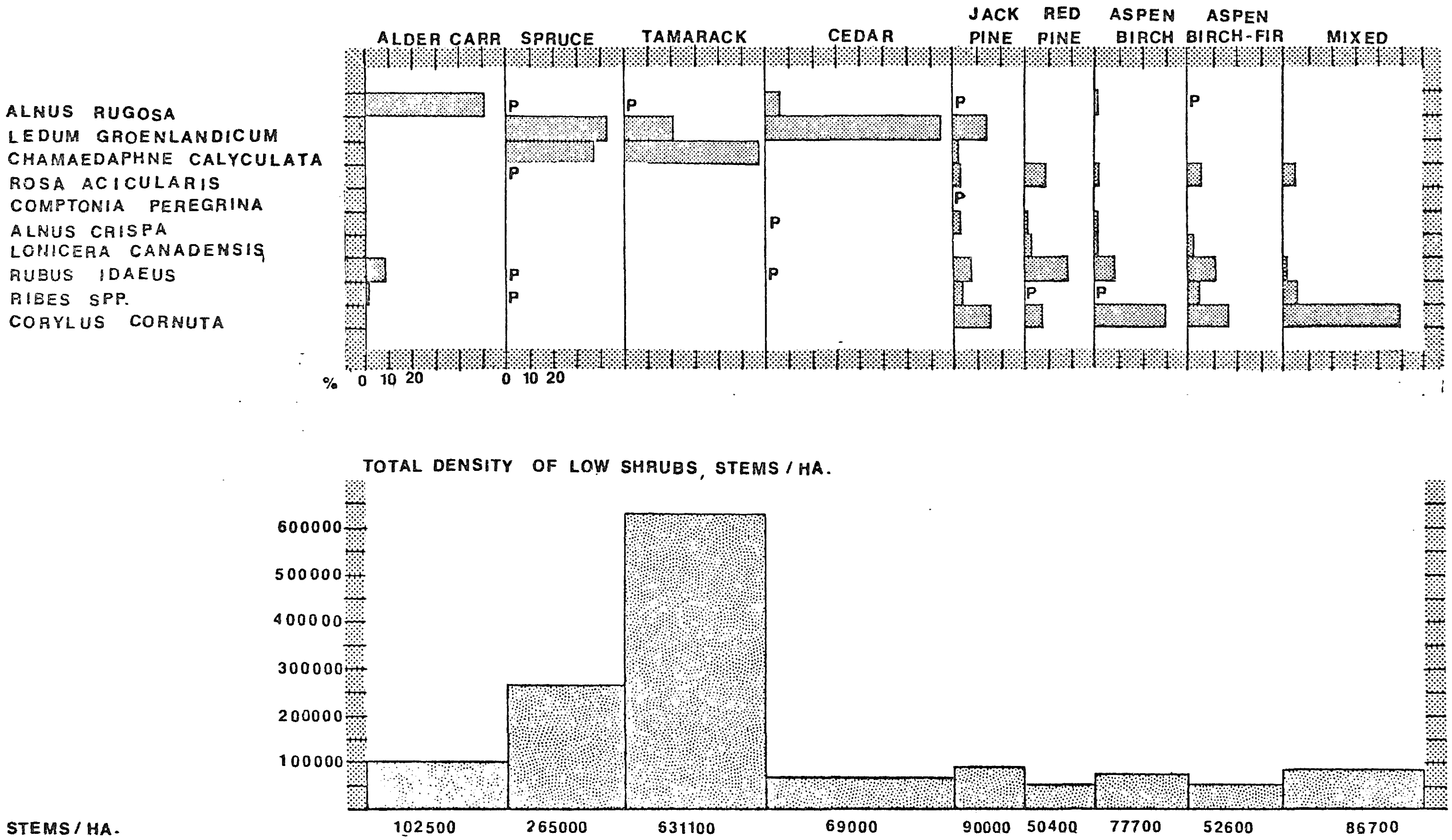


FIGURE 13 AVERAGE PERCENT GROUNDCOVER OF LEADING HERB SPECIES IN EACH COMMUNITY

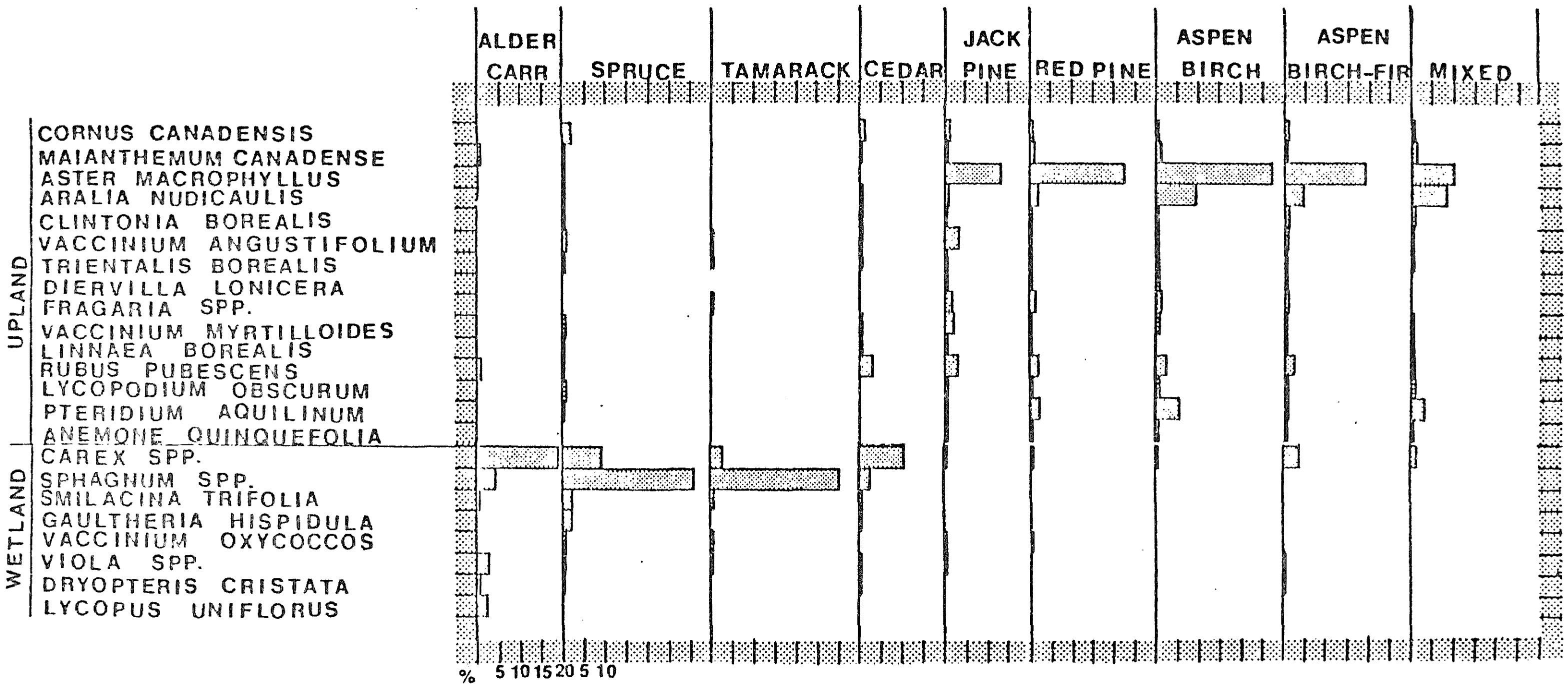


FIGURE 14 GROUNDCOVER IN EACH COMMUNITY

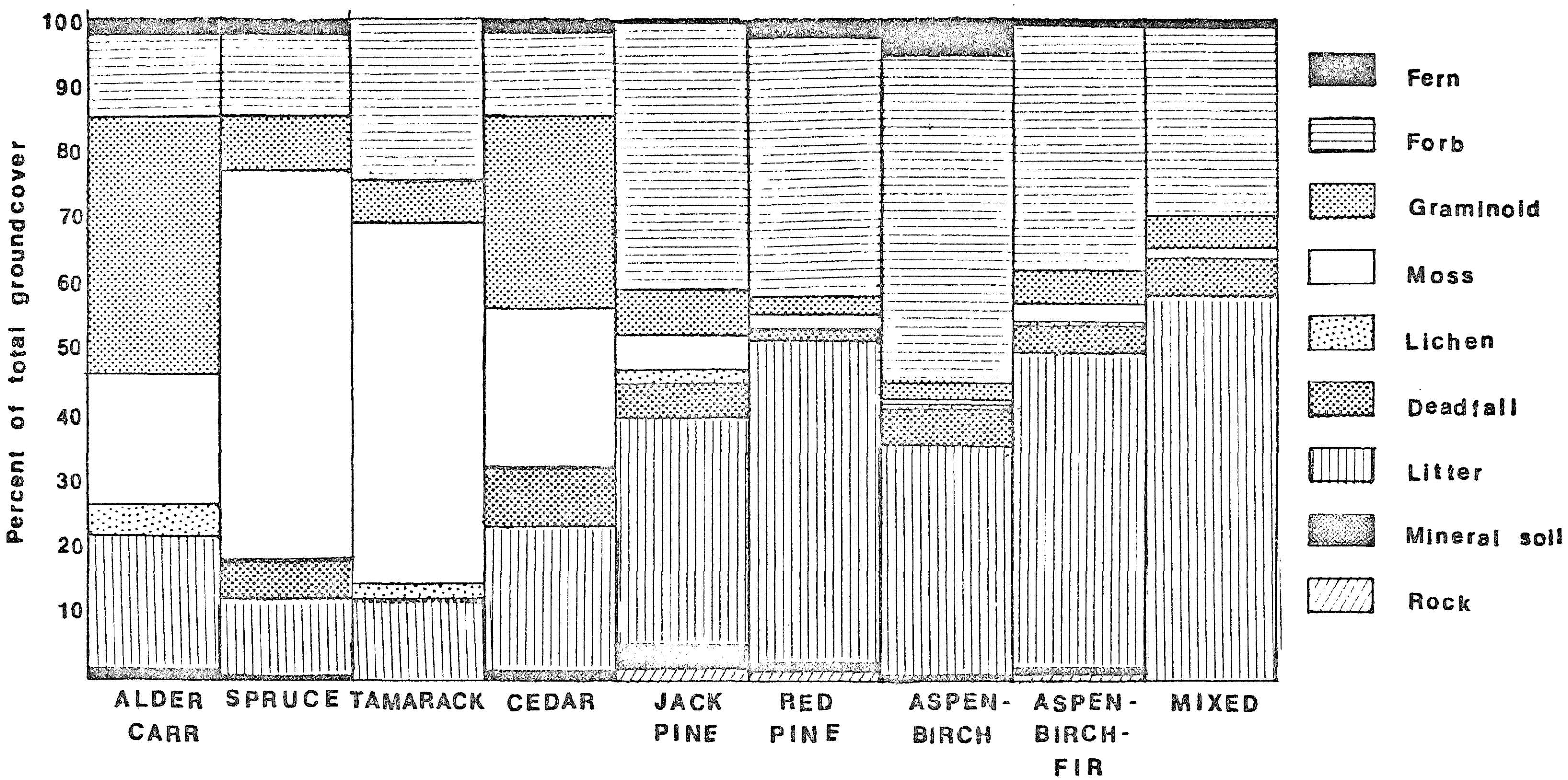
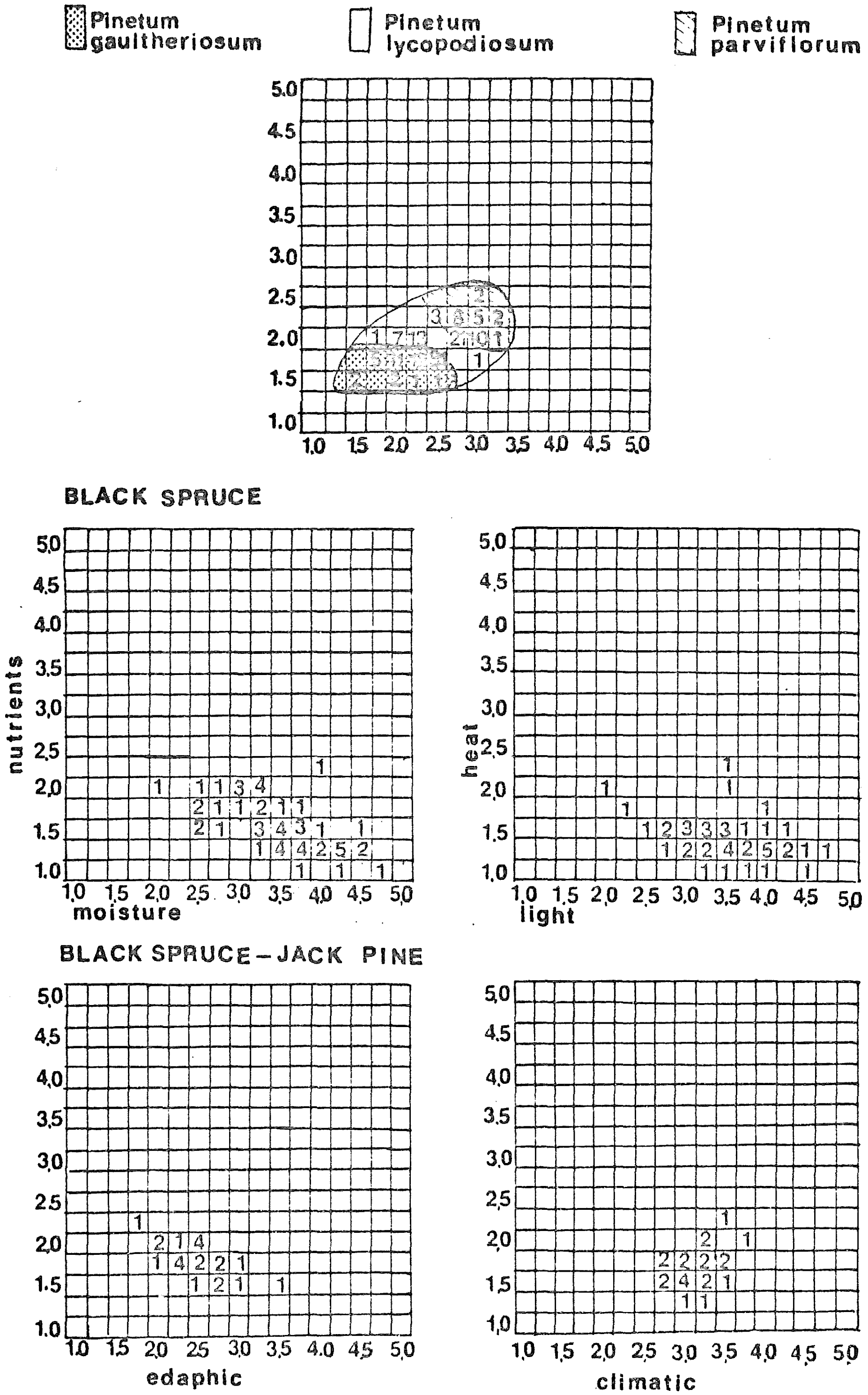


FIGURE 15a DISTRIBUTION OF COMMUNITIES IN SYNECOLOGICAL FIELDS

THREE COMMUNITIES RECOGNIZED BY WARING (1959)



Numbers in each section of the graph indicate the number of stands within the designated community falling in that portion of the synecological field

FIGURE 15b

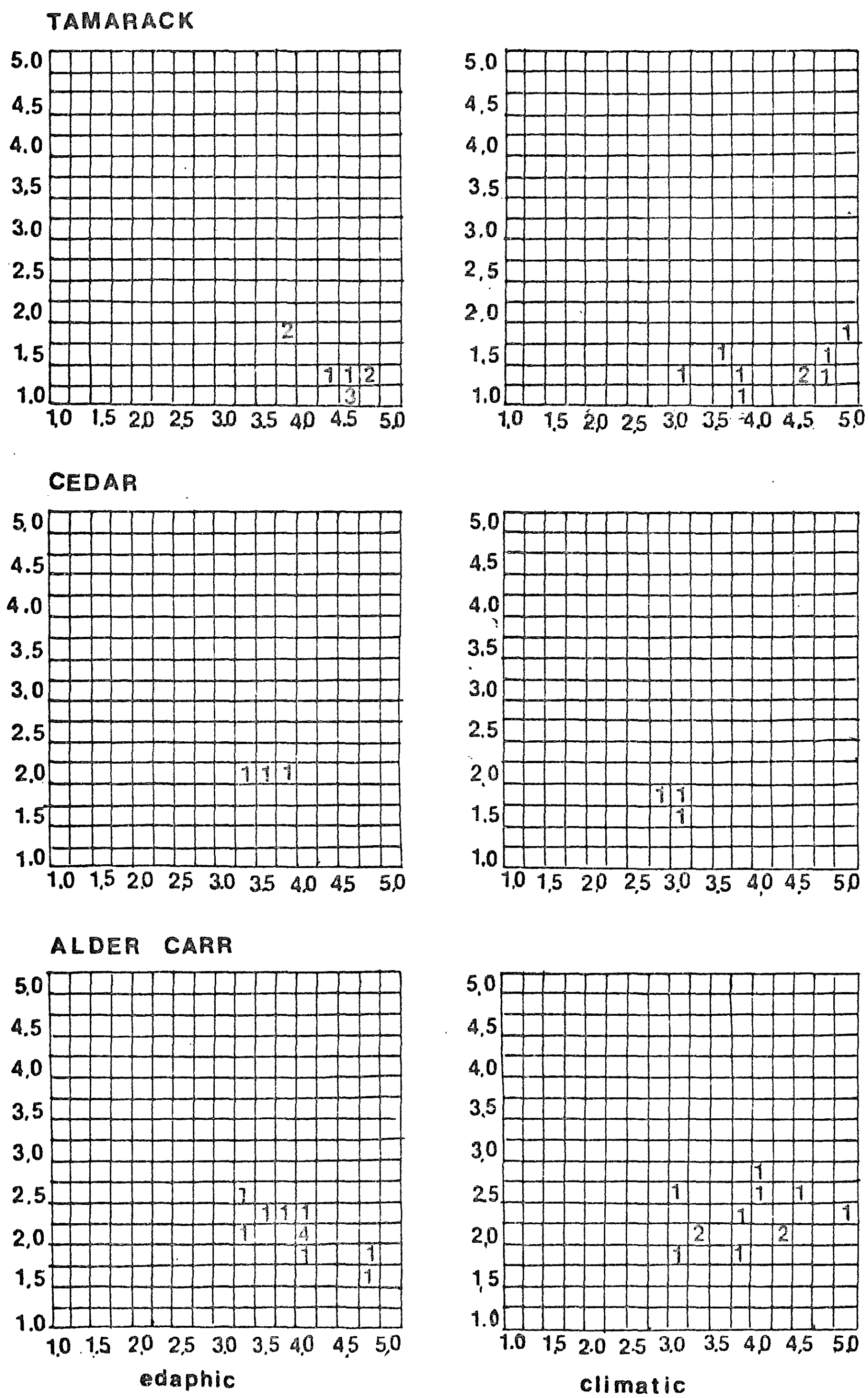


FIGURE 15c

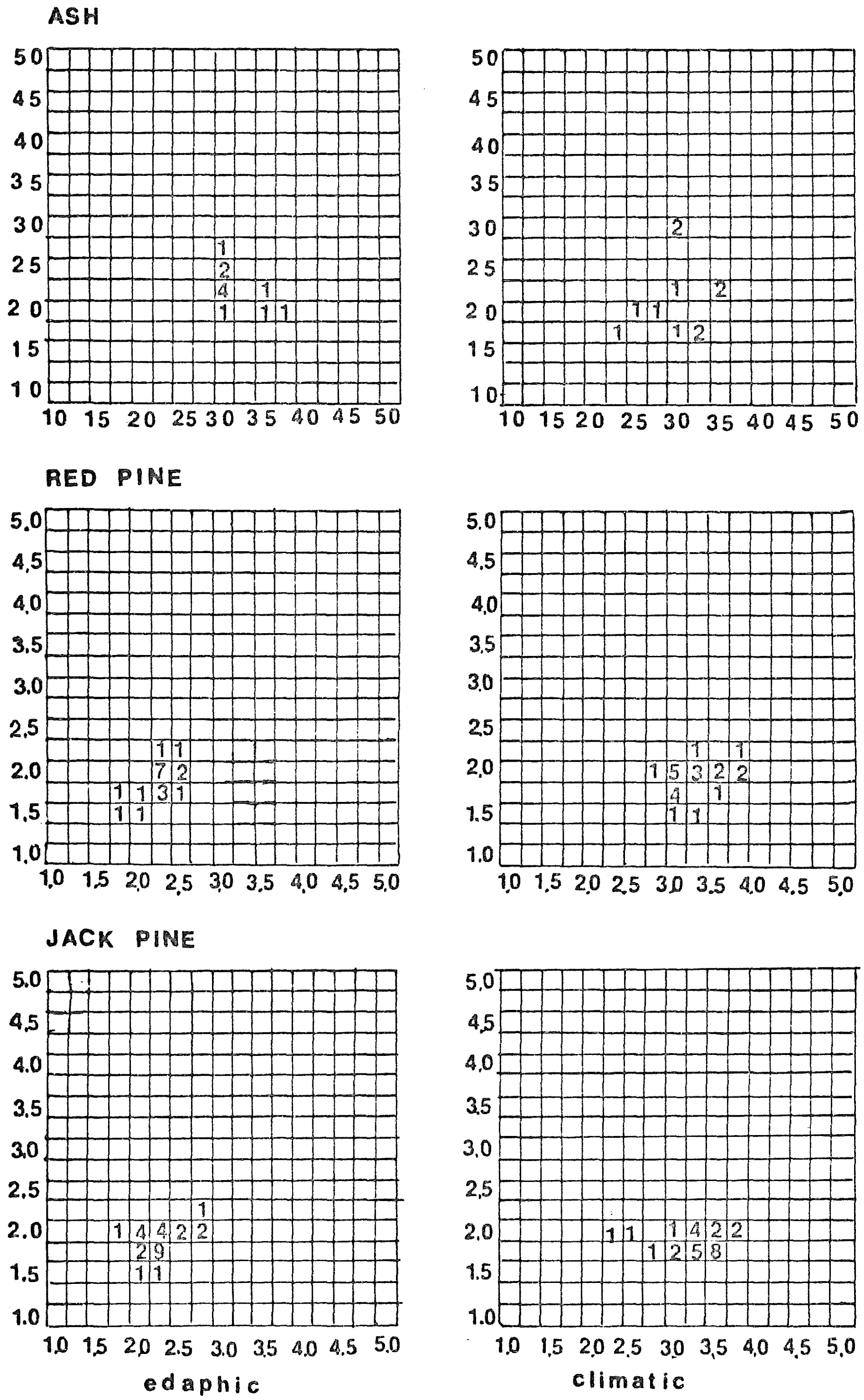


FIGURE 15d

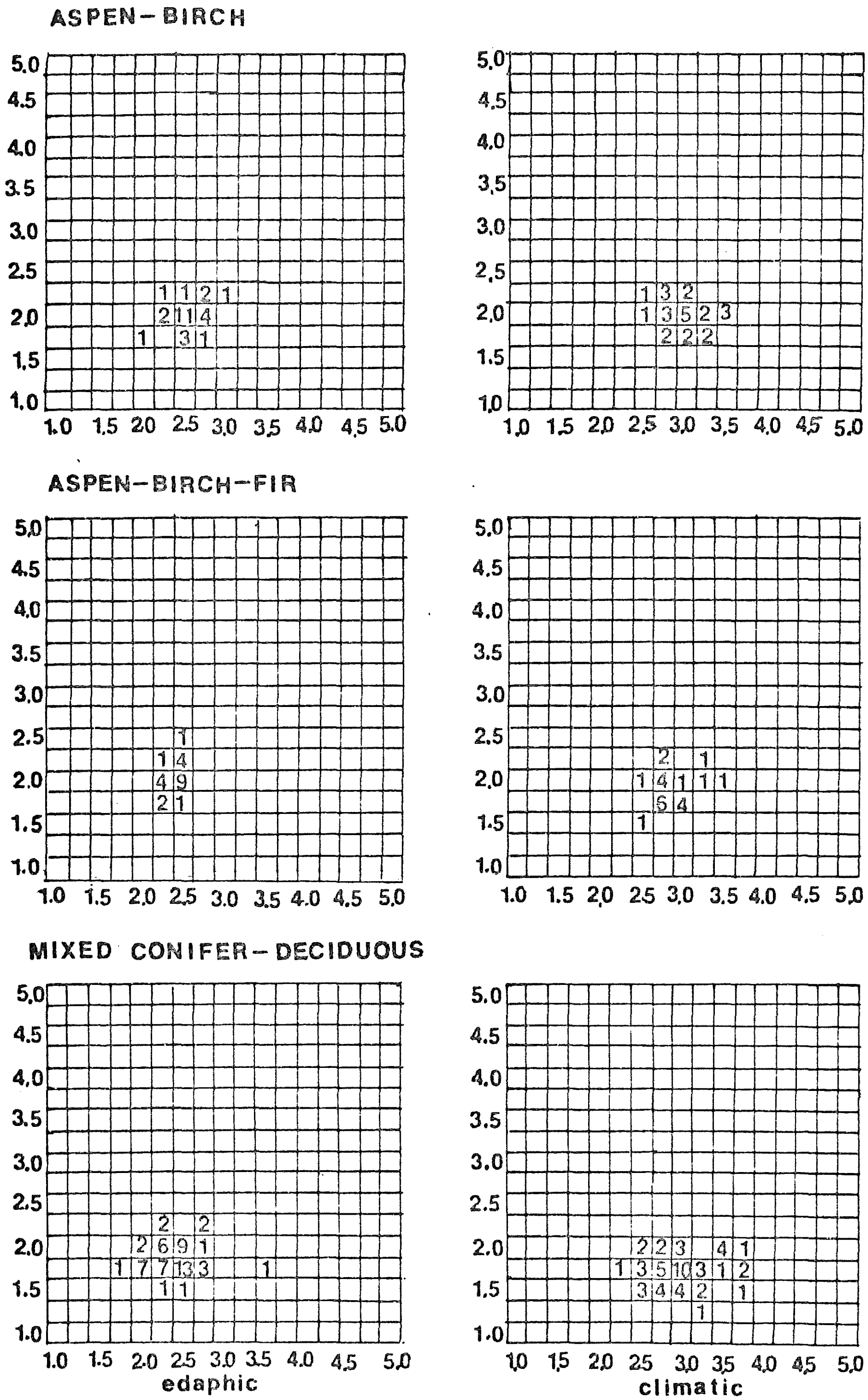
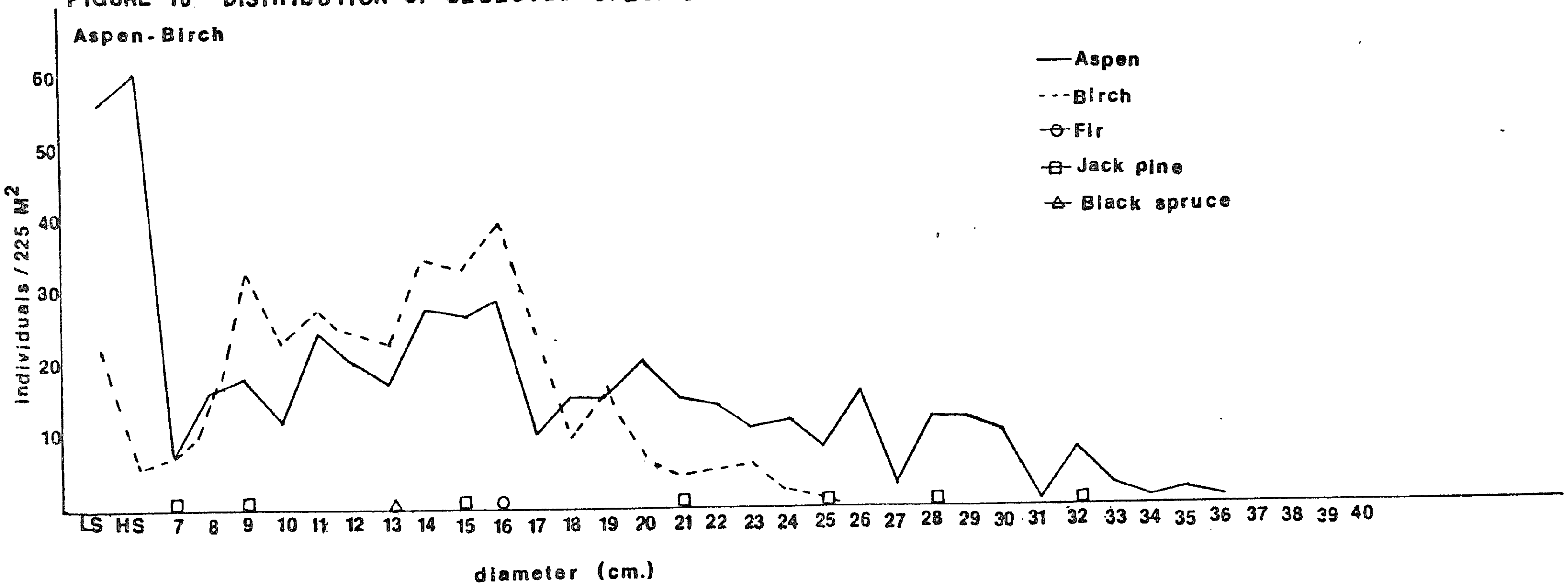
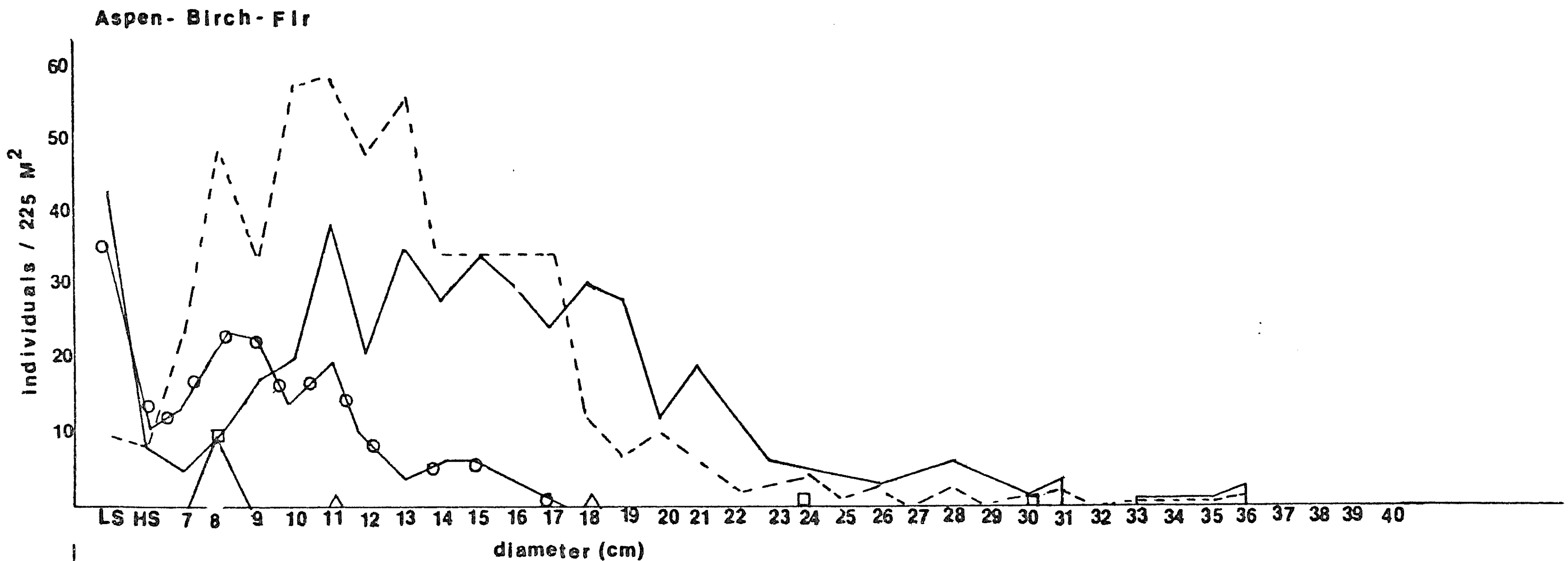

ASPEN-BIRCH
ASPEN-BIRCH-FIR
MIXED CONIFER-DECIDUOUS
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
edaphic
climatic

FIGURE 16 DISTRIBUTION OF SELECTED SPECIES BY DIAMETER CLASS IN THREE UPLAND COMMUNITIES




Aspen- Birch- Fir
individuals / 225 M2
60
50
40
30
20
10
LS HS 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
diameter (cm)

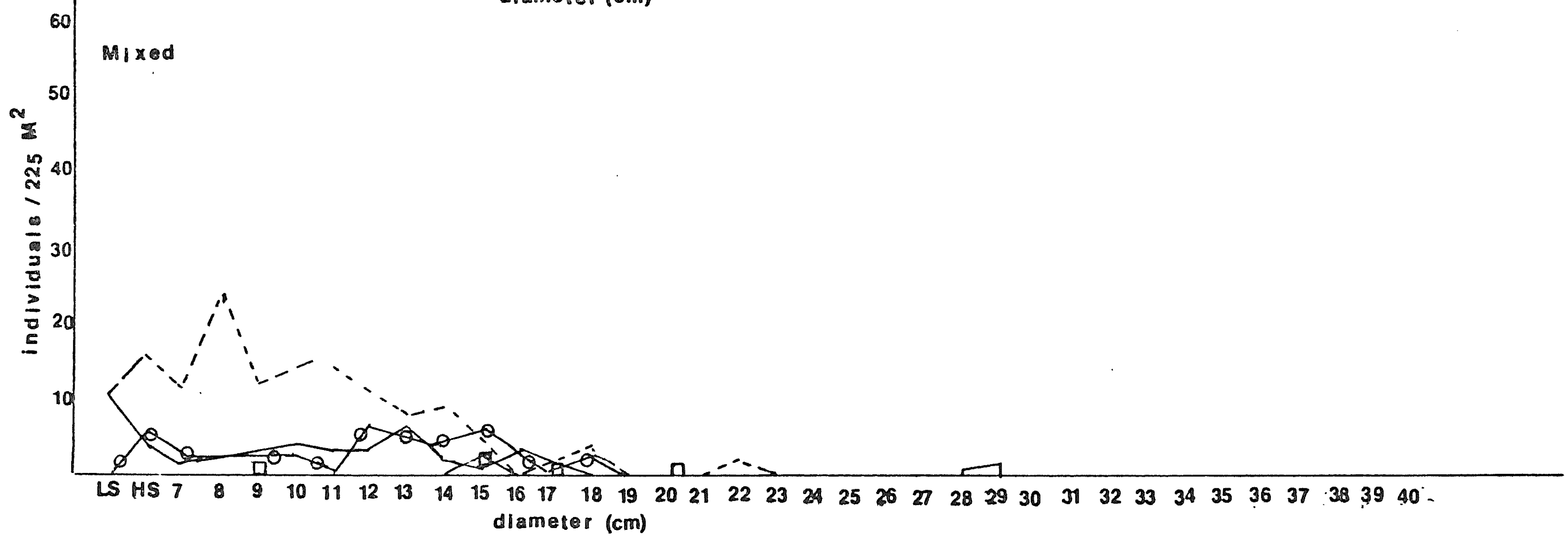

Mixed
individuals / 225 M2
60
50
40
30
20
10
LS HS 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
diameter (cm)

FIGURE 17 AVERAGE BASAL AREA OF HIGH SHRUB SPECIES IN EACH HIGH SHRUB CLUSTER

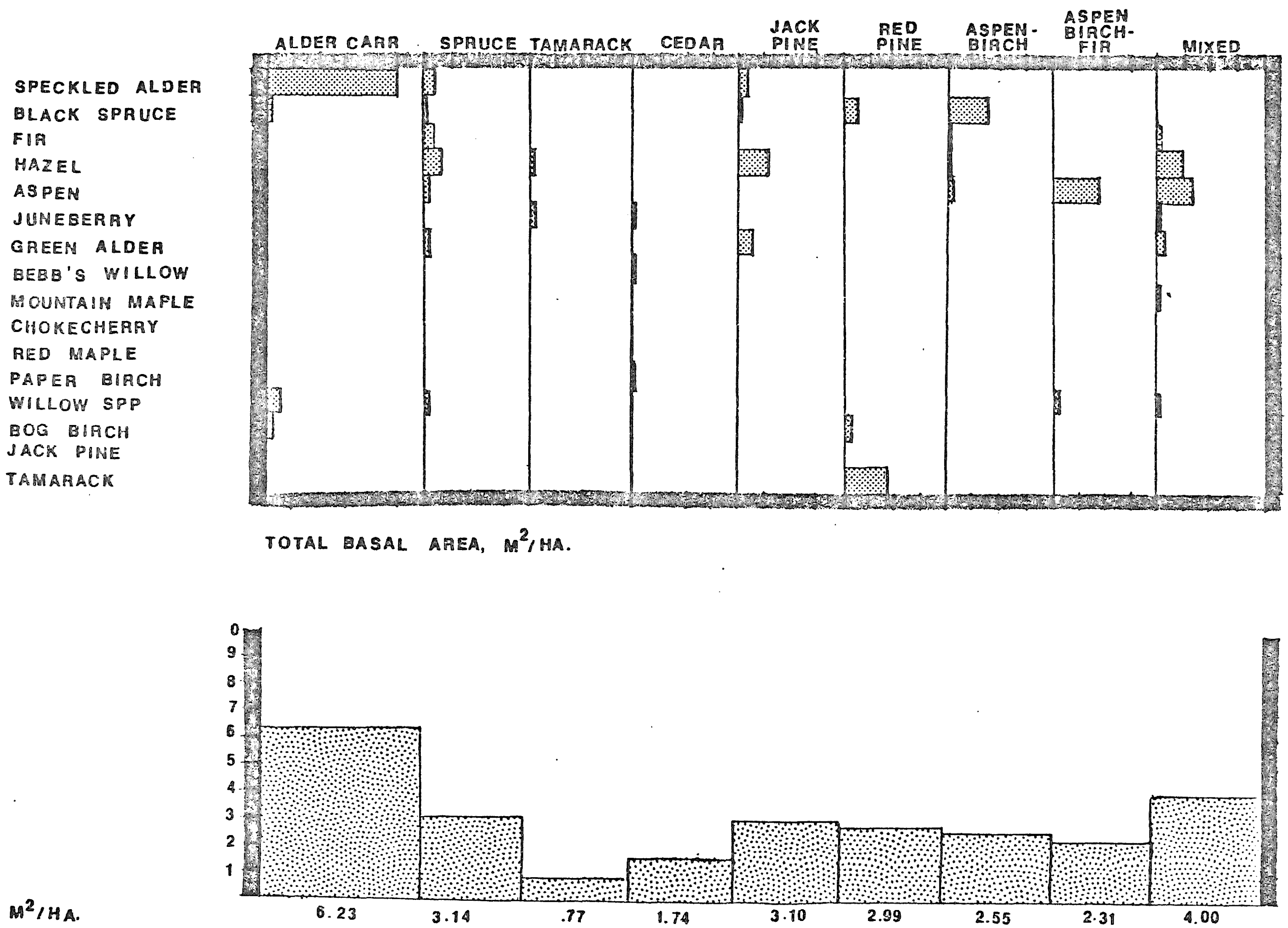
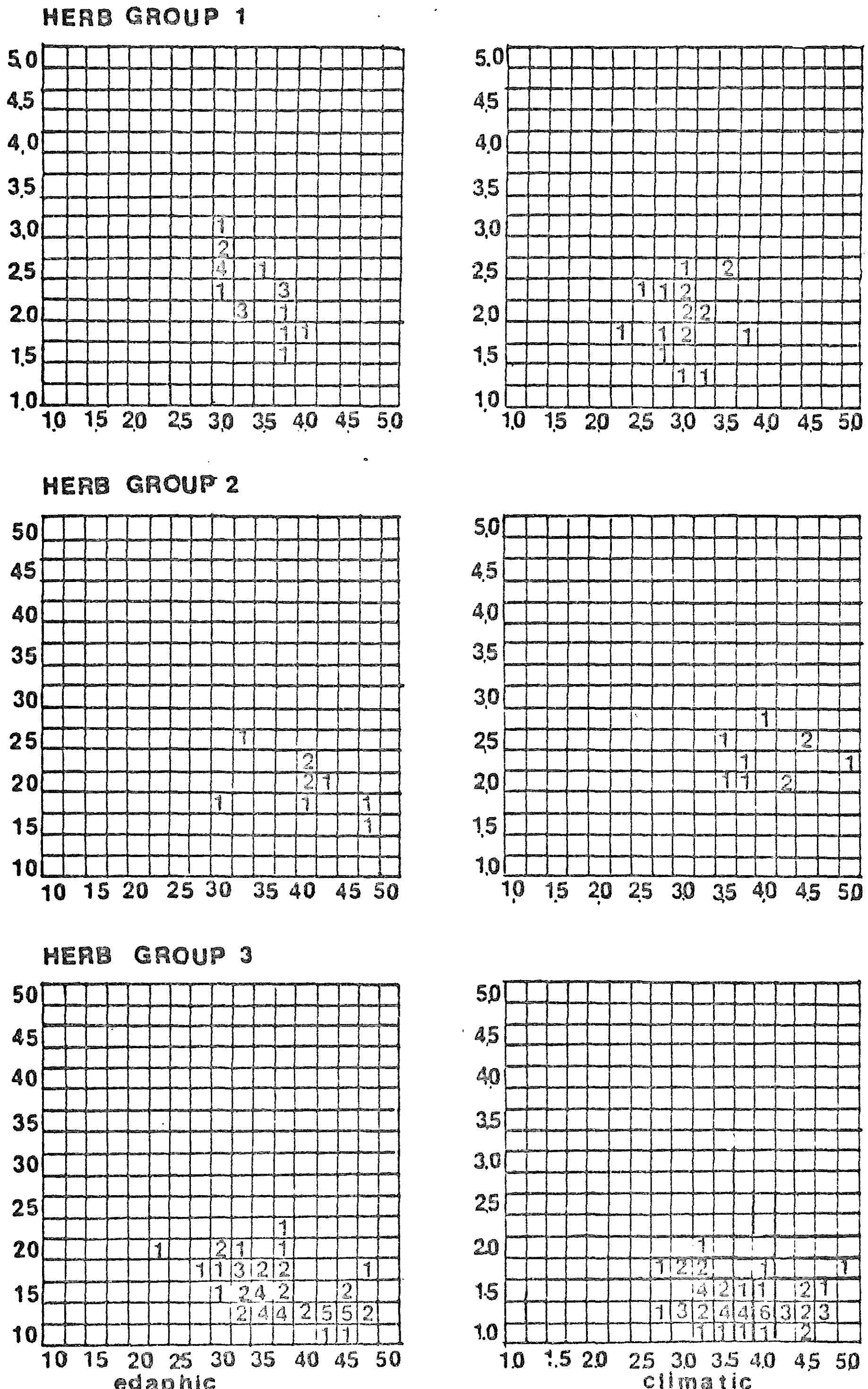


FIGURE 18a DISTRIBUTION OF HERB CLUSTERS IN SYNECOLOGICAL FIELDS



Numbers in each section of the graph indicate the number of stands in that herb group that lie in that portion of the synecological field

FIGURE 18 b

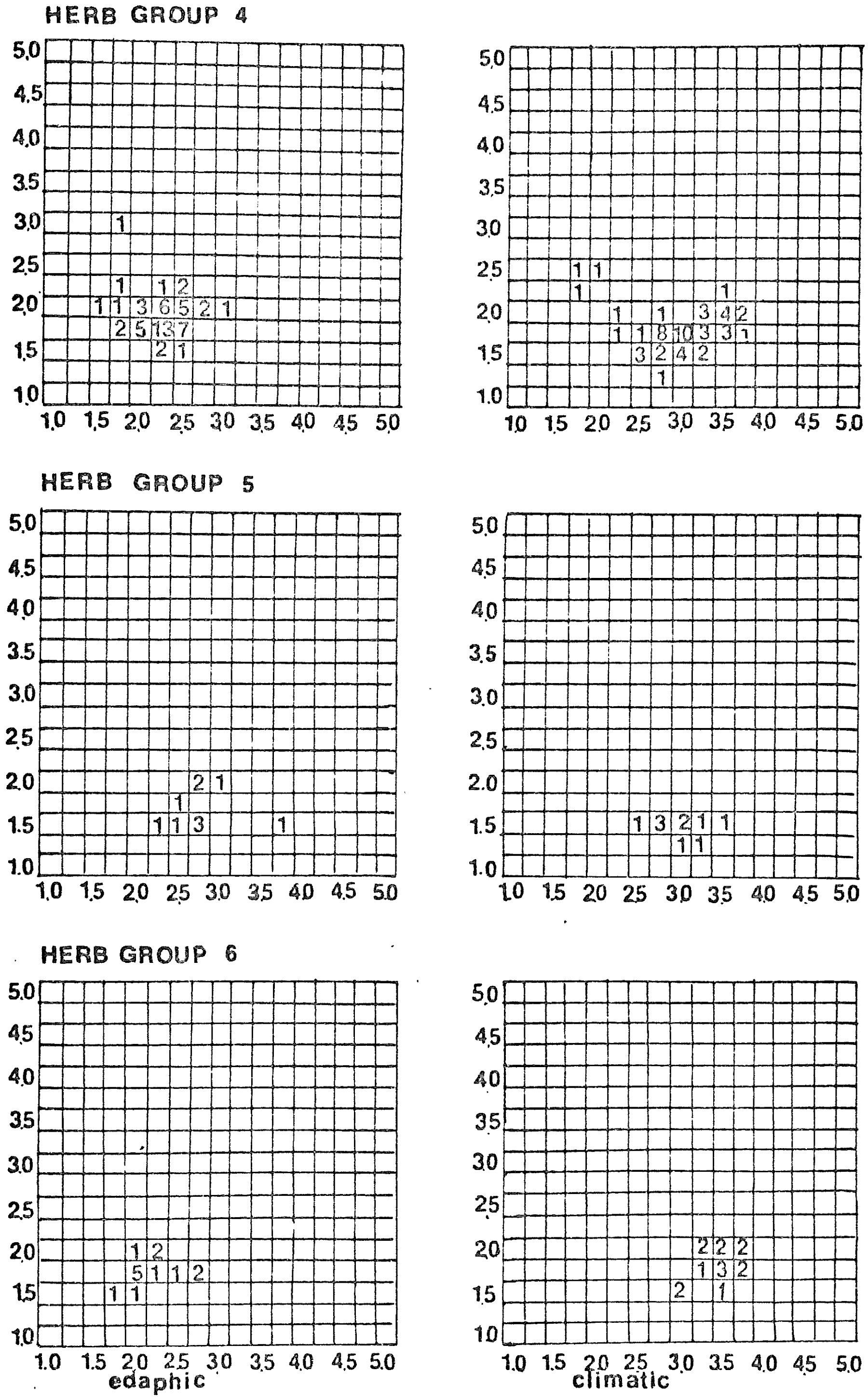


FIGURE 18c

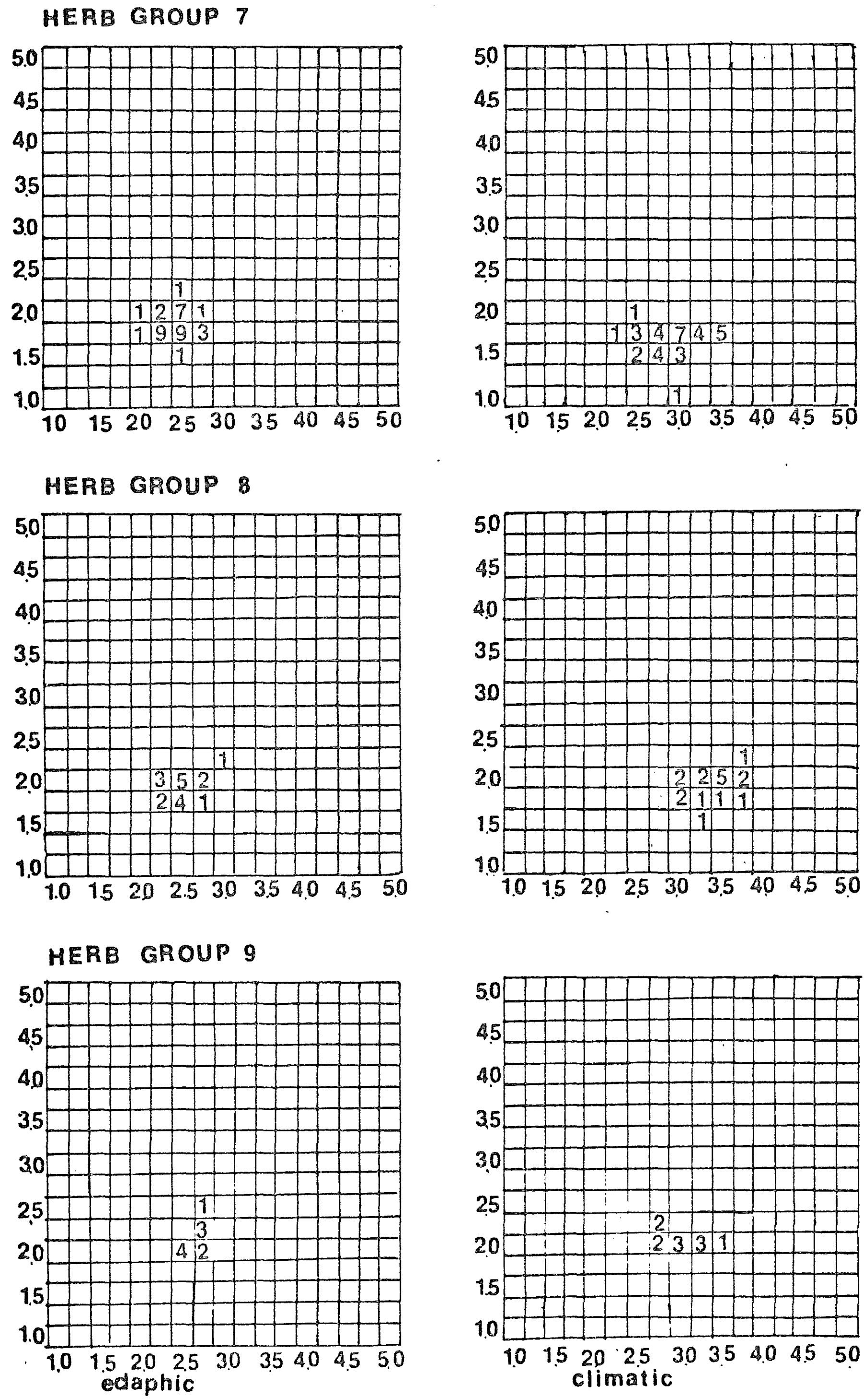
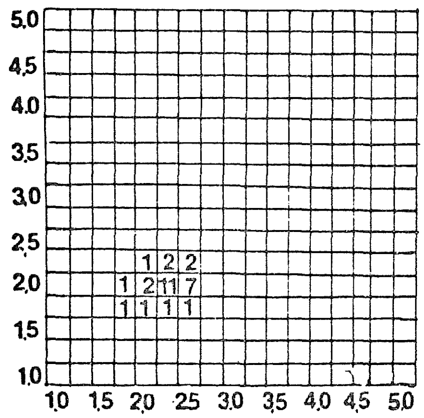
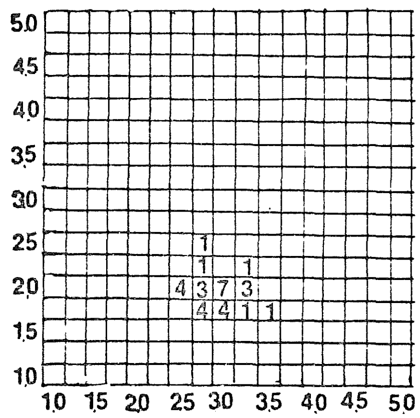

HERB GROUP 7
HERB GROUP 8
HERB GROUP 9
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
edaphic
climatic

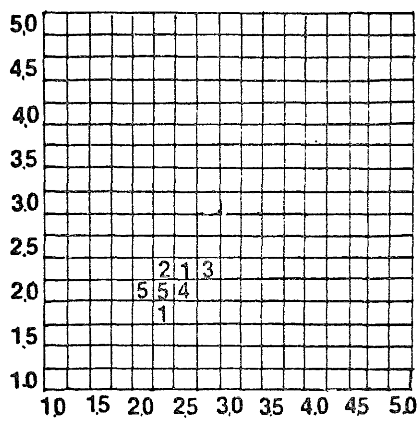
FIGURE 18d.

HERB GROUP 10





HERB GROUP 11



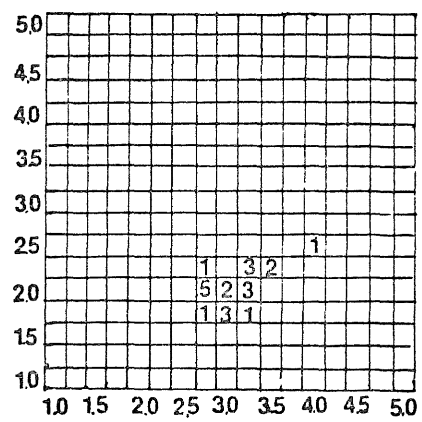
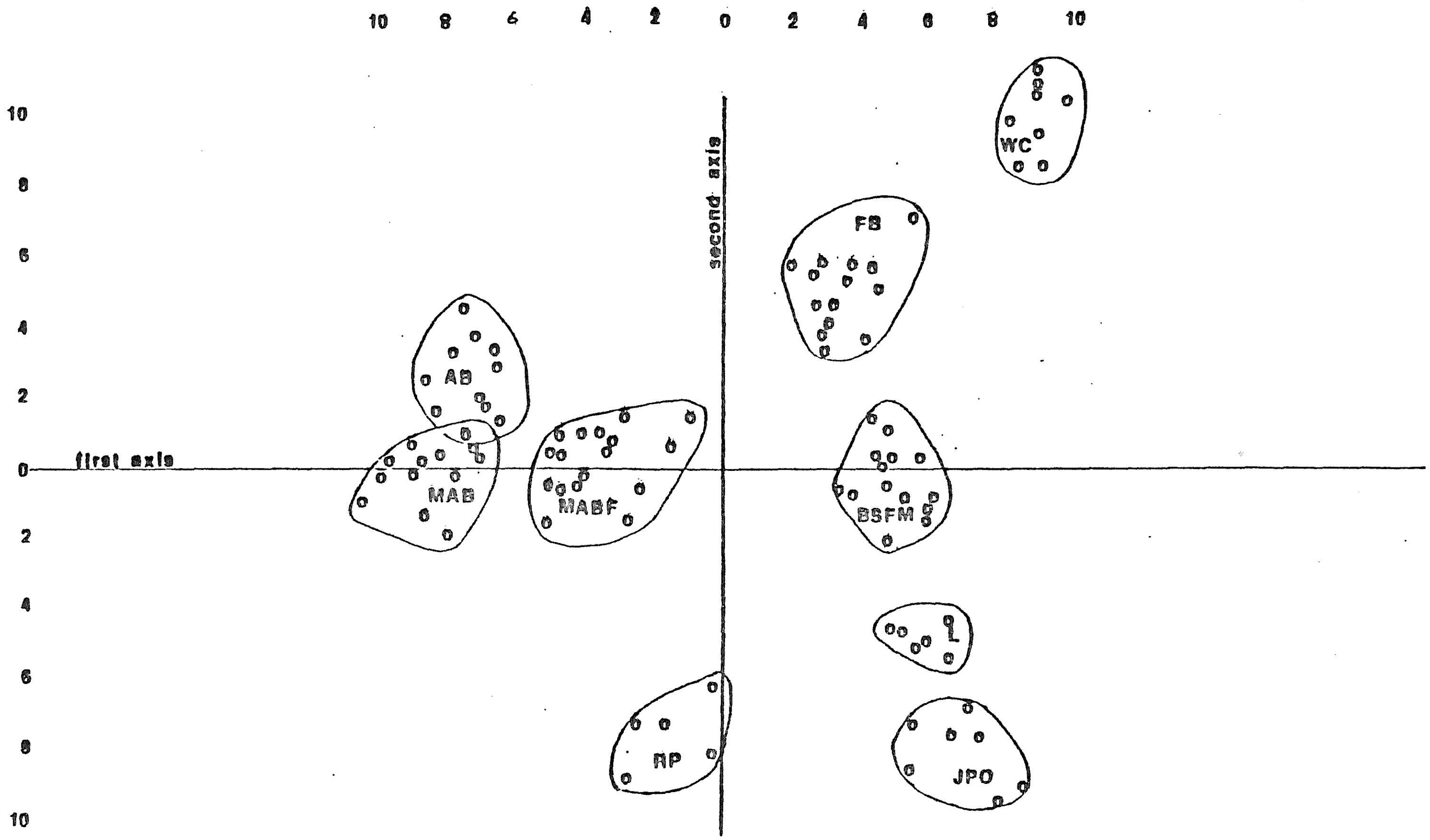


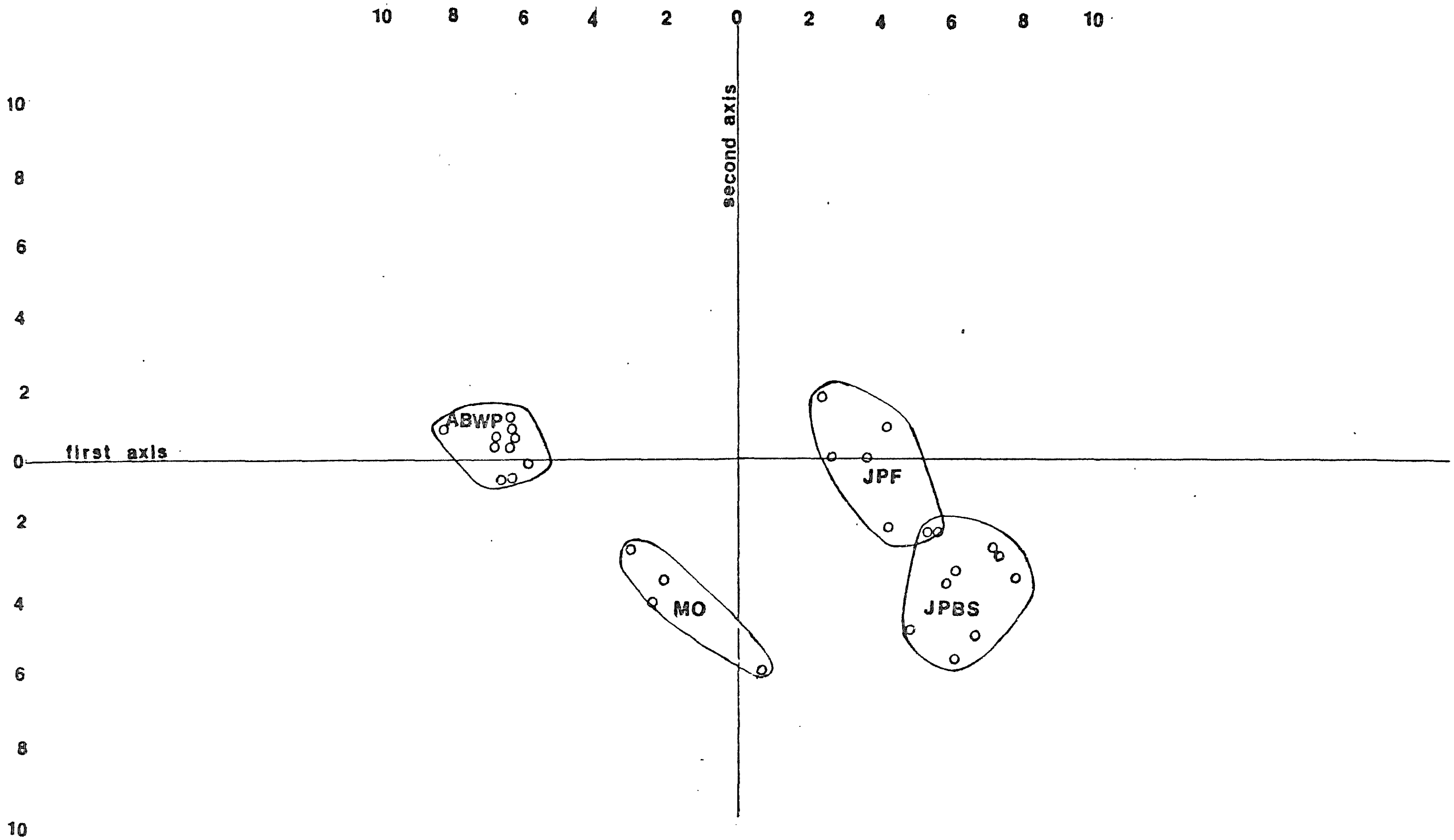
FIGURE 19 a POSITIONS OF BWCA STANDS IN CANONICAL SPACE
FIRST AND SECOND AXES



COMMUNITY TYPES

AB Aspen-Birch
MAB Maple-Aspen-Birch
FB Fir-Birch
MABF Maple-Aspen-Birch-Fir
BSFM Black spruce-Feather moss
L Lichen
JPO Jack pine-Oak
RP Red pine
WC White cedar

FIGURE 19 b POSITIONS OF BWCA STANDS IN CANONICAL SPACE
FIRST AND SECOND AXES



COMMUNITY TYPES

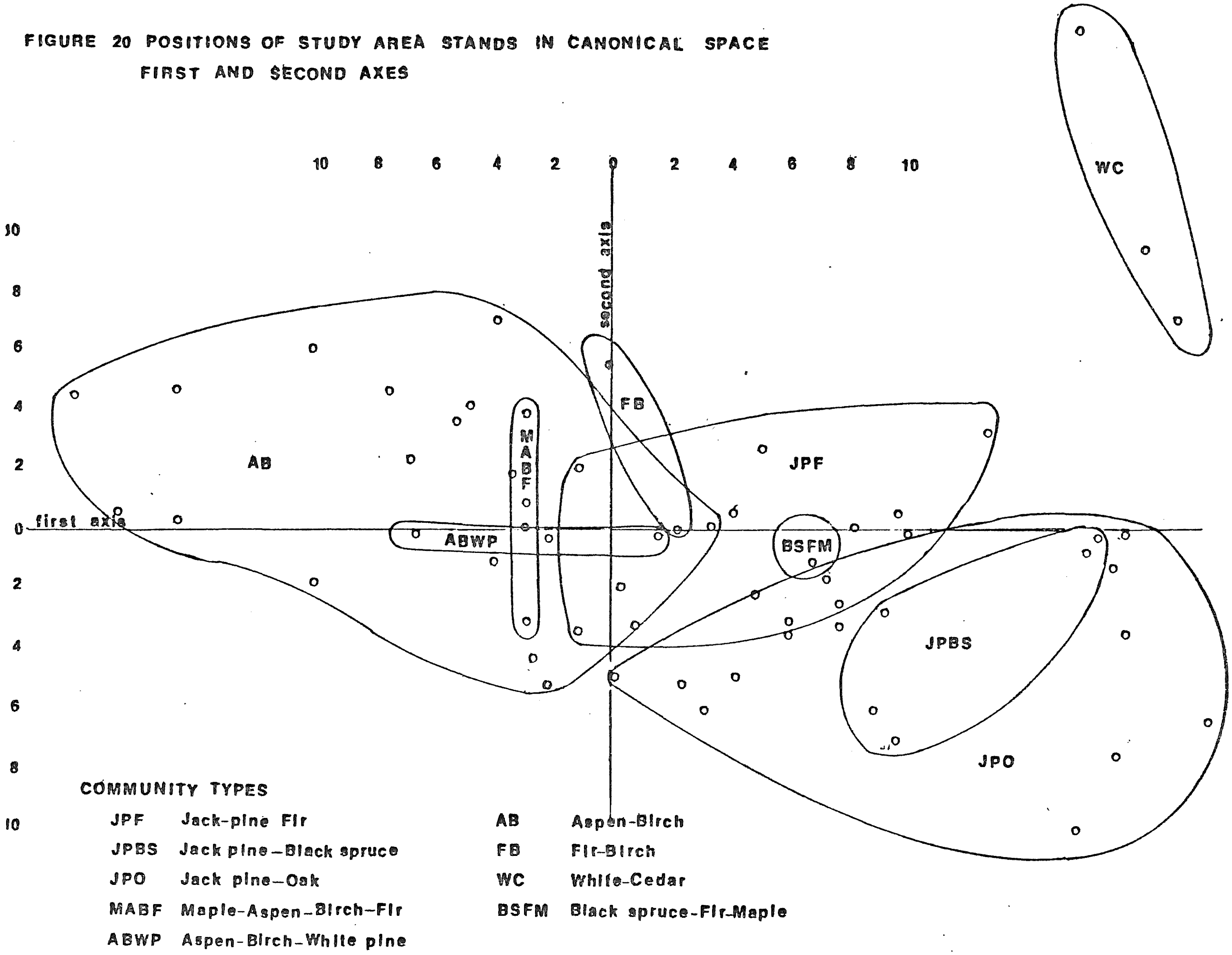
JPF Jack pine – Fir

ABWP Aspen–Birch–White pine

JPBS Jack pine–Black spruce

MO Maple–Oak

FIGURE 20 POSITIONS OF STUDY AREA STANDS IN CANONICAL SPACE
FIRST AND SECOND AXES



APPENDIX I

REGIONAL COPPER-NICKEL STUDY

1977 VEGETATION FIELD METHODS

TREES -- 15 x 15 m quadrats

Definition: A tree is an individual of a woody species greater than or equal to 7.0 cm DBH and/or an individual that is less than 7.0 cm DBH and greater than 7.0 cm in diameter at 10 cm above ground level

Location: Five 15 x 15 m quadrats located within 105 x 105 m grid (see diagram of vegetation plot 1977 for exact location)

Methods: -- record species

-- measure DBH of each tree

-- crown height -- height of the crown will be determined using a range-height finder

HIGH WOODY STEMS -- 2 x 2 m plots

Definition: Any woody stem greater than or equal to 1 m in height and less than 7.0 cm in diameter at 10 cm above ground level

Location: Four 2 x 2 m plots located in the upper left corner of the 15 x 15 m quadrat, adjacent to one another along border A-B

Methods: -- record species

-- count number of stems per 0.5 cm diameter class

LOW WOODY STEMS -- 1 x 1 m plots

Definition: Any woody stem less than 1 m and greater than 10 cm in height

Location: Three 1 x 1 m plots located in the upper-left and lower-right corners one meter in from the 15 x 15 m quadrat boundaries and one in the middle of the 15 x 15 m quadrat. These are the same plots used for measuring herbs and seedlings. (See diagram of vegetation plot 1977 for exact location.)

Methods: -- record species

-- count number of stems of each individual

SEEDLINGS -- 1 x 1 m plots

Definition: Tree seedlings less than or equal to 10 cm in height

Location: The same three plots used for low woody stems and herbaceous plants

Methods: -- record species

-- count individuals

HERBACEOUS PLANTS -- 1 x 1 m plots

Definition: Any non-woody plant and those species of woody plants that act as non-woody plants (*Vaccinium augustifolium*, *Vaccinium myrtilloides*, *Gaultheria procumbens*, *Gaultheria hispidula*, and *Rubus pubescens*)

Location: The same three plots used for low woody stems and seedlings

Methods: -- record species

-- estimate per cent cover using acetate grid

-- per cent "total"

-- per cent "total"

total cover of each species

-- per cent "visible"

ground cover -- total to equal 100%

(per cent cover divided into 10 categories: forbs, graminoid, fern, moss, lichen, rock outcrop, mineral soil, litter, dead fall, and water)

OTHER -- 1 x 1 m plots

Definition: Any ground cover not previously accounted for (deadfall, rock outcrop, mineral soil, moss, litter, lichens, water)

Location: The same three plots used for low woody stems, seedlings, and herbaceous plants

Methods: Estimate per cent cover using acetate grid

Appendix I. Distribution of moss species among communities.

	Shrub carr	Spruce			Tamarack			Cedar	Jack pine					Red pine		Aspen-birch					Aspen-birch-fir			Total species occurrence
	T22	T06	T28	T05	T15	T14	T16	T17	T01	T02	T19	T20	T21	T03	T04	T07	T09	T11	T12	T13	T08	T10	T18	
Drepanocladus aduncus v. polycarpus	+																		+					1
Campylium radicale	+																							1
Plagiothecium laetrum	+		+	+																				3
Fissidens osmundoides	+						+	+																3
Calliergon cordifolium	+						+	+																3
Bryum pseudotriquetrum	+		+	+			+	+											+					6
Sphagnum centrale	+		+	+	+	+	+	+															+	8
Sphagnum capillifolium	+		+	+	+	+	+	+																7
Sphagnum fuscum		+																						1
Leptodictyum riparium		+						+																2
Sphagnum recurvum		+		+	+			+															+	5
Sphagnum magellanicum		+		+	+			+																4
Campylium stellatum				+	+			+																3
Mnium punctatum			+			+																		2
Mnium punctatum v. elatum			+			+	+																	3
Mnium pseudopunctatum			+				+																	2
Drepanocladus exannulatus			+					+																2
Sphagnum wulfianum			+	+																				2
Dicranum montanum			+	+																				2
Campylium polygamum			+	+																				2
Calliergon giganteum			+																					1
Sphagnum warnsdorfii			+																					1
Plagiothecium denticulum			+																					1
Fissidens adiantoides			+																					1
Mnium spinulosum			+																					1
Campylium chrysophyllum				+																				1
Calliergon richardsonii				+				+																2
Tomenthypnum nitens v. falcifolium					+																			1
Polytrichum strictum					+																			1
Hypnum lindbergii					+	+		+																3
Campylium hispidulum						+		+																2
Ceratodon purpureus						+																		1
Rhynchostegia serrulata						+																		1
Brachythecium rutabulum							+																	1
Leptodictyum tripodum							+																	1
Polytrichum formosum v. aurantiacum							+																	1
Meersia triquerta							+																	1
Hypnum pratense	+					+									+									3
Polytrichum commune	+	+		+						+						+				+				6
Tomenthypnum nitens		+	+				+									+								4
Thuidium recognitum	+												+			+								3
Platygyrium repens	+											+	+		+				+		+			6
Climacium dendroides	+					+	+												+	+	+		+	7

Dicranum drummondii		+	+	+		+	+	+	+					+	+						+	+		11
Dicranum flagellare	+	+	+				+	+	+	+				+	+		+				+	+	+	13
Polytrichum formosum		+																					+	2
Pohlia nutans		+	+	+		+		+	+	+						+		+					+	10
Polytrichum juniperinum		+	+			+		+	+		+	+	+	+		+	+		+	+	+	+	+	16
Tetraphis pellucida		+	+	+				+						+		+					+			7
Ptilium crista-castrensis		+	+	+		+				+				+	+	+			+	+	+		+	12
Pleurozium schreberi		+	+	+		+	+	+	+	+		+	+	+	+	+	+		+	+	+	+	+	19
Dicranum polysetum		+		+		+		+	+	+		+		+	+	+	+	+	+	+				14
Drepanocladus fluitans		+																					+	2
Hylocomnium splendens			+	+		+				+									+	+				6
Calladium haldianum			+	+	+	+		+	+	+	+			+	+	+	+	+	+	+	+	+	+	18
Dicranum scoparium		+	+	+			+					+	+			+						+	+	9
Polytrichum juniperinum v. affine			+	+	+															+				4
Hypnum pallescens			+	+				+	+	+		+					+			+				8
Hedwigia ciliata			+									+	+			+		+	+	+	+	+	+	10
Haplocladium microphyllum			+															+	+			+		4
Dicranum undulatum			+		+	+															+			4
Drepanocladus uncinatus			+			+	+	+				+		+		+			+	+	+		+	11
Aulocomnium palustre			+		+	+	+	+											+	+			+	8
Thuidium delicatulum			+			+	+	+										+		+	+		+	8
Rhytidiodelphus triquetrus			+					+									+				+		+	5
Brachythecium curtum			+												+									2
Sphagnum subsecundum						+																	+	2
Campylium hispidulum						+										+							+	3
Ceratodon purpureus						+		+			+	+		+		+		+		+			+	9
Pylaisiella polyantha						+			+	+	+	+		+	+	+	+	+	+	+	+	+	+	15
Mnium cuspidatum							+				+	+			+	+	+	+	+	+	+	+	+	12
Homomallium odonatum							+					+	+		+	+	+			+	+	+		9
Drepanocladus uncinatus v. plumulosus							+																+	2
Drepanocladus aduncus v. Kneiffii							+																+	2

Appendix III. Distribution of lichen species among communities

* Supplemental sites

Species	Shrub carr		Spruce					Tamarack		Cedar			Ash	Jack pine								
	G18	G48	G01	G02	G03	G06	G44	G31	G45	G43	G46	*	*	G25	G26	G11	G13	G16	G17	G27	G28	G30
Chaenothecopsis debilis					+	+																
Chaenotheca chrysocephala					+		+															
Calicium parvum					+							+										
Collema subflaccidum			+										+									
Calicium salicinum	+	+			+																	
Stenocybe pullatula	+	+			+			+		+	+		+									
Usnea cavernosa				+			+	+		+	+									+		
Cetraria sepincola								+	+													
Chaenotheca trichialis										+	+											
Pannaria pityrea										+	+											
Cetraria aurescens										+	+	+										
Peltigera apthosa			+					+		+		+		+								
Chaenotheca laevigata											+											
Parmelia revoluta											+											
Physcia setosa											+		+									
Parmelia subargentifera													+									
Parmelia albertana													+									
Lobaria quercizans													+									
Hypogymnia physodes	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+	+
Cladonia rangiferina			+	+	+	+	+	+		+				+	+	+	+	+	+			
Parmeliopsis placordia	+		+	+			+	+	+							+	+	+	+	+		+
Cladonia multiformis							+						+	+				+		+		+
Bryoria trichodes				+	+	+	+	+			+								+	+		
Cladonia deformis	+		+			+									+						+	
Pseudevernia consocians			+				+	+		+	+											+
Cladonia cenotea	+	+	+	+	+	+		+			+						+			+	+	+
Cladonia gracilis			+					+		+					+			+	+		+	
Cladonia grayi		+			+	+		+	+					+					+		+	
Usnea dasypoga								+		+	+									+		+
Stenocybe major										+	+											
Ramalina dilacerata						+		+		+	+								+			
Cladonia cariosa																		+				
Parmeliopsis capitata			+	+		+	+	+	+					+	+			+	+	+		+
Parmeliopsis aleurites	+			+	+	+		+		+	+								+	+		+
Ramalina intermedia										+	+			+	+							
Cetrelia chicitae											+											
Calicium abietinum	+																					
Hypogymnia tubulosa					+		+			+	+											
Cladonia parasitica			+																			
Cladonia rei															+							
Cetraria orbata									+												+	
Parmelia infumata															+							
Peltigera lepidophora															+							
Platismatia tuckermannii	+			+	+	+	+	+	+	+	+	+					+	+	+	+		+
Parmeliopsis hyperopta	+		+		+	+	+	+	+					+	+		+	+	+			+
Cladonia botrytes			+	+		+		+	+						+			+			+	
Bryoria furcellata			+	+	+	+	+		+	+	+						+	+	+	+		+
Calicium trabinellum	+					+		+				+										
Chaenotheca ferruginea										+												
Cladonia merochlorophaea			+				+									+					+	
Cladonia pyxidata			+	+											+							
Cladonia uncialis			+	+											+							
Mycocalicium subtile			+	+							+	+			+							
Parmelia flaventior	+			+	+	+			+				+							+		

Species	Red pine						Aspen-birch								Aspen-birch-fir								Mixed		Other			
	G19	G20	G21	G22	G23	G24	G08	G09	G10	G32	G33	G39	G40	G07	G05	G12	G14	G15	G37	G38	G41	G42	G04	G47	G34	G35	G36	G29
Chaenothecopsis debilis																												
Chaenotheca chrysocephala																												
Calicium parvum																												
Collema subflaccidum																												
Calicium salicinum																												
Stenocybe pullatula																				+								
Usnea cavernosa																												
Cetraria sepincola																												
Chaenotheca trichialis																												
Pannaria pityrea																												
Cetraria aurescens																												
Peltigera apthosa																	+											
Chaenotheca laevigata																												
Parmelia revoluta																												
Physcia setosa																			+									
Parmelia subargentifera																												
Parmelia albertana																												
Lobaria quercizans																												
Hypogymnia physodes	+	+	+	+	+	+																						
Cladonia rangiferina		+	+	+		+		+							+		+				+							
Parmeliopsis placordia		+			+			+																				
Cladonia multiformis		+	+		+	+									+	+				+	+	+			+	+	+	
Bryoria trichodes																												
Cladonia deformis										+															+			
Pseudevernia consocians																												
Cladonia cenotea						+										+												
Cladonia gracilis				+				+							+		+						+		+	+		+
Cladonia grayi																	+											
Usnea dasypoga																	+											
Stenocybe major																	+	+										
Ramalina dilacerata					+	+												+					+				+	
Cladonia cariosa	+			+																						+		
Parmeliopsis capitata								+							+	+												
Parmeliopsis aleurites		+	+		+													+						+				
Ramalina intermedia															+													
Cetrelia chicitae					+																							
Calicium abietinum		+																										
Hypogymnia tubulosa																											+	
Cladonia parasitica		+				+																						
Cladonia rei				+		+																			+	+		+
Cetraria orbata																												
Parmelia infumata																												
Peltigera lepidophora																												
Platismatia tuckermannii			+		+								+						+									
Parmeliopsis hyperopta												+				+	+										+	
Cladonia botrytes	+			+	+										+								+					
Bryoria furcellata		+	+			+						+					+	+	+									
Calicium trabinellum		+					+			+																		
Chaenotheca ferruginea																				+								
Cladonia merochlorophaea																		+									+	
Cladonia pyxidata	+						+	+							+		+											+
Cladonia uncialis															+		+											
Mycocalicium subtile								+		+						+				+				+				
Parmelia flaventior			+						+	+		+	+														+	

Species																																																		
Parmelia flaventior	+			+	+	+			+				+							+					+						+	+		+	+														+	
Parmelia rudecta	+							+		+	+		+							+																														
Cetraria halei		+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+	+		+	+			+		+		+		+	+		+		+	+	+	+	+	+	+	+				
Peltigera elizabethae										+										+																				+				+						
Cetraria pinastri		+	+	+	+	+	+	+	+	+				+	+		+	+	+			+		+	+	+	+	+	+	+				+				+	+	+									+	
Cladonia coniocraea		+	+		+		+	+		+	+					+		+	+		+	+		+	+	+	+		+	+		+	+	+	+	+	+			+	+	+	+	+						+
Cladonia cristatella			+					+			+			+	+	+		+		+	+			+		+	+	+									+		+	+					+			+		+
Cladonia mitis	+	+	+	+		+	+			+	+			+	+		+	+	+					+		+				+		+		+			+	+	+								+	+	+	+
Evernia mesomorpha	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+		+		+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+
Parmelia caperata	+				+		+	+	+	+	+		+		+		+	+	+	+		+	+	+	+		+	+	+	+		+	+	+	+		+	+	+	+	+	+	+	+	+	+		+		
Parmelia septentrionalis	+	+						+	+	+	+				+			+				+		+	+				+	+			+			+	+		+	+		+		+	+	+			+	
Parmelia sorediosa														+	+	+							+	+	+	+		+		+			+	+			+													
Parmelia squarrosa	+				+		+	+		+	+		+							+									+			+	+	+	+		+		+		+	+	+	+		+		+		
Parmelia subaurifera	+	+					+	+	+	+	+				+		+			+	+	+					+	+	+	+		+	+				+	+	+	+		+	+	+	+			+	+	+
Parmelia subrudecta	+						+	+							+					+					+									+			+					+	+		+	+		+		
Parmelia sulcata	+	+	+	+	+			+	+	+			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+	+
Parmelia ullophyllodes								+																								+															+			
Usnea subfloridana					+		+	+		+	+				+		+		+	+		+					+					+			+				+	+	+	+			+	+		+	+	+
Candelaria efflorescens	+							+				+											+												+							+						+		
Cladonia bacillaris			+			+							+										+				+		+		+						+										+	+		
Cladonia coccifera			+											+																+																		+		
Cladonia digitata			+	+			+											+	+					+	+			+						+				+	+				+							
Cladonia squamosa					+					+																	+	+						+	+								+							
Heterodermia speciosa		+	+	+						+	+	+	+										+		+			+	+	+			+	+			+	+	+	+	+	+			+	+				
Parmelia olivacea			+																	+								+			+	+		+	+			+			+		+							+
Parmelia taractica			+											+	+															+			+	+								+								+
Peltigera horiz-poly							+							+															+	+								+	+				+							
Peltigera neckeri			+										+															+					+							+			+						+	
Umbilicaria deusta				+										+	+															+				+			+		+											
Usnea hirta				+		+			+		+							+	+	+		+		+	+			+		+		+		+			+		+	+	+	+	+							
Cladonia chlorophaea											+	+		+									+		+	+		+	+				+						+	+		+	+	+	+			+		
Candelaria vitellina	+	+									+			+				+		+			+	+	+	+		+	+	+	+		+	+			+	+								+				+
Peltigera canina		+	+							+			+	+		+		+			+	+	+	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+	+			+	+	+
Physcia grisea	+	+								+	+		+					+					+		+		+	+		+	+	+	+	+	+		+	+	+	+	+	+	+		+	+				
Chaenotheca brunneola	+	+																										+												+										
Stereocaulon pachale														+		+					+				+			+		+				+			+	+	+	+			+						+	+
Xanthoria polycarpa	+	+	+											+			+	+				+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	
Lobaria pulmonaria													+																											+								+		
Actinogyra muhlenbergii			+											+	+	+									+	+			+	+			+	+			+		+											
Stereocaulon saxatile			+											+										+			+						+			+								+				+	+	
Cladonia crispata				+											+				+	+				+	+	+		+					+						+	+										
Cladonia scabriuscula													+	+														+		+												+		+						
Cladonia amaurocraea														+	+															+								+		+										
Cladonia pleurota														+	+																									+										
Stereocaulon tomentosum														+	+			+						+		+				+													+	+				+	+	+
Cladonia conista																		+														+															+	+		+
Cladonia furcata																				+							+										+											+	+	
Cladonia farinacea														+																																				
Parmelia conspersa														+																+				+										+						+
Cladonia stellaris														+															+	+			+	+		+		+							+					
Cladonia gonecha															+															+							+		+						+		+	+		+
Parmelia cumberlandica															+			+						+	+	+		+										+	+											+
Diploschistes scruposus																				+					+								+						+											
Parmelia plittii															+																+						+										+	+		
Praeocalicium populneum																							+										+				+													
Parmelia exasperata			+														+	+				+		+	+		+	+		+	+	+	+			+	+	+	+	+	+	+	+		+	+			+	
Physcia ascendens																																																		

							+	+		+		+		+	+	+	+	+	+			+		+	+	+	+		+	+		+	+			
Physcia aipolina												+																+								
Parmelia exasperatula							+	+					+	+	+		+	+	+			+	+	+	+			+		+	+	+	+			
Physcia ciliata							+					+												+		+										
Cladonia turgida								+				+																								
Cladonia verticellata																																				
Cladonia subulata									+	+							+									+										+
Usnea fulvoreagens																																		+		
Cladonia cornuta																					+															
Cladonia fimbriata																																				
Nephroma helveticum																																				
Parmelia trabeculata																									+											
Peltigera horizontalis																								+												
Phaeocalicium polyporaem																									+											
Physcia dubia																								+												
Physcia subtilis																								+												
Parmelia galbina	+	+			+			+				+	+		+	+	+	+		+	+	+	+		+		+	+	+	+	+		+			
Physcia stellaris	+	+		+	+			+					+	+		+	+	+	+	+	+	+	+				+	+	+	+	+		+			
Xantnoria fallax															+		+			+		+		+	+	+			+	+						
Physcia pusilloides		+			+				+	+			+				+			+		+		+	+	+	+		+	+	+	+	+			
Leptogium cyanescens																	+	+			+	+									+					
Physcia luganensis																	+		+	+				+				+		+						
Physcia orbicularis		+			+	+														+	+	+		+	+											
Physcia teretiuscula						+											+	+						+												
Ramalina fastigata					+										+				+					+			+		+	+						
Nephroma parile																	+				+								+		+					
Peltigera evansiana					+																+										+					
Ramalina sinensis																			+					+	+			+								
Nephroma resupinatum																+				+						+										
PHyscia phaea																		+								+	+	+								
Parmelia aurulenta																				+	+															
Physia caesia					+															+																
Leptogium hirsutum																	+			+																
Mycocalicium compressulum					+											+																				
Peltigera polydactyla												+					+				+					+							+			
Cladonia cylindrica													+								+			+					+	+						
Collema nigrescens																		+												+						
Cladonia pityrea											+						+									+	+	+								
Candelaria concolor																		+												+	+	+			+	
Lasallia papulosa																						+														
Parmelia fravdans																					+															
Leptogium tenuissimum																	+																			
Cladonia phyllophora					+										+													+								
Candelaria fibrosa			+														+							+												
Cladonia arbuscula																												+								
Cladonia caespiticea																														+						
Cladonia macilenta																															+					
Cyphelium lucidum																														+						
Cyphelium tigillare																																+				
Leptogium saturnum	+																															+				
Nephroma bellum																													+							
																+																				