Report 73-1

FOREST/SOIL RELATIONSHIPS AND MANAGEMENT CONSIDERATIONS IN A PORTION OF THE CHIP LAKE MAP AREA, ALBERTA

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FOREST/SOIL RELATIONSHIPS AND MANAGEMENT CONSIDERATIONS IN A PORTION OF THE CHIP LAKE MAP AREA, ALBERTA

Abstract

This study was undertaken to find relationships between forest characteristics and soil conditions, and to interpret the soil survey map for management conditions in the study area.

Forest and soil were described in detail for approximately 100 sample plots, followed by classification of the stands into 15 forest types and the soils into 30 soil series. The mean site index of white spruce at 70 years age ranged from 67 to 87 feet in the forest types and from 72 to 88 feet in the soil series. The site index of lodgepole pine ranged from 59 to 75 feet in the forest types and from 61 to 76 in the soil series. Soil drainage and soil texture were found to be the most important factors influencing the growth of both white spruce and lodgepole pine.

Relationship between forest types and soil series was close and specific only at the extremes of the drainage spectrum. Finally, the study area was divided into 11 soil management areas and their forest productivity and engineering properties are discussed.

INTRODUCTION

Mapping activities of the Alberta Soil Survey cover an ever increasing amount of forested land. The usefulness of the soil survey maps to foresters is somewhat limited by the lack of understanding on the relationships between mapping units and forest productivity or other factors important in forest management.

Early studies of the Alberta forests by Lewis, Dowding, and Moss (1928), Dowding (1929), and Moss (1932, 1953, 1955) described floristic composition and succession of different communities. Their observations on edaphic factors were related to floristic differences and succession rather than to forestry problems.

Horton (1956) studied the ecology of lodgepole pine *(Pinus contorta* var. *latifolia)* in Alberta from a forest management point of view, but the units were based on phytogeographical divisions without making an attempt to relate them to edaphic factors. In a later study, Horton and Lees (1961) divided black spruce communities on the basis of drainage and rated them according to height growth as follows:

Forest Unit	Moisture Regime	Maximum Height at 100 years (feet)
Mesic Upland	2.3	76
Upland Transition	4.5	74
Bog Border	6	69
Shallow Bog	7	53
Deep Bog	8	45

Ogilvie (1963) classified forest communities in the Rocky Mountains of Alberta including soil descriptions in plant associations, and rated the communities for spruce *(Picea glauca* and *Picea engelmanii)* and lodgepole pine communities in terms of very good, good, medium, fair, and poor.

Duffy (1962, 1964) studied the productivity of lodgepole pine in soil survey units in Alberta. It was found that height growth in Lobley and Caroline soil series in the Rocky Mountain House area was significantly greater than in the Horburg series. Multiple regression analysis also showed that tree height can be predicted from edaphic factors more accurately than basal area or volume.

The purpose of this paper is to characterize soil survey mapping units in terms of forest communities, tree growth, and some other forest management criteria in a portion of the Chip Lake map area. An effort was also made to find the most important soil property regulating tree growth in the study area.

Acknowledgment

The authors wish to express their gratitude to Dr. C. D. Bird for the identification of mosses and lichens in this study.

THE LANDSCAPE

Location and Extent

The Cynthia study area (Fig. 1) includes about 300,000 acres of land in the south-central portion of the Chip Lake map area. It covers all or parts of townships 49 to 52 between ranges 9 and 12 west of the fifth meridian.

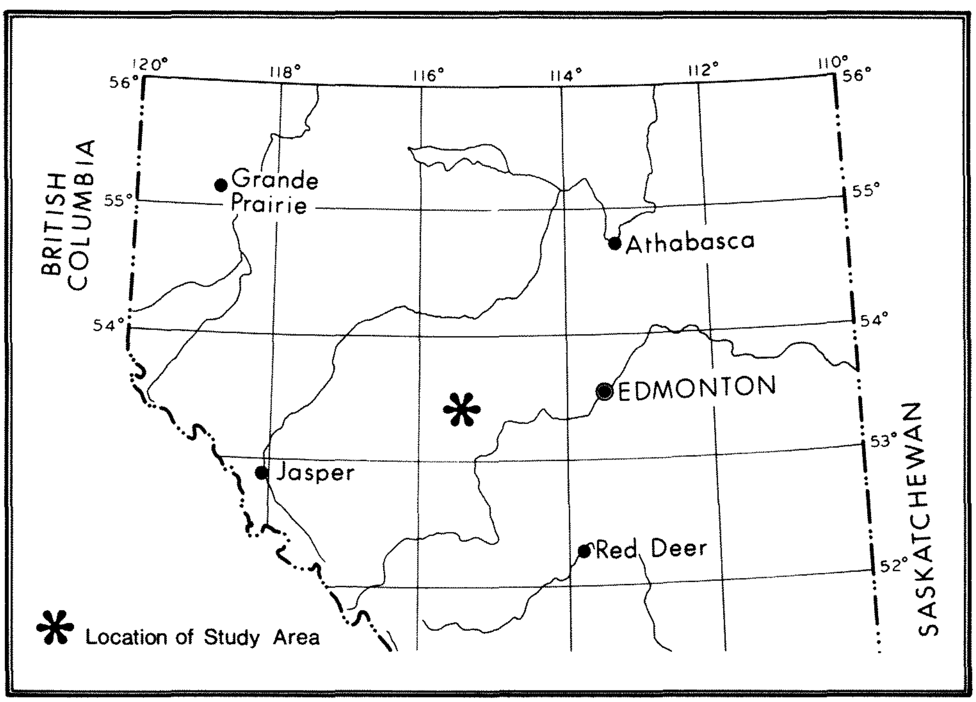


FIGURE 1. Location of the study area.

Surficial Geology

The area was glaciated during the late Pleistocene by the continental ice sheet which advanced from the central region of Keewatin (Gravenor and Bayrock, 1955). Glaciation resulted in the deposition of till on the subglacial land surface. Later, postglacially, some of this material was moved, sorted, and redeposited, giving rise to lacustrine clay, aeolian sand, gravelly outwash, and recent alluvial deposits. In some of the lowland basin areas organic soils are predominant. The general distribution of surficial deposits or soil parent materials in the Cynthia study area is shown in figure 2.

Climate

The climate of the Cynthia area is continental, characterized by relatively warm summers and cold winters. There are no meteorological recording stations within the study area; however, records kept in adjacent areas indicate a mean summer temperature of about 58°F and a mean winter temperature of 9°F. The mean annual precipitation decreases from west to east and ranges from about 20 to 18 inches. The rainfall peak occurs in July when it is best utilized by the vegetation. Meteorological data for stations near the study area are shown in table 1.

Drainage

A major portion of the study area is drained by the Pembina River and its tributaries. A small area in the northwest section is drained by Carrot Creek which flows to the McLeod River and subsequently to the Athabasca River. All drainage is part of the MacKenzie system.

The Pembina River has its source in the mountains, but many of the small streams originate in organic soil basins (muskegs). Their discharge varies greatly throughout the year but the streams are rarely, if ever, dry. Lakes are not common in the area, the largest being Sinkhole Lake.

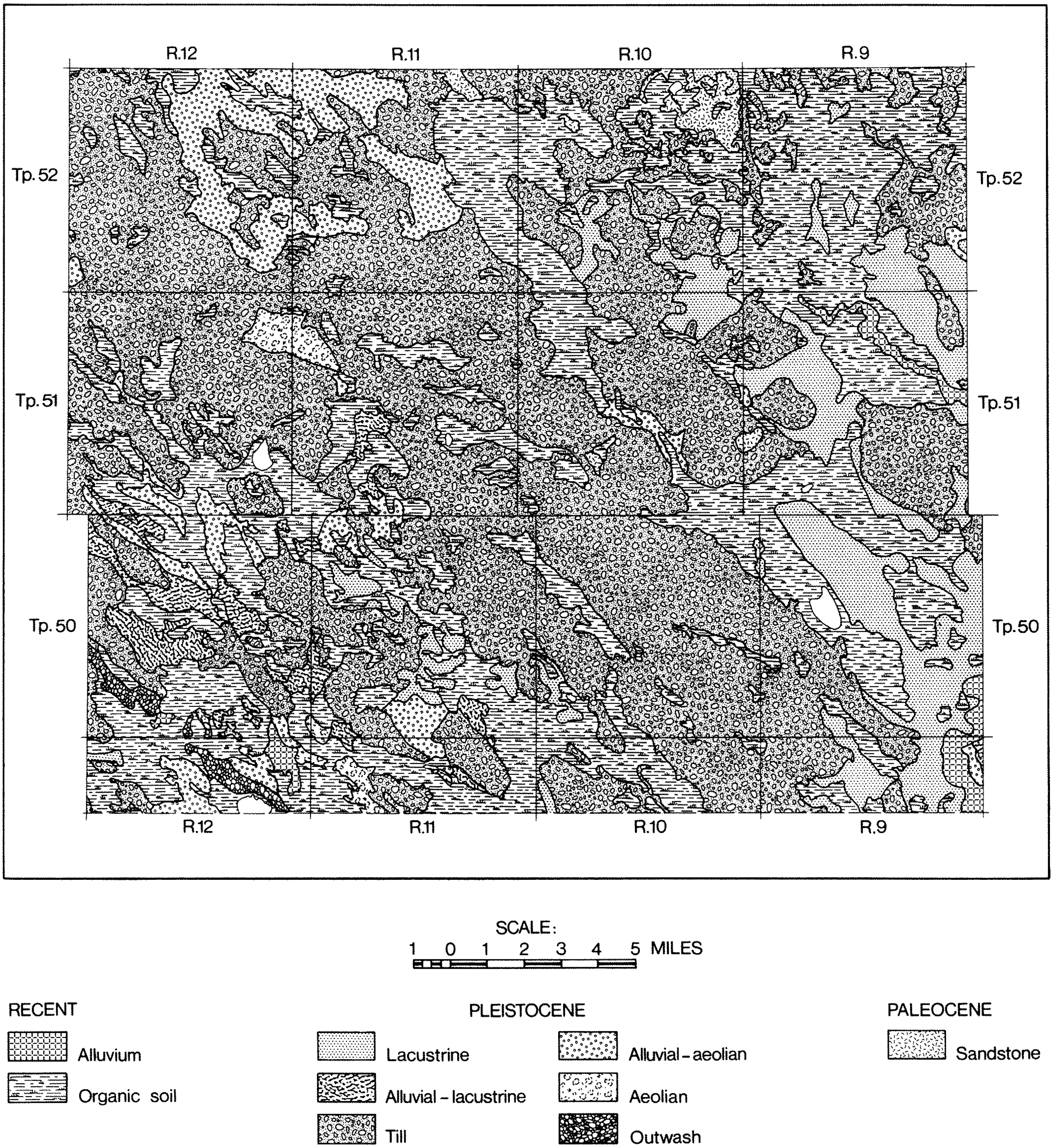


FIGURE 2. Surficial deposits of the study area (after Twardy and Lindsay 1971).

Table 1. Climatic summaries for stations around the study area[1]

Station	Elev. (feet)	Climatic Variables	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual	Frost Free Days
Edson	3027	T[2]	8.4	13.8	23.6	37.2	48.2	53.9	58.7	56.2	48.7	38.4	23.5	12.5	35.3	63
		P_t[3]	1.00	0.75	0.95	1.06	2.05	3.59	3.66	3.16	1.63	0.98	1.03	0.99	20.85	
		S[4]	9.3	5.2	9.1	7.2	1.8	Tr.	-	-	2.3	5.3	8.2	8.9	57.3	
Calmar	2200	T	5.7	10.4	20.7	38.2	50.05	56.2	61.4	57.9	50.4	40.1	23.9	12.6	35.7	93
		P_t	0.84	0.67	0.83	1.16	2.06	3.21	3.43	2.69	1.65	0.88	0.92	0.82	19.16	
		S	8.3	6.6	7.8	5.6	1.4	-	-	-	0.9	4.4	7.8	7.6	50.4	
Nordegg	4300	T	10.7	15.2	21.9	33.6	44.1	49.7	55.1	52.1	45.8	37.4	24.7	15.2	33.8	40
		P_t	1.02	0.96	1.27	1.34	2.42	4.18	3.17	3.00	1.60	1.01	0.96	0.80	21.73	
		S	9.9	6.9	14.8	12.0	6.6	0.3	-	0.3	4.9	7.9	7.4	7.20	78.2	
Rocky Mountain House	3330	T	10.5	16.2	24.1	38.1	48.8	54.6	60.3	57.2	50.1	41.0	26.8	17.9	37.1	73
		P_t	0.87	0.93	1.06	1.48	2.23	3.69	3.32	2.97	1.94	0.98	0.78	0.95	21.2	
		S	7.2	5.3	10.1	8.5	2.4	0.3	-	Tr.	1.7	6.4	6.1	7.7	55.7	

[1] Source: Canada Dept. of Transport, Meteorological Branch (1968): Climatic Normal, Vols. 1, 2, and 6
[2] Temperature in °F
[3] Total precipitation in inches
[4] Snowfall in inches

Topography

Physiographically, the area is in the Great Plains region of Canada to the east of the Rocky Mountain Foothills. The elevation of this area is from 2,800 to 3,500 feet above sea level. In general the land surface rises from east to west. The topography is not extreme, ranging from relatively level lacustrine plains to gently rolling and rolling morainic areas. Slopes seldom exceed 10 percent except in areas of sand dunes and along some of the deeply incised meltwater channels.

METHODS

Data Collection

Field data were collected from 100 sample plots. The aim was to locate an equal number of sample plots in forest types on the various soil series in the area. However, because of natural distribution, this was not possible. The number of replicates ranged from 1 to 9 depending largely upon the areal extent of the soils and forest types in the area.

At each site a 1/10-acre plot was established on which the diameter of all trees over 1 inch (D.B.H.) was recorded. Also the height and age of four dominant or codominant trees *(Picea glauca* or *Pinus contorta)* were determined for estimating site index.

The vegetation was described on the entire plot according to the following layers:

upper crown layer (A1)
lower crown layer (A2)
high shrub layer (B1)
lower shrub layer (B2)
herb layer (C)
moss layer (D)

The total coverage of each layer was estimated in percent, and the relative importance of all species was noted separately in each layer according to Braun-Blanquet's (1932) combined abundance-dominance scales.

A soil pit was located on each sample plot and the soil described and classified according to The System of Soil Classification for Canada (1970). Soil samples of genetic horizons were obtained for laboratory analyses. In addition, the slope, aspect, topographic position, and soil drainage were recorded at each sampling site.

Soils were analyzed according to standard methods used by the Soil Survey Division of the Research Council of Alberta.

Data Analyses

The classification of soil and vegetation was carried out independently in an attempt to keep the forest/soil relationship study unbiased.

Forest communities were classified entirely on the basis of their floristic composition to avoid stratification of the forest stands by edaphic differences. Tentative communities were recognized in the early stage of the field work and a deliberate effort was made to lay out subsequent sample plots in floristically homogenous areas.

The floristic data from individual sample plots were analyzed and synthesized according to Braun-Blanquet's methods, as described by Becking (1957). The analyzed stands were classified into forest associations, and were described by their character and constant species as defined in appendix C.

Associations were grouped into larger units (forest) on the basis of dominant tree species. Smaller units within associations (forest types) were separated on the basis of abundance or scarcity of some species.

Each forest type was evaluated in terms of (a) site index (Kirby, 1969) in white spruce and lodgepole pine, as height in feet at 70-year age; (b) total number of trees per acre according to species; (c) total basal area according to species; and (d) percent cover in A1, A2, B1, B2, C, and D layers. The above characteristics were examined statistically by analysis of variance, and by Duncan's multiple range test.

Broad relationships between forest types and soils were established graphically as percentage distribution of the forest types into parent material and drainage groups.

Relationships between drainage class and tree site index were determined by linear regression for white spruce *(Picea glauca)* and lodgepole pine *(Pinus contorta* var. *latifolia)*.

Productivity of the soil series was expressed as the site index of white spruce or lodgepole pine. Differences in productivity were established by use of analysis of variance and by Duncan's multiple range test using the site indices of individual trees as basic data.

Finally, the study area was divided into parent material groups and soil management areas. The soil management areas are associations of soil series corresponding to soil survey units. Forest productivity was given for the management areas when the component soil series did not have significantly different productivities, or for component soil series when their individual productivities were significantly different.

Botanical nomenclature of vascular plants follows Moss (1959), and of the bryophytes, Bird (1968). Author's names are not included with the botanical name of the plants in the text; a species list is given in appendix C with authors' names and common names.

RESULTS

Soils

The soils of the study area have been described in detail by Twardy and Lindsay (1971); thus, only a generalized soils description is provided in this report.

The soils of the study area represent four orders in The System of Soil Classification for Canada - Luvisolic, Brunisolic, Gleysolic, and Organic.

The Luvisolic soils are the most common. They are characterized by an eluvial (Ae) horizon and an illuvial (Bt) horizon in which silicate clay is the main accumulation product. Based on the occurrence of various horizon characteristics, the Luvisolic soils can be subdivided into the Gray Wooded Great Group and into a number of subgroups. The subgroups found in the study area include Orthic Gray Wooded, Gleyed Orthic Gray Wooded, Brunisolic Gray Wooded and Bisequa Gray Wooded. Soil profiles of these subgroups are well to imperfectly drained but may be developed on one of a number of soil parent materials. Where a subgroup profile is recognized on a particular soil parent material, the series level of the classification system is reached. The soil series, or in most cases a combination of dominant soil series, represent the mapping units.

The Brunisolic soils are well to imperfectly drained soils. In this region these soils show evidence of degradation and for the most part are characterized by a fairly well developed eluvial (Ae) horizon but lack a textural or sesquioxide B horizon. Only the Degraded Eutric Brunisol and Gleyed Degraded Eutric Brunisol Subgroups are represented in the area. These soils generally occur on coarse textured material.

Gleysolic soils are poorly drained and have strongly gleyed mineral horizons. They are developed in areas of groundwater discharge in the presence of a high or fluctuating water table. Both Humic Gleysol and Eluviated Gleysol Great Groups are represented in the area. The former consists of soils that have an organo/mineral (Ah) horizon but no eluviated (Ae) horizon, whereas the Eluviated Gleysols have a prominent Aeg horizon. The main subgroups are Orthic Humic Gleysol and Low Humic Eluviated Gleysol. These soils occur on a wide variety of parent materials where excessive wetness resulting in reducing conditions is a dominant process in soil development.

Soils of the Organic Order are very poorly drained and are characterized by an accumulation of peat at the surface. The criteria used to define these soils include a compact thickness of greater than 12 inches of peat with an organic matter content greater than 30 percent. Two types of Organic soils were recognized - one developed from sedges, the other from mosses. Both were classified in the Mesisol Great Group, which is indicative of an intermediate stage of decomposition.

The soils of the study area, together with some of their properties, are summarized in table 2. In all, 30 soil series or complexes have been recognized and mapped in the area.

The soils are arranged in table 2 according to parent materials. Many of the differences between soils are evident from the data presented.

Some chemical and physical analyses of representative soil profiles in the area are shown in table 3. The soil profiles shown were selected as representative of the major parent materials in the area. These soils are for the most part strongly to medium acid in reaction except for the Regosol developed on alluvial material which, because of the presence of free lime, is mildly alkaline in reaction. The organic matter content in all soils of the area is relatively low, except in the surface litter horizon. This is fairly typical of soils developed under forest vegetation in the Great Plains region.

The particle size distribution analyses indicate the wide range of soil textures encountered in the area. The Maywood soils are developed on fine textured clay, the Hubalta soils on medium textured clay loam, and the Heart soils on coarse textured loamy sand and sand. The corresponding available moisture percentages, which are largely a function of soil texture, range from about 14 percent in the Maywood soil to 9 percent in the Hubalta to 3 percent in the Heart soils. In the Regosol developed on alluvial material, the available moisture percentage is variable because of the stratified nature of the material.

Table 2. Some properties of soil series occurring within the study area

Soil Series or Complex	Soil Subgroup	Parent Material	Drainage Class	Texture Surface	Texture Subsoil	Capacity[1]	Perme-ability	Thick-ness (ins)[2]
Bremay	Gleyed Orthic Gray Wooded	Till	Imperfect	Loam	Clay loam	Moderate	Moderate	3
Breton	Orthic Gray Wooded	Till	Moderately well	Silt loam	Loam	Moderate	Moderate	2
Hubalta	Orthic Gray Wooded	Till	Moderately well	Loam	Clay loam	Moderate	Moderate	2
Newbrook	Low Humic Eluviated Gleysol	Till	Poorly	Loam	Clay loam	Moderate	Slow	5
O'Chiese	Bisequa Gray Wooded	Till	Moderately well	Silt loam	Clay loam	Moderate	Moderate	2
Onoway	Orthic Humic Gleysol	Till	Poorly	Silty clay loam	Clay loam	Moderate	Slow	5
Bigoray	Orthic Gray Wooded	Lacustrine	Moderately well	Silt loam	Silty clay	High	Slow	3
Caroline	Bisequa Gray Wooded	Lacustrine	Well	Silt loam	Silt loam	Moderate	Moderate	1
Codner	Orthic Humic Gleysol	Lacustrine	Poorly	Loam	Loam	Moderate	Moderate	10

1 Available water holding capacity
2 Thickness of L-H horizon

Table 2 continued

Soil Series or Complex	Soil Subgroup	Parent Material	Drainage Class	Texture Surface	Texture Subsoil	Capacity	Perme-ability	Thick-ness (ins)
Eta	Gleyed Orthic Gray Wooded	Lacustrine	Imperfectly	Loam	Loam	Moderate	Moderate	2
Evansburg	Gleyed Orthic Gray Wooded	Lacustrine	Imperfectly	Silty clay	Heavy clay	High	Slow	3
Macola	Dark Gray Wooded	Lacustrine	Moderately well	Clay loam	Heavy clay	High	Slow	1
Maywood	Orthic Gray Wooded	Lacustrine	Moderately well	Silty clay	Heavy clay	High	Slow	3
Raven	Orthic Humic Gleysol	Lacustrine	Poorly	Clay	Heavy clay	High	Slow	5
Tolman	Orthic Gray Wooded	Lacustrine	Well	Sandy loam	Sandy loam	Moderate	Moderate	2
Wildwood	Low Humic Eluviated Gleysol	Lacustrine	Poorly	Silty clay	Heavy clay	High	Slow	10
Codesa	Degraded Eutric Brunisol	Alluvial	Well	Sandy loam	Clay loam	Moderate	Moderate	2
Culp	Orthic Gray Wooded	Alluvial	Well	Loamy sand	Loamy sand	Low	High	2
Pinto	Bisequa Gray Wooded	Alluvial	Well	Sandy loam	Sandy clay	Moderate	Moderate	2

Table 2 continued

Soil Series or Complex	Soil Subgroup	Parent Material	Drainage Class	Texture Surface	Texture Subsoil	Capacity	Perme- ability	Thick- ness (ins)
Rat	Gleyed Degraded Eutric Brunisol	Alluvial	Imperfectly	Sandy loam	Clay loam	Moderate	Moderate	1
Rochester	Orthic Humic Gleysol	Alluvial	Poorly	Loamy sand	Loamy sand	Low	High	6
Sundance	Bisequa Gray Wooded	Alluvial	Well	Sandy loam	Loamy sand	Low	High	3
Heart	Degraded Eutric Brunisol	Aeolian	Rapidly	Loamy sand	Sand	Low	High	3
Nicot	Brunisolic Gray Wooded	Aeolian	Rapidly	Loamy sand	Loamy sand	Low	High	2
Clouston	Orthic Gray Wooded	Outwash	Well	Sandy loam	Gravelly	Low	High	2
Horburg	Bisequa Gray Wooded	Outwash	Well	Silt loam	Gravelly	Low	High	2
Modeste	Orthic Gray Wooded	Bedrock	Well	Loam	Silt loam	Moderate	Moderate	2
Alluvium	Orthic Regosol	Alluvial	Well to poorly	Variable	Variable	Variable	Variable	4
Kenzie	Undiffer- entiated	Organic	Very poorly	-	-	High	-	12+
Eaglesham	Undiffer- entiated	Organic	Very poorly	-	-	High	-	12+

Table 3. Analyses of some representative soils in the Cynthia forest area

	Horizon	Thick-ness (ins)	pH	N (%)	C (%)	C/N Ratio	S (%)	Si (%)	C (%)	F.C. (%)	$CaCO_3$ equiv. (%)	Bulk Density	Avail. Moist. (%)
Maywood Series (Lacustrine)													
	L	1	-	-	-	-	-	-	-	-	-	-	-
	F	3	6.2	-	40.08	-	-	-	-	-	-	-	-
	Ah	2	5.8	0.50	7.65	15	20	55	25	8	-	-	26.6
	Ae	4	5.9	0.05	0.65	13	24	64	12	4	-	1.37	14.3
	AB	9	5.2	0.07	0.86	12	17	31	52	31	-	1.32	12.6
	Bt	15	5.0	0.05	0.95	19	6	21	73	38	-	1.36	14.5
	Ck at	34	7.3	-	0.33	-	7	46	47	22	6.23	-	18.2
Hubalta Series (Till)													
	L-F	3	6.3	-	40.09	-	-	-	-	-	-	-	24.9
	Ae1	3	5.6	0.07	0.77	11	33	54	13	6	-	1.25	9.9
	Ae2	5	5.5	0.05	0.79	16	28	54	18	10	-	1.35	9.0
	AB	2	5.5	0.06	0.70	12	32	44	24	14	-	-	8.3
	Bt	12	6.3	0.05	0.65	13	27	37	36	23	-	1.48	10.4
	Ck at	25	7.3	-	0.43	-	33	40	27	14	6.62	-	9.6
Heart Complex (Aeolian)													
	L-F	4	4.1	-	42.78	-	-	-	-	-	-	-	25.1
	Ae	4	5.0	0.03	0.62	21	84	11	5	-	-	1.02	3.7
	Bfj	3	5.5	0.02	0.54	27	83	15	2	2	-	1.00	3.4
	BC	29	5.9	-	0.03	-	90	3	7	3	-	-	0.8
	C at	40	5.9	-	0.11	-	90	6	4	4	-	-	-
Regosol (Alluvial)													
	L	1	-	-	-	-	-	-	-	-	-	-	-
	Ck	11	6.9	-	2.21	-	37	39	25	12	0.98	-	10.6
	II Ck	12	7.7	-	1.87	-	47	30	23	15	1.35	-	14.1
	III Ck	12	7.7	-	0.89	-	43	34	23	12	2.01	-	11.5
	IV Ck	6	7.7	-	0.53	-	77	11	12	7	1.84	-	4.2
	V Ck at	42	7.6	-	0.75	-	71	14	15	8	1.81	-	5.2

Forests

Forests in the study area were divided into four major groups:

- White Spruce Forest
- Lodgepole Pine Forest
- Black Spruce Forest
- Alluvial Forest Complex

The first three forests are collections of mature plant communities in which a single tree species is dominant. The Alluvial Forest complex is composed of young, dynamic plant communities with a variety of dominant species. The forests are further divided into associations and forest types.

The White Spruce Forest

The white spruce forest is the most important community both economically and floristically in the study area. It is composed of four associations and seven forest types covering a wide range of edaphic conditions.

The dominant tree is white spruce in the undisturbed stands. Lodgepole pine or trembling aspen *(Populus tremuloides)* may become dominant only in stages of secondary succession after fire or logging.

White Spruce-Horsetail Association

The white spruce-horsetail association is distinguished from other associations in the study area by 17 character species (Appendix B). The most important of these are *Carex sprengelii, C. disperma, Caltha palustris, Circaea alpina, Urtica gracilis* and *Petasites sagittatus.*

Constant species are *Picea glauca, Lonicera involucrata, Rosa acicularis, Ribes aureum, Ribes lacustre, Rubus pubescens, Equisetum arvense, Linnaea borealis, Mitella nuda, Cornus canadensis, Mertensia paniculata, Petasites palmatus, Galium boreale, Fragaria virginiana, Carex sprengelii, Hylocomium splendens,* and *Ptilium crista-castrensis.*

The association has two forest types which occupy excessively moist or wet habitats characterized by seepage during the entire growing season. These are as follows:

White Spruce-Black Spruce-Horsetail Forest Type. This forest type is characterized by a white spruce upper crown layer and a black spruce lower crown canopy. Stand characteristics of this and all other forest types are summarized in table 4.

White Spruce-Horsetail Forest Type. The white spruce-horsetail forest type has a single crown layer of white spruce mixed with trembling aspen.

White Spruce-Sarsaparilla Association

The white spruce-sarsaparilla association is the most common plant community in the study area. Its distinguishing character species are *Lycopodium obscurum, Dryopteris dilatata, Aralia nudicaulis, Pyrola asarifolia.*

Constant species of the association are *Picea glauca, Populus tremuloides, Viburnum edule, Rosa acicularis, Lonicera involucrata, Aralia nudicaulis, Rubus pubescens, Cornus canadensis, Linnaea borealis, Petasites palmatus, Schizachne purpurascens, Mitella nuda, Mertensia paniculata, Pyrola asarifolia,* and *Hylocomium splendens.*

The association, which occurs on moderately well to imperfectly drained soils, is divided into two forest types.

White Spruce-Sarsaparilla Forest Type. The white spruce-sarsaparilla forest type has a single crown layer of white spruce with the occasional trembling aspen and balsam poplar in mature stands. Lodgepole pine, trembling aspen, and paper birch are important in stages of secondary succession after fire or logging.

White Spruce-Sarsaparilla-Dogwood Forest Type. This forest type has a single crown layer in mature stands. The dominant species is white spruce

Table 4. Stand table of the forest types

Forest Types	Site Index		Basal Area (square feet per acre)								Number of Trees (per acre)								Vegetation Cover (percent)					
	White Spruce	Lodgepole Pine	White Spruce	Lodgepole Pine	Black Spruce	Alpine Fir	Aspen	Poplar	Birch	Total	White Spruce	Lodgepole Pine	Black Spruce	Alpine Fir	Aspen	Poplar	Birch	Total	Upper Crown Layer	Lower Crown Layer	High Shrub Layer	Low Shrub Layer	Herb Layer	Moss Layer
White Spruce-Black Spruce-Horsetail	79	-	131	0	26	1	9	0	1	168	282	0	113	2	10	0	2	409	35	21	9	31	65	64
White Spruce-Horsetail	81	-	131	0	0	0	6	28	4	169	208	0	0	0	2	44	8	262	62	7	1	21	85	38
White Spruce-Sarsaparilla	78	75	41	41	0	6	39	3	4	134	91	92	0	12	60	6	23	284	52	9	23	21	77	14
White Spruce-Sarsaparilla-Dogwood	79	-	79	0	0	0	41	20	7	147	170	0	0	0	62	37	36	305	64	7	2	49	77	18
White Spruce-Feather Moss-Alpine Fir	67	-	53	0	0	11	13	6	1	84	177	0	0	70	20	10	7	284	56	15	0	18	46	91
White Spruce-Feather Moss	75	72	76	19	0	0	23	5	0	123	253	25	0	0	54	4	0	336	65	1	2	10	46	64
White Spruce-Feather Moss-Paper Birch	87	-	160	0	0	0	0	20	5	185	460	0	0	0	0	20	48	528	87	5	0	10	50	80
White Spruce-Club Moss	70	65	23	73	0	0	19	2	2	119	52	233	0	0	65	5	17	372	56	27	6	21	80	44
White Spruce-Black Spruce-Blueberry	76	70	42	81	33	0	14	4	0	174	96	188	185	0	40	12	0	521	49	28	14	27	59	77
Lodgepole Pine-Black Spruce-Bearberry	-	59	0	36	10	0	1	0	0	47	0	109	137	0	8	0	0	254	38	29	2	20	50	58
Lodgepole Pine-White Spruce-Bearberry	73	65	8	33	0	0	5	0	0	46	30	289	0	0	25	0	0	344	40	2	2	40	70	65
Black Spruce-Blueberry	-	61	0	50	40	0	0	0	0	90	0	240	362	0	0	0	0	602	45	45	0	12	18	80
Black Spruce-Aspen-Blueberry	-	70	0	74	39	0	12	1	1	127	0	280	392	0	49	6	9	736	46	32	2	15	43	70
Black Spruce-Peat Moss Bog Complex	-	-	0	0	48	0	0	0	0	48	0	0	580	0	0	0	0	580	32	0	2	64	12	96
Alluvial Complex	70	68	109	7	0	1	6	3	1	127	290	7	6	4	10	4	6	327	51	12	5	7	30	45

mixed with trembling aspen, balsam poplar, and paper birch. The presence of *Cornus stolonifera* in the shrub layer distinguishes this forest type from the former.

White Spruce-Feather Moss Association

The white spruce-feather moss association does not have character species. Its separation from the floristically closest associations was based on the lack of the following species in this association: *Lonicera dioica* var. *glaucescens*, *Ledum groenlandicum*, *Vaccinium myrtilloides*, *Aralia nudicaulis*, *Galium aparine*, *Aconitum delphinifolium*, *Gymnocarpium dryopteris*, and *Dryopteris dilatata*.

Constant species of the association are *Picea glauca*, *Rosa acicularis*, *Viburnum edule*, *Lonicera involucrata*, *Linnaea borealis*, *Petasites palmatus*, *Rubus pubescens*, *Mertensia paniculata*, and *Hylocomium splendens*.

The association has three forest types which mainly occur on moderately well-drained, fine-textured lacustrine deposits.

White Spruce-Feather Moss Forest Type. The white spruce-feather moss forest type has a single crown layer dominated by white spruce in mature stands. Trembling aspen or lodgepole pine may exceed white spruce in successional stages after fire or logging.

White Spruce-Feather Moss-Alpine Fir Forest Type. The white spruce-feather moss-alpine fir forest type is distinguished from the other forest types within this association by the presence of alpine fir in the stands.

White Spruce-Feather Moss-Paper Birch Forest Type. The white spruce-feather moss-paper birch forest type has an upper crown layer of white spruce and a lower crown layer of paper birch.

White Spruce-Blueberry Association

Lycopodium annotinum is the only character species of this association. Constant species are *Picea glauca*, *Pinus contorta* var. *latifolia*, *Ledum* *groenlandicum, Rosa acicularis, Viburnum edule, Lonicera involucrata, Vaccinium myrtilloides, Vaccinium vitis-idaea, Linnaea borealis, Petasites palmatus, Cornus canadensis, Rubus pubescens, Galium boreale, Lathyrus ochroleucus, Maianthemum canadensis, Hylocomium splendens,* and *Pleurozium schreberi.*

The association has two forest types, occurring mainly on moderately well to imperfectly drained soils on gently sloping till or lacustrine areas.

White Spruce-Club Moss Forest Type. The white spruce-club moss forest type has a mixed tree canopy of white spruce, lodgepole pine, trembling aspen, balsam poplar, and paper birch.

White Spruce-Black Spruce-Blueberry Forest Type. The white spruce-black spruce-blueberry forest type has two crown layers with black spruce forming the lower stratum.

The Lodgepole Pine Forest

Lodgepole pine forests occupy only a small portion of the study area, forming small, isolated stands mainly on sand dunes. This forest is floristically poor having only one association which is composed of about 50 species. Lodgepole pine is able to regenerate under the open canopy and perpetuate itself as an edaphic climax species.

Lodgepole Pine-Bearberry Association

Character species of the association are *Geocaulon lividum, Pyrola virens, Arctostaphylos uva-ursi, Elymus innovatus, Campanula rotundifolia,* and *Shepherdia canadensis.*

Constant species are *Pinus contorta* var. *latifolia, Picea mariana, Ledum groenlandicum, Rosa acicularis, Arctostaphylos uva-ursi, Vaccinium myrtilloides, Vaccinium vitis-idaea, Cornus canadensis, Pleurozium schreberi,* and *Dicranum polysetum.*

The association is divided into two forest types based on the occurrence or absence of white spruce and black spruce.

Lodgepole Pine-Black Spruce-Bearberry Forest Type. The lodgepole pine-black spruce-bearberry forest type has a lodgepole pine upper crown layer and a black spruce lower crown layer.

Lodgepole Pine-White Spruce-Bearberry Forest Type. The lodgepole pine-white spruce-bearberry forest type has a single crown layer of lodgepole pine and white spruce with some trembling aspen.

The Black Spruce Forest

The black spruce forest covers a large portion of the study area, occurring on a variety of parent materials in moderately well to very poorly drained soils. In undisturbed stands the dominant species is black spruce. Lodgepole pine is very important on better drained soils as a pioneer species after fire. The forest is divided into one association and an association complex.

Black Spruce-Blueberry Association

This association has no character species, but the presence of the following species distinguish it from the lodgepole pine-bearberry association: *Viburnum edule*, *Petasites palmatus*, *Equisetum sylvaticum*, *Mitella nuda*, *Arnica cordifolia*, *Rubus pubescens*, *Moneses uniflora*, *Elymus glaucus*, and *Ptilium crista-castrensis*.

Constant species of the association are *Pinus contorta* var. *latifolia*, *Picea mariana*, *Ledum groenlandicum*, *Rosa acicularis*, *Petasites palmatus*, *Vaccinium myrtilloides*, *Vaccinium vitis-idaea*, *Cornus canadensis*, *Linnaea borealis*, *Epilobium angustifolium*, *Ptilium crista-castrensis*, *Pleurozium schreberi*, and *Peltigera aphthosa*.

The association has two forest types.

Black Spruce-Blueberry Forest Type. The black spruce-blueberry forest type has a lodgepole pine upper crown layer and a black spruce lower crown layer.

Black Spruce-Aspen-Blueberry Forest Type. The black spruce-aspen-blueberry forest type is distinguished from the previous forest type by the presence of trembling aspen in the crown layer. The greater numbers of *Viburnum edule* in the shrub layer and *Mertensia paniculata* in the herb layer also aids the separation of these two forest types.

Black Spruce-Peat Moss Bog Association Complex

This forest unit is composed of more than one association, but they are included in a single forest type because an insufficient number of sample plots did not allow their separation. All stands are noncommercial.

Character species of the complex are *Larix laricina, Rubus chamaemorus, Oxycoccus microcarpus,* and *Betula pumila* var. *glandulifera.*

The constant species are *Picea mariana, Ledum groenlandicum, Vaccinium vitis-idaea, Equisetum arvense, Sphagnum fuscum, Pleurozium schreberi, Hylocomium splendens,* and *Peltigera aphthosa.*

The Alluvial Forest Complex

The alluvial forest complex is handled as a single forest type, although its vegetation composition is diverse. It includes all stands on the stream and river floodplains with a dynamic vegetation in various stages of primary succession toward some of the previously described forest types.

Most of the stands are dominated by white spruce. Other species in the crown layer include trembling aspen, balsam poplar, and alpine fir. Important species in the shrub layer are *Rosa acicularis, Viburnum edule, Symphoricarpos albus,* and *Cornus stolonifera. Mertensia paniculata, Fragaria* *virginianum, Rubus pubescens, Galium boreale, Linnaea borealis,* and *Lathyrus ochroleucus* are common species in the herb layer and *Hylocomium splendens* in the moss layer.

Summary of Productivity in Forest Types

The site index of two commercial species, white spruce and lodgepole pine, was selected as a measure of productivity. Such data were given with the description of the forest types (Table 4). At this point, the site indices will be summarized for easier comparison.

White spruce occurs in 11 of the 15 forest types. The ranked mean site indices for this species with standard deviations according to forest types are presented below:

White Spruce-Feather Moss-Paper Birch	87 ± 11
White Spruce-Horsetail	81 ± 14
White Spruce-Black Spruce-Horsetail	79 ± 6
White Spruce-Sarsaparilla-Dogwood	79 ± 8
White Spruce-Sarsaparilla	78 ± 9
White Spruce-Black Spruce-Blueberry	76 ± 10
White Spruce-Feather Moss	75 ± 9
Lodgepole Pine-White Spruce-Bearberry	73 ± 9
Alluvial Complex	70 ± 9
White Spruce-Club Moss	70 ± 3
White Spruce-Feather Moss-Alpine Fir	67 ± 10

Means not connected by the same vertical line are significantly different at the 95 percent probability level. The difference between the mean site index of the least and most productive forest type is only 20 feet. The narrow range and the relatively large standard deviations within forest types did not produce statistical significance of practical value.

Lodgepole pine occurs in 9 of the 15 forest types. However, with artificial regeneration, lodgepole pine probably would have a site index between 65 and 70 feet in white spruce-sarsaparilla-dogwood, white spruce-feather moss-alpine fir, and white spruce-feather moss-paper birch forest types.

The ranked mean site indices for lodgepole pine with the standard deviations according to forest types are summarized below:

White Spruce-Sarsaparilla	75 ± 9
White Spruce-Feather Moss	72 ± 8
White Spruce-Black Spruce-Blueberry	70 ± 8
Black Spruce-Aspen-Blueberry	70 ± 8
Alluvial Complex	68 ± 3
Lodgepole Pine-White Spruce-Bearberry	65 ± 8
White Spruce-Club Moss	65 ± 5
Black Spruce-Blueberry	61 ± 7
Lodgepole Pine-Black Spruce-Bearberry	59 ± 8

Means not connected by the same vertical line are significantly different at the 95 percent probability level. The difference between the lowest and highest mean site index is only 16 feet. However, a smaller variation within forest types resulted in more statistically significant differences than in white spruce. The data also indicate that lodgepole pine in general performs better in white spruce forest types than either in Lodgepole Pine or Black Spruce forests.

All forest types were grouped according to white spruce and lodgepole pine productivity in a further step to form units which are all significantly different from each other (Table 5).

Four groups were recognized for both species and are arranged in decreasing order of productivity. The difference in the mean site indices among the first three groups is approximately 5 feet, while Group IV is naturally unproductive for the given species.

Table 5. Productivity grouping of forest types

	White Spruce		Lodgepole Pine	
	Site Index	Forest Type	Site Index	Forest Type
Group I[1]	79 ± 10[2]	White Spruce-Feather Moss-Paper Birch White Spruce-Horsetail White Spruce-Black Spruce-Horsetail White Spruce-Sarsaparilla-Dogwood White Spruce-Sarsaparilla	72 ± 9	White Spruce-Sarsaparilla White Spruce-Feather Moss Black Spruce-Aspen-Blueberry White Spruce-Black Spruce-Blueberry
Group II	75 ± 4	White Spruce-Black Spruce-Blueberry White Spruce-Feather Moss	65 ± 6	White Spruce-Club Moss Lodgepole Pine-White Spruce-Bearberry Alluvial Complex
Group III	70 ± 8	Lodgepole Pine-White Spruce-Bearberry Alluvial Complex White Spruce-Club Moss White Spruce-Feather Moss-Alpine Fir	60 ± 8	Black Spruce-Blueberry Lodgepole Pine-Black Spruce-Bearberry
Group IV	Nonpro- ductive	Black Spruce-Peat Moss Bog Complex Lodgepole Pine-Black Spruce-Bearberry Black Spruce-Aspen-Blueberry	Nonpro- ductive	White Spruce-Black Spruce-Horsetail White Spruce-Horsetail White Spruce-Sarsaparilla-Dogwood White Spruce-Feather Moss-Alpine Fir White Spruce-Feather Moss-Paper Birch Black Spruce-Peat Moss Bog Complex

[1] All groups are significantly different from each other at the 95 percent probablity level
[2] Mean with standard deviation

Succession After Fire

The nomenclature of forest associations and forest types in the previous section reflects the climax composition of the communities. At present, many stands or sites, including some used for the synthesis of vegetation units, do not have the composition of the climax communities. Some stands classified as members of the white spruce forest are dominated by trembling aspen or lodgepole pine. The reason for this anomaly is the frequent occurrence of fires. Intensive fires destroyed the vegetation of the forest, starting a new successional cycle on the burned area.

Secondary succession in the study area is strongly influenced by the soil drainage class of the sites. In dry lodgepole pine forests, pine and black spruce readily regenerate after fire and the stable community is reestablished without any intermediate tree cover.

In poorly drained white spruce forests a willow brush establishes first after fire, followed by a birch, black spruce, and balsam poplar stand. The slowly regenerating white spruce gradually replaces this stand reestablishing the climax conditions.

In moderately well drained white spruce forests the succession starts with an aspen, aspen-birch, or aspen-lodgepole pine stand depending on the seed supply and soil conditions. In the white spruce-sarsaparilla association alder may play a role in the early stages of the succession. White spruce readily regenerates under these trees and becomes dominant as aspen, birch, and lodgepole pine die of old age or from overshading.

In moderately well to imperfectly drained black spruce forests succession starts with a willow brush which is replaced by lodgepole pine, black spruce, and some aspen. The climax cover type is reestablished by the disappearance of lodgepole pine and aspen from the canopy. In poorly and very poorly drained black spruce forests, black spruce regenerates after fire without the competition of lodgepole pine or aspen.

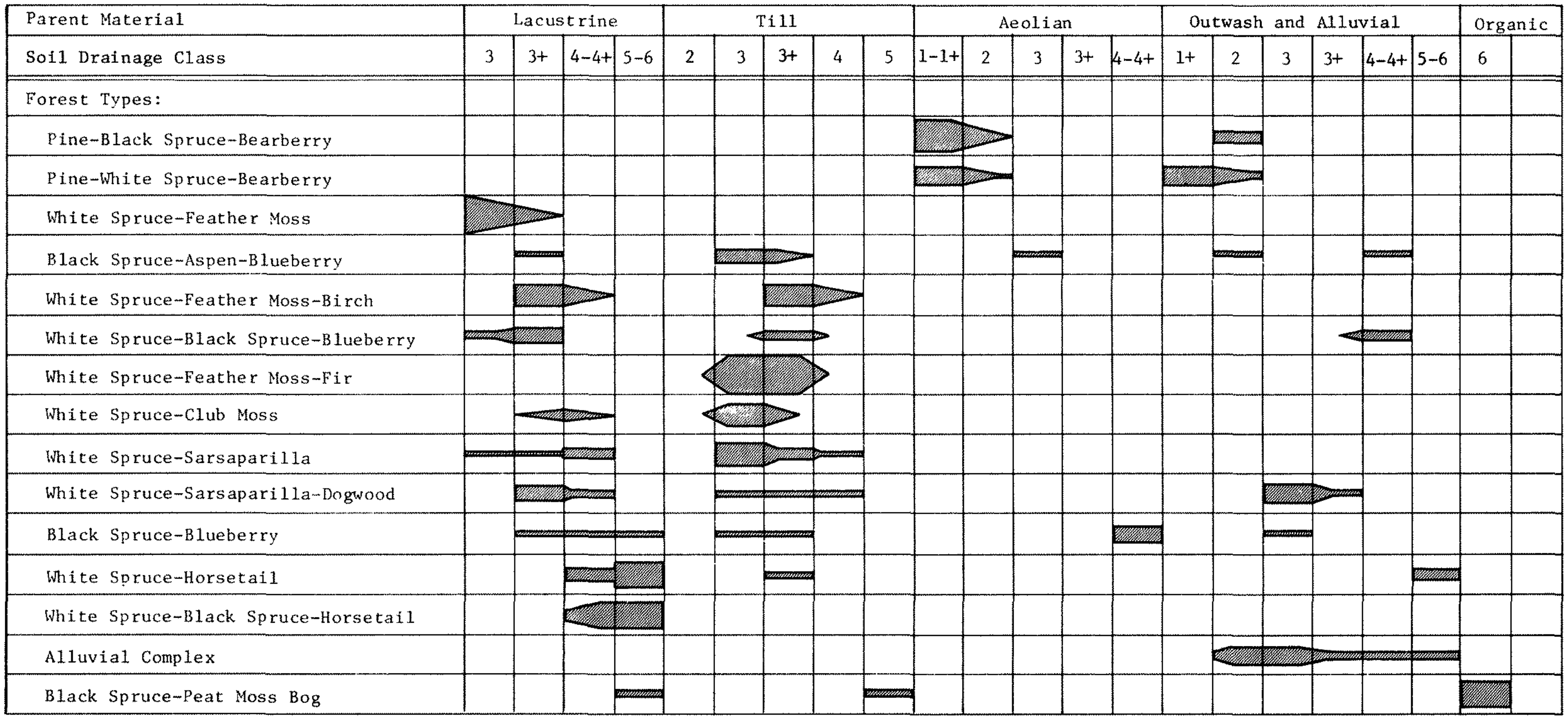
The length of time required for the reestablishment of climax communities depends on the availability of seed and on the type of forest. If seed of climax trees are readily available a stable condition may be reached within 100 years in pine forests and within 250 years in spruce forests. If the seed supply of spruce and fir is inadequate, the pioneer trees will provide new generations until the climax species develop such a density as to prevent the regeneration of the pioneer species.

Soil-Vegetation Relationships

Forest Types, Parent Materials, and Drainage Classes

Distribution of forest types in parent materials and drainage classes is summarized in figure 3. A close relationship between forest types and edaphic properties exists only at the extremes of the drainage spectrum. The two forest types of the lodgepole pine forests are confined to rapidly and well drained soils on aeolian or coarse alluvial parent materials. The black spruce-peat moss bog complex occurs on very poorly drained lacustrine or till parent materials, but mainly it is found on very poorly drained organic soils. The white spruce and black spruce forests have a wider edaphic range than the lodgepole pine forest. These communities occur on lacustrine, till, or alluvial parent materials. Differences in drainage classes extend from drainage class 3 to 6. Individual forest types, however, do not spread over more than two drainage classes. The white spruce-horsetail association is the only exception, extending from drainage class 4 to 6, but the vigor of the community is very much reduced in drainage class 6.

A large portion of the forest types overlap in parent material and drainage conditions. The reason for this botanical diversity within similar conditions is the sensitivity of the vegetation to small edaphic and microclimatic changes, which were not detected or analyzed in this study.



Soil Drainage Class				
	1-1+	Rapidly drained	3+	Imperfectly drained
	2-2+	Well drained	4-4+	Poorly drained
	3	Moderately well drained	5-6	Very poorly drained

FIGURE 3. Relationship between forest types, parent material and soil drainage class.

Relationships Between Forest Types and Soil Series

Relationships between forest types and soil series are summarized in table 6. Hubalta, Maywood, Bremay, and Evansburg soil series are widely distributed in the mesic forest types, but missing from the wet or dry communities. Soil series Kenzie, Wildwood, Raven, Heart, Horburg, and Sundance seem to have a definite affinity to certain forest types or associations. This pattern again underlines the fact that close association between a plant cummunity and a particular soil exists only at the extremes of the edaphic range.

Forest Productivity of Soil Series

Observations on site index and basal area in different soil series are compiled in table 7. From these data the relatively narrow range of mean site indices among soil series is apparent. The range in basal areas is much wider. However, this greater variation in basal areas is probably not a reflection of productivity differences between soil series. The large standard deviations within individual soil series suggest that most of the variation is due to chance rather than to soil differences. For this reason site index was chosen as the site quality indicator in the productivity rating of soil series. Standard deviation of site indices within individual soil series is only about 10 percent of the mean site index values for both spruce and pine.

Productivities of soil series were examined for white spruce and lodgepole pine separately, because their requirements and tolerances are different. Figure 4 shows the effect of drainage on the site index of spruce and pine. Height growth of the white spruce increases linearly from drainage class 2 to 5. The occurrence of white spruce outside of these limits is insignificant. Lodgepole pine site index distribution in drainage classes follows a symmetrical parabola with a maximum close to drainage class 3.

Table 6. Forest communities and associated soil series

Forest Association	Forest Type	Principal Associated Soil Series
White Spruce-Horsetail	White Spruce-Black Spruce-Horsetail	Wildwood, Raven
	White Spruce-Horsetail	Raven, Wildwood
White Spruce-Sarsaparilla	White Spruce-Sarsaparilla	Hubalta, Bremay, Maywood, Evansburg
	White Spruce-Sarsaparilla-Dogwood	Bremay, Evansburg
White Spruce-Feather Moss	White Spruce-Feather Moss-Alpine Fir	Hubalta
	White Spruce-Feather Moss	Maywood
	White Spruce-Feather Moss-Paper Birch	Evansburg, Regosol
White Spruce-Blueberry	White Spruce-Club Moss	Hubalta
	White Spruce-Black Spruce-Blueberry	Hubalta, Maywood, Bremay, Evansburg
Lodgepole Pine-Bearberry	Lodgepole Pine-Black Spruce-Bearberry	Heart, Horburg, Sundance
	Lodgepole Pine-White Spruce	Heart, Horburg
Black Spruce-Blueberry	Black Spruce-Blueberry	Hubalta, Codesa , Maywood, Gleyed Heart
	Black Spruce-Aspen-Blueberry	Hubalta, Maywood
Black Spruce-Peat Moss Bog Complex	Black Spruce-Peat Moss Bog Complex	Kenzie
Alluvial Forest Complex	Alluvial Forest Complex	Orthic Regosol, Gleyed Orthic Regosol

Table 7. Forest productivity of soil series
(Data are means with standard deviation)

Soil Series	Site Index		Basal Area (square feet per acre)				
	White Spruce	Lodgepole Pine	White Spruce	Lodgepole Pine	Black Spruce	Aspen	Total[1]
Raven	88 ± 8	-	120 ± 55	-	-	8 ± 13	175 ± 79
Macola[2]	81 ± 4	-	74	-	-	97	170
Maywood	75 ± 8	76 ± 8	50 ± 35	56 ± 60	14 ± 23	32 ± 30	157 ± 63
Newbrook	87 ± 4	63 ± 4	13 ± 19	49 ± 69	58 ± 82	27 ± 16	150 ± 112
Wildwood	76 ± 11	59 ± 7	95 ± 60	21 ± 51	51 ± 34	8 ± 16	145 ± 33
Alluvial	68 ± 11	65 ± 7	74 ± 56	9 ± 17	17 ± 38	30 ± 51	127 ± 69
Codesa	81 ± 9	74 ± 9	25 ± 29	54 ± 40	21 ± 27	12 ± 20	127 ± 45
Bremay	79 ± 9	67 ± 6	9 ± 10	96 ± 65	9 ± 15	-	123 ± 61
Hubalta	75 ± 10	68 ± 7	30 ± 38	41 ± 50	7 ± 13	26 ± 32	111 ± 59
Evansburg	72 ± 7	56 ± 2	62 ± 29	14 ± 24	10 ± 22	34 ± 22	111 ± 43
Heart	-	60 ± 8	-	31 ± 13	18 ± 13	1 ± 2	50 ± 12
Horburg	-	64 ± 8	-	71 ± 26	6 ± 8	-	83 ± 26
Sundance	-	61 ± 4	-	29 ± 22	6 ± 6	6 ± 10	42 ± 15

[1] Includes all species present on the sample plots
[2] One sample plot only

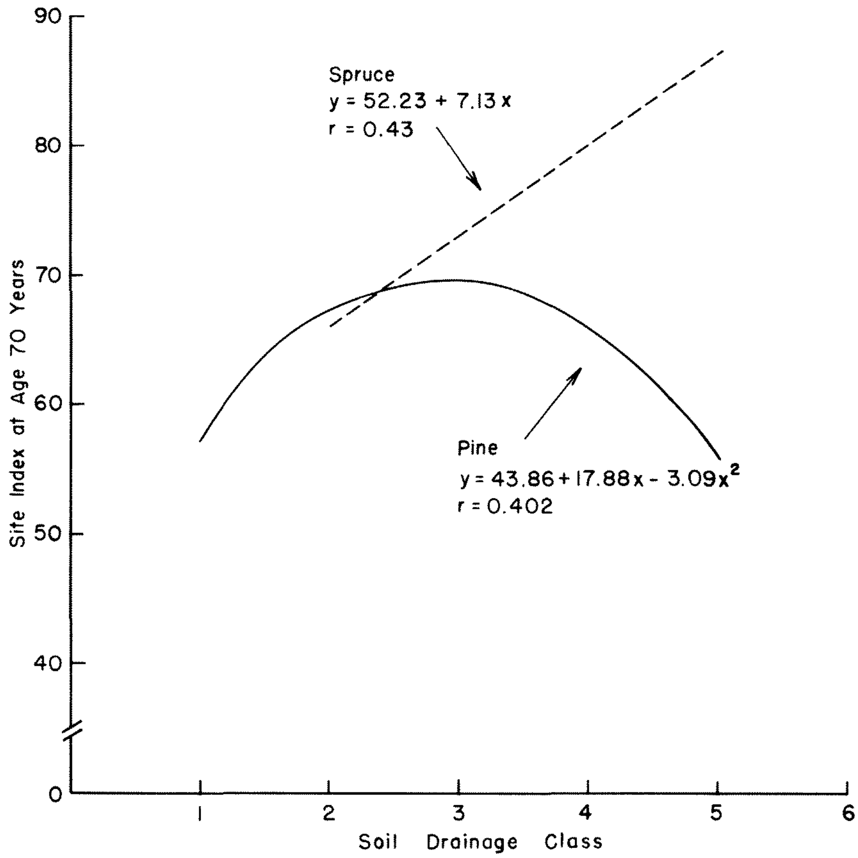


FIGURE 4. The effect of soil drainage on the site index of white spruce and lodgepole pine.

All studied soil series were organized into four groups according to white spruce or lodgepole pine productivity (Table 8). Mean site index of each soil series group is significantly different from that of any other group at the 95 percent probability level. Division of soil series into white spruce productivity groups coincides with drainage groups. Soils are poorly drained in the first group, moderately well to imperfectly drained in the second, well to moderately well drained in the third, and either excessively or very poorly drained in the nonproductive fourth group.

Table 8. Soil series grouped according to white spruce and lodgepole pine productivity

	White Spruce		Lodgepole Pine	
	Site Index	Soil Series	Site Index	Soil Series
Group I[1]	83 ± 9[2]	Codner Raven Wildwood Newbrook Wet Alluvial	75 ± 8	Maywood Codesa
Group II	75 ± 9	Macola Hubalta Maywood Bremay Evansburg Codesa Moist Alluvial	69 ± 8	Hubalta Bremay Caroline Tolman
Group III	65 ± 9	Horburg Caroline Dry Alluvial	60 ± 7	Newbrook Wildwood Evansburg Horburg Sundance Heart
Group IV	Nonproductive	Kenzie Eaglesham Heart Sundance	Nonproductive	Kenzie Eaglesham Codner Raven

[1] All groups are significantly different from each other at the 95 percent probability level

[2] Mean with standard deviation

Parent material does not seem to influence white spruce productivity except where the parent material has extreme drainage properties like the aeolian sand or organic deposits.

In the first and second lodgepole pine productivity groups the soils are moderately well drained. The separation between these groups is due to parent materials. The dominant parent material is lacustrine in the first group while mainly till in the second group. Productivity in the third and fourth groups seem to be controlled by drainage because soils of different parent materials occur in these groups in more or less balanced proportions. In the third group the drainage is either rapid or poor, while in the fourth group all soils are poorly or very poorly drained.

Management Considerations

Management considerations in the study area are based on the properties of soil series interpreted for forestry or engineering operations. The interpretations are based on drainage properties, soil texture, horizon development and on plant communities associated with soil series. The results for forestry use are summarized in table 9 and for engineering considerations in table 10.

Soil Management Areas

The soils in the Cynthia area have a tendency to occur in regular patterns or soil associations depending upon their particular position in the landscape. In determining the mapping associations, primary consideration was given to soil areas with similar parent materials, soil genesis, topography, and soil drainage. This results in areas that have similar broad management conditions.

For the purpose of establishing soil management areas the soils were first broadly grouped according to parent material. In all, seven groups were established representing ground moraine (till), lacustrine, ground moraine-lacustrine complex, gravelly outwash, aeolian-organic complex, organic, and alluvial. Each of these major groups was then subdivided into management areas on the basis of the principally occuring soils within a parent material group.

Each management area, therefore, contains a number of soils which are usually developed on a particular parent material. However, some of

Table 9. Interpretation of soil series for some management conditions

Soil Series or Complex	Management Interpretation			
	Limitations to Regeneration	Wind Throw Hazard	Fire Hazard	Resistance to Trampling
Alluvial	some brush hazard; competition and smothering	moderate	low	medium
Bigoray	none	low	moderate	medium
Bremay	5-inch duff; some smothering	moderate	moderate	low
Breton	some competition and smothering	low	moderate to high	medium
Clouston	heavy moss cover; droughty	low	moderate to high	medium
Codesa	heavy moss cover	low	moderate	medium
Codner	10 to 12 inch duff; smothering	high	low	low
Culp	heavy moss cover; droughty	low	moderate	medium
Eaglesham	nonforest	-	low	low
Eta	moderate moss cover	moderate	low to moderate	medium
Evansburg	some brushing and smothering	moderate	moderate	medium
Heart	heavy moss cover; droughty	low	high	low
Horburg	heavy moss cover; droughty	low	high	medium
Hubalta	some competition and smothering	low	moderate	medium
Kenzie	nonproductive	high	low	low

Table 9 continued

Soil Series or Complex	Management Interpretation			
	Limitations to Regeneration	Wind Throw Hazard	Fire Hazard	Resistance to Trampling
Maywood	occasionally heavy moss cover	low	moderate	medium
Modeste	none	low	moderate to high	medium
Newbrook	5-inch duff; some smothering	high	low	low
Nicot	heavy moss cover; droughty	low	high	low
O'Chiese	none	low	moderate	medium
Onoway	5-inch duff; smothering	high	low	low
Rat	some smothering	moderate	moderate	medium
Raven	6-inch duff; brushing and smothering	high	low	low
Rochester	4-inch duff; smothering	high	low	low
Sundance	droughty	low	high	medium
Tolman	none	low	moderate	medium
Wildwood	10-inch duff; brushing and smothering; heavy moss cover	high	low	low

the soil survey mapping associations include soils developed on dissimilar parent material or contain soils with very different drainage characteristics. Two or three soil series, covering 80 percent or more of the area, are recognized within each management area, but because of the minor occurrence

Table 10. Physical properties and engineering classification of some representative soils

Soil Series or Complex	Horizon	Parent Material	Sand (%)	Silt (%)	Clay (%)	F. Clay (%)	Liquid Limit	Plastic Limit	Plasticity Index	Activity No.	Classification USDA	Classification Unified
Hubalta	Bt	Till	31	28	41	26	43.1	17.0	26.1	0.6	Clay	CL
	Ck		38	29	33	17	37.8	14.0	23.8	0.7	Clay loam	CL
Breton	Ck	Till	32	40	28	15	35.5	14.8	20.7	0.7	Loam	CL
Maywood	Bt	Lacus-trine	12	17	71	47	67.5	25.8	41.7	0.6	H. Clay	CH
	Ck		3	23	74	39	74.6	24.6	50.0	0.7	H. Clay	CH
Evansburg	Btg	Lacus-trine	2	28	70	41	71.2	25.3	45.9	0.6	H. Clay	CH
	Ckg		1	46	53	24	52.0	21.2	30.8	0.6	Silty clay	CH
Sundance	Bt	Alluvial	82	13	5	2	-	-	N.P.[1]	-	Loamy sand	SP
	C		81	13	6	4	-	-	N.P.	-	Loamy sand	SP
Heart	BC	Aeolian	91	6	3	1	-	-	N.P.	-	Sand	SP
	Ck		90	7	3	3	-	-	N.P.	-	Sand	SP

[1] Nonplastic

of other soils, the soil management areas described can only be used for broad, multiple-use planning. Detailed, operational planning would require the field identification of individual soil series.

Eleven soil management areas are defined for the Cynthia area. Their major landscape characteristics and major soil features are described and general information is given on their use, suitability, and management. These management areas are shown in figure 5 and are described as follows:

Ground Moraine Group

This group consists primarily of soils developed on glacial till. The topography is undulating to rolling with slopes seldom exceeding 10 percent. The elevations range from about 2,850 to 3,400 feet above mean sea level. Soil drainage is variable ranging from moderately well in upland positions to poor in lower lying depressional locations.

Hubalta-Bremay-Codesa Area. This management area consists of moderately well to imperfectly drained soils; the Hubalta and Bremay soils are developed on till. They are deep soils, clay to clay loam in texture and slightly stony. The Codesa soil consists of a thin deposit of medium to coarse textured alluvial or aeolian material overlying till.

Soils of minor occurrence in this area include Modeste, Clouston, Raven, Newbrook, Tolman, Onoway, O'Chiese, and Breton.

This soil management area has a moderately high potential for timber production.

Hubalta-Kenzie-Eaglesham Area. The Hubalta-Kenzie-Eaglesham management area consists of the moderately well drained Hubalta soil developed on till and the very poorly drained Kenzie and Eaglesham soils developed on organic material. These latter soils occupy low-lying positions in the ground moraine landscape where groundwater discharge has resulted in an accumulation of peaty material. The exact depth of the peat was not determined but it is known to exceed 6 feet in portions of the Cynthia area. The Kenzie soil is developed primarily in peat of moss origin while the Eaglesham soil is developed in areas of sedge peat accumulation.

Soils of minor occurrence in this area include the Bremay, Codesa, and Raven soils.

Forest production varies from moderately high on the Hubalta soil to nonproductive on the Kenzie and Eaglesham soils.

Newbrook-Hubalta-Onoway Area. The Newbrook-Hubalta-Onoway management area represents soils that are, for the most part, imperfectly to poorly drained. They occur in depressional areas or in lower slope positions where moving (oxygenated) groundwater is a characteristic of the area. These soils are deep but are generally characterized by mottling or gleyed grey colors indicative of excessive wetness.

The productivity of this management area is high for white spruce, and low to medium for lodgepole pine.

The moderately well to imperfectly drained soils of this group pose few problems for the construction or roads in the area. They are classified as CL in the Unified Classification System and are moderately plastic (Table 10). For the most part, the slopes associated with these soils are not a serious handicap to construction. The poorly drained soils (Newbrook, Onoway, Kenzie, and Eaglesham soils), however, have serious limitations for road building and require provision for adequate drainage. This is particularly necessary for the organic soils (Kenzie and Eaglesham) where the organic material may have to be removed or adequately drained and compacted in roadbed preparation.

The major soils of this group are not generally highly erodible, and since slopes are not excessive, there does not appear to be a serious erosion hazard associated with the soils in this group.

Lacustrine Group

This management group consists primarily of soils developed on fine to medium textured lacustrine materials. The topography is generally level to very gently sloping; slopes in excess of 2 percent are seldom associated with the soils developed on lacustrine material. These soils occur for the most part in the east-central portion of the study area at elevations ranging from about 2,800 to 3,000 feet above sea level. Soil drainage is variable, ranging from moderately well in the upland positions to poorly drained in the lower lying depressions.

Maywood-Evansburg-Bigoray Area. The Maywood and Evansburg soils are moderately well and imperfectly drained soils, respectively. These soils are very fine textured clays to heavy clays that are generally stone free. They are found primarily in the Sinkhole Lake area in the east-central portion of the study area. Soils of minor occurrence include the Raven and Macola soils.

The soils of this area have a moderately high potential for timber production.

Tolman-Eta-Hubalta Area. The Tolman and Eta soils are medium textured lacustrine soils that are moderately well and imperfectly drained respectively. The Hubalta soil is a medium to fine textured soil developed on till. These soils are found primarily in the west-central portion of the study area.

Soils of minor occurrence include Culp, Rat, O'Chiese, Bremay, Kenzie, and Maywood.

Site index data for the soils of this particular management area were not determined owing to a lack of suitable sites. However, on the basis of soil properties, the timber potential of these soils can be inferred as being moderately high.

Raven-Evansburg Area. The Raven and Evansburg soils are fine textured soils developed on lacustrine clay. Generally, these soils occur in lower slope positions where groundwater discharge has an important influence on the growth of plants. In areas of Raven soils, in particular, the groundwater appears to be moving and well oxygenated. Such a phenomenon appears beneficial to the growth of white spruce. The Raven soils are poorly drained and the Evansburg soils imperfectly drained. Such soils are often characterized by mottling or dull grey colors in the lower part of the solum. The Maywood, Kenzie, Wildwood, Bigoray, and Eaglesham soils occur to a minor extent in this management area.

The productivity is moderate to high for white spruce and low for lodgepole pine.

A number of soil properties associated with some of the soils of this group present serious problems to the construction of roads in the area. The Maywood, Evansburg, Bigoray and Raven soils are high in clay content. They are classified as CH soils in the Unified Classification System which is indicative of a high shrink-swell potential (Table 10). Also, the poor drainage or excessive wetness associated with Raven soils suggests that adequate drainage must be provided for these soils to minimize the possibility of failure in roads built in the area.

The Tolman, Eta, and Hubalta soils are of medium texture and pose few problems to road construction.

The fine textured Maywood, Evansburg, Bigoray, and Raven soils are potentially highly erodible. Even on very gentle slopes these soils appear to be susceptible to water erosion, and precautions should be taken during construction or development to minimize the hazard. Other soils (Tolman, Eta, and Hubalta) are not as potentially erodible and do not pose a serious construction problem.

Ground Moraine-Lacustrine Group

In some portions of the study area, soils developed on till often occur in close association with soils developed on lacustrine deposits. At the scale of mapping employed in the soil survey (1 inch to 2 miles) it was not always possible to separate these soils and, therefore, this group represents areas of soils of mixed parent materials. For the most part the soils in this group are moderately well drained.

Hubalta-Maywood Area. Hubalta and Maywood are the most commonly occurring soils in this management area. These moderately well drained soils are developed on till and lacustrine materials respectively. Timber productivity of this management area is high for both white spruce and lodgepole pine.

As mentioned previously, the high clay content of the Maywood soils presents some problems in regard to use as a construction material. Also, these soils are potentially highly erodible. The Hubalta soils, on the other hand, are less likely to erode and generally pose few problems when used as a construction material.

Gravelly Outwash Group

This group includes coarse textured, well drained soils developed on gravelly outwash materials. For the most part these soils are found along meltwater channels in the southwestern portion of the area. The associated topography is generally level to undulating.

Horburg-Clouston Area. The Horburg and Clouston soils, the principal soils of this management area, are droughty, considered to be nonproductive for white spruce, and have a low productivity potential for lodgepole pine.

The soils of this management area present few problems for the construction of roads. In the Unified Soil Classification System such soils would be classified as GW or GP. In some locations, these soils are presently being used as a source of gravel for road building.

Soil erosion is not a problem with these permeable soils.

Aeolian-Organic Group

The group includes areas of U-shaped and longitudinal sand dunes. The dunes have a distinctive pattern in which organic soils occupy the interdune areas. From a soil mapping standpoint, it is not possible to separate the dunes from the interdune organic soil areas and they must be regarded as one management area. The topography is variable. Some of the dunes are steep sided and slopes of 30 percent are not uncommon.

Heart-Kenzie Area. The Heart soils are rapidly drained soils developed on aeolian sand. This soil is extremely permeable with a low moisture holding capacity. The Kenzie soil is a very poorly drained organic soil. Soils of minor occurrence in this area include Hubalta, Codesa, and Rochester.

This management area has a very low potential for timber production.

These soils have moderate to severe limitations for road construction. The dry unconfined sandy Heart soil has a low bearing strength while the very poorly drained Kenzie soil requires adequate drainage and either compaction or removal of the organic material for satisfactory road bed preparation.

The Heart soils are subject to wind erosion when the protective vegetative cover is disturbed or removed. Precautions should be taken to protect as much of the native vegetative cover as possible so that the erosion hazard is kept to a minimum.

Organic Group

This group consists of organic soils (muskeg) that are characterized by a variable depth of peaty material. The depth of peat was not determined throughout the area but it is known to exceed 6 feet in some locations.

These very poorly drained soils are nearly level and occupy the wettest portions of the landscape. They are found most extensively in the eastern and southwestern portions of the area.

Kenzie-Eaglesham Area. The Kenzie and Eaglesham soils are organic soils, the former being developed from the decomposition of feather mosses and *Sphagnum* moss and the latter from the remains of sedges. Generally, the Kenzie soils support stands of black spruce and tamarack but the Eaglesham soils are for the most part treeless.

Both the Kenzie and Eaglesham soils are nonproductive for white spruce and lodgepole pine.

The soils of this management area have severe limitations for road building. Drainage and fill are usually required which results in higher costs of construction.

Erosion is not a serious problem in areas of Kenzie and Eaglesham soils.

These soils are important to the watershed management of the area. They are saturated most of the time and therefore act as storage sites and release water gradually throughout the growing season.

Alluvial Group

This group consists of comparatively young soils developed on the alluvial floodplains and terraces of rivers and streams. Alluvial soils are extremely variable in regard to texture and drainage. Soil textures range from loamy sand to silty clay loam while the drainage varies from well to poorly drained. The scale of mapping employed in the soil survey of this area was not of sufficient detail to permit delineation of the many variants of alluvial soils encountered on floodplain deposits.

Alluvial. The site index values obtained for white spruce in this management area were quite variable and appear to be directly related to the moisture status of the soil. Wet and moist sites have a higher growth potential than the dry sites. Lodgepole pine is not of widespread occurrence on these soils.

Because of topographic position many of the soils of this management area are subject to periodic flooding. Such a feature should be taken into consideration where road construction is contemplated. Also, the steeply sloping banks associated with many of the streams and rivers represent sites of high erosion hazard and precautions should be taken to ensure that grades are such as to keep this hazard to a minimum.

SUMMARY AND CONCLUSIONS

Forests and soils were studied in the south-central part of the Chip Lake area, Alberta, to find relationships among soils and forest conditions and to interpret the soil series for forest management purposes.

Fifteen forest types and thirty soil series were recognized in the study area. The forest types were classified into white spruce, black spruce, and lodgepole pine forests, and into associations within the forests. Forest productivity and other stand characteristics were described in detail for each forest type.

Soils in the study area are developed on till, lacustrine, aeolian, outwash, alluvial, and organic parent materials. Physical and chemical properties of the soil series are given in tables 2 and 3.

Site index was found more useful for the evaluation of forest productivity in this study than basal area, since basal area shows great variation within forest type or soil series due rather to chance than to environmental differences.

The mean site index of white spruce varied from 67 to 87 feet in individual forest types, while lodgepole pine ranged from 59 to 75 feet. The ranges of site index in soil series were similar for both white spruce and lodgepole pine, respectively. These site index differences were large enough to allow the differentiation of four productivity groups for each species which are significantly different from each other at the 95 percent probablility level (Tables 5 and 8).

Soil drainage class was found to be the most important single factor influencing the growth of both white spruce and lodgepole pine. White spruce occupies a drainage class range from 2 to 5. Its productivity increases linearly with increasing wetness (Fig. 4). Lodgepole pine was found in drainage classes 1 to 5. Its growth response follows a symmetrical parabola with a maximum at drainage class 3.

In general, the parent material affected tree growth mainly through its drainage properties. The single exception was the higher productivity of lodgepole pine on moderately well drained lacustrine parent material than on moderately drained till (Maywood *versus* Hubalta soil series).

Relationships between parent material, drainage class, and forest types are shown in figure 3. Parent materials with extreme drainage properties (aeolian, outwash, organic) have very specific forest types which do not occur on other substrata. In lacustrine, till, and alluvial parent materials, there is a large diversity of forest types arranged along drainage classes with wide overlappings. However, some forest types show preference to a certain parent material. The white spruce-feather moss forest type was found only on lacustrine deposits, while the white spruce-feather moss-fir forest type occurs only on till. The white spruce-sarsaparilla forest type shows a preference for till parent material, while the white spruce-sarsaparilla-dogwood forest type mainly occurs on lacustrine or alluvial deposits. The two forest types of the white spruce-horsetail association are closely associated with lacustrine parent material. However, this may be due to the general scarcity of poorly drained sites on till.

The soil series were interpreted individually for some management considerations. The interpretation was based on drainage, soil properties, and on the nature of associated forest vegetation.

The study area was divided into eleven soil management areas, based on the dominant parent material and soil series.

Forest productivity and engineering properties were described in each soil management area.

REFERENCES CITED

Becking, R. W. (1957): The Zürich-Montpellier school of phytosociology; Bot. Rev. 23(7), p. 411-488.

Bird, C. D. (1968): A Preliminary Flora of the Alberta Sphagna and Musci. II; Dept. Biol., Univ. Calgary, Alberta, 116 pages.

Braun-Blanquet, J. (1932): Plant Sociology (trans. G. D. Fuller and H. S. Conard); McGraw-Hill, New York, 439 pages.

Dowding, E. S.(1929): The vegetation of Alberta; J. Ecol. 17(1), p. 80-105.

Duffy, P. J. B. (1962): The use of soil survey reports in the appraisal of forest land productivity in Alberta; For. Chron. 38(2), p. 208-211.

-------------- (1964): Relationships between site factors and growth of lodgepole pine *(Pinus contorta* Dougl. var. *latifolia* Engelm.) in the Foothills section of Alberta; Can. Dept. Forest. Pub. 1065, 58 pages.

Gravenor, C. P. and L. A. Bayrock (1955): Use of indicators in the determination of ice-movement directions in Alberta; Geol. Soc. Amer., Bull. 66, p. 1325-8.

Horton, K. W. (1956): Ecology of lodgepole pine in Alberta and its role in forest succession; Forest Res. Div. Tech. Note No. 45, 29 pages.

Horton, K. W. and J. C. Lees (1961): Black spruce in the Foothills of Alberta; Forest Res. Branch Tech. Note No. 110, 54 pages.

Kirby, C. L. (1969): Site index and height growth prediction for dominant and codominant white spruce and lodgepole pine in Alberta; Northern Forest Research Centre, Canadian Forestry Service unpublished Rept.

Lewis, F. J., E. S. Dowding and E. H. Moss (1928): The vegetation of Alberta. II. The swamp, moor, and bog forest vegetation of central Alberta; J. Ecol. 16(1), p. 19-70.

Moss, E. H. (1932): The vegetation of Alberta. IV. The poplar associations and related vegetation of central Alberta; J. Ecol. 20(2), p. 380-415.

----------- (1953): Forest communities in northwestern Alberta; Can. J. Bot. 31, p. 212-252.

----------- (1955): The vegetation of Alberta; Bot. Rev. 21(9), p. 493-567.

----------- (1959): Flora of Alberta; Univ. Toronto Press, Toronto, 546 pages.

Ogilvie, R. T. (1963): Ecology of the forests in the Rocky Mountains of Alberta; Can. Dept. Forest., Forest. Res. Br., Res. Dept. 63-A-12, 57 pages.

Canada Department of Agriculture (1970): The System of Soil Classification for Canada; The Queen's Printer, Ottawa, Ontario, 240 pages.

Twardy, A. G. and J. D. Lindsay (1971): Reconnaissance soil survey of the Chip Lake area; Alberta Soil Survey Rept. 71-28, 71 pages.

APPENDIX A

IDENTIFICATION KEY FOR THE FOREST TYPES

A - White spruce is dominant; if lodgepole pine or trembling aspen dominates, white spruce is always present as regeneration or small trees.

B - *Equisetum* and *Carex* dominate the herb layer. Herb layer dense, soil poorly drained.

C - Black spruce, and/or *Sphagnum* moss present.

White Spruce-Black Spruce-Horsetail Forest Type

C - Black spruce and *Sphagnum* moss absent.

White Spruce-Horsetail Forest Type

B - Herb layer dense, moss layer light or almost absent. *Aralia nudicaulis* always present, and often numerous. *Equisetum* or *Carex* are not dominant. Soil is moderately well to imperfectly drained.

C - *Cornus stolonifera* present, often dominant in the shrub layer.

White Spruce-Sarsaparilla-Dogwood Forest Type

C - *Cornus stolonifera* is absent from the shrub layer.

White Spruce-Sarsaparilla Forest Type

B - Herb layer light or moderate, moss layer moderate to heavy.

C - *Vaccinium myrtilloides* and *V. vitis-idaea* is always present in the herb layer.

D - *Picea mariana* is present in the second crown layer or shrub layer.

White Spruce-Black Spruce-Blueberry Forest Type

D - *Picea mariana* is absent. *Lycopodium annotinum* is present in the herb layer.

White Spruce-Club Moss Forest Type

C - *Vaccinium myrtilloides* and *V. vitis-idaea* are rare. The continuous moss layer is dominated by *Hylocomium splendens.* Soil is moderately well drained.

D - *Abies lasiocarpa* is always present in the tree or shrub layer.

White Spruce-Feather Moss-Alpine Fir Forest Type

D - *Abies lasiocarpa* missing, *Betula papyrifera* and *Populus balsamifera* are present in the stand.
White Spruce-Feather Moss-Paper Birch Forest Type

D - *Abies lasiocarpa, Populus balsamifera* and *Betula papyrifera* are missing from the stand. Mostly on moderately well drained lacustrine deposits.
White Spruce-Feather Moss Forest Type

A - Dominant species is *Pinus contorta* var. *latifolia*. *Picea mariana* forms a second crown layer. When *Picea glauca* is present and *Picea mariana* is missing *Arctostaphylos uva-ursi* is frequent in the herb layer.

B - *Arctostaphylos uva-ursi* and *Elymus innovatus* are present in the herb layer. Soil rapidly drained.

C - *Picea mariana* forms a second crown layer.
Lodgepole Pine-Black Spruce-Bearberry Forest Type

C - *Picea glauca* is present. *Picea mariana* is missing.
Lodgepole Pine-White Spruce-Bearberry Forest Type

B - *Arctostaphylos uva-ursi* and *Elymus innovatus* are absent. *Vaccinium myrtilloides* is present in the herb layer.

C - *Populus tremuloides* is present in the stand.
Black Spruce-Aspen-Blueberry Forest Type

C - *Populus tremuloides* is absent from the stand.
Black Spruce-Blueberry Forest Type

A - *Picea mariana* is dominant in the stand, *Larix laricina* is mostly present. *Sphagnum* moss dominates the ground cover. Soil is Organic or Peaty Gleysol.
Black Spruce-Peat Moss Bog Complex Forest Type

A - The forest is on river floodplain. The community does not fit into any of the foregoing forest types. Soil is Regosolic.
Alluvial Complex Forest Type

APPENDIX B

SPECIES DISTRIBUTION IN FIDELITY GROUPS ACCORDING TO ASSOCIATIONS

Species	Association						
	White Spruce Sarsaparilla	White Spruce Blueberry	White Spruce Horsetail	White Spruce Feather Moss	Black Spruce Blueberry	Lodgepole Pine Bearberry	Black Spruce Peat Moss Bog Complex
Character Species							
Exclusive species							
Lycopodium obscurum	X	.	.	.	.	.	.
Dryopteris dilatata	X	.	.	.	.	.	.
Geum rivale	.	.	X	.	.	.	.
Carex sprengelii	.	.	X	.	.	.	.
Carex disperma	.	.	X	.	.	.	.
Caltha palustris	.	.	X	.	.	.	.
Circaea alpina	.	.	X	.	.	.	.
Urtica gracilis	.	.	X	.	.	.	.
Cardamine pensylvanica	.	.	X	.	.	.	.
Petasites sagittatus	.	.	X	.	.	.	.
Geocaulon lividum	.	.	.	.	.	X	.
Pyrola virens	.	.	.	.	.	X	.
Larix laricina	.	.	.	.	.	.	X
Rubus chamaemorus	.	.	.	.	.	.	X
Oxycoccus microcarpus	.	.	.	.	.	.	X
Selective species							
Clematis verticillaris	X	.	.	.	.	.	.
Aralia nudicaulis	X	.	.	.	.	.	.
Pyrola asarifolia	X	.	.	.	.	.	.

Species	Association						
	White Spruce Sarsaparilla	White Spruce Blueberry	White Spruce Horsetail	White Spruce Feather Moss	Black Spruce Blueberry	Lodgepole Pine Bearberry	Black Spruce Peat Moss Bog Complex
Amelanchier alnifolia	X	.	.	.	.	.	.
Pyrola secunda	X	.	.	.	.	.	.
Lonicera dioica var. *glaucescens*	X	.	.	.	.	.	.
Equisetum scirpoides	.	.	X	.	.	.	.
Aconitum delphinifolium	.	.	X	.	.	.	.
Populus balsamifera	.	.	X	.	.	.	.
Ribes hirtellum	.	.	X	.	.	.	.
Salix myrtillifolia	.	.	X	.	.	.	.
Lycopodium annotinum	.	X	.	.	.	.	.
Arctostaphylos uva-ursi	.	.	.	.	.	X	.
Elymus innovatus	.	.	.	.	.	X	.
Betula pumila var. *glandulifera*	.	.	.	.	.	.	X
Preferential species							
Smilacina stelata	X	.	.	.	.	.	.
Botrichium virginianum	X	.	.	.	.	.	.
Ribes aureum	.	.	X	.	.	.	.
Achillea sibirica	.	.	X	.	.	.	.
Equisetum arvense	.	.	X	.	.	.	.
Heracleum lanatum	.	.	X	.	.	.	.
Campanula rotundifolia	.	.	.	.	.	X	.
Shepherdia canadensis	.	.	.	.	.	X	.
Ledum groenlandicum	.	.	[illegible]		.	.	X

Species	White Spruce Sarsaparilla	White Spruce Blueberry	White Spruce Horsetail	White Spruce Feather Moss	Black Spruce Blueberry	Lodgepole Pine Bearberry	Black Spruce Peat Moss Bog Complex
	Association						
Companion Species							
Picea glauca	X	X	X	X	X	.	.
Viburnum edule	X	X	X	X	X	.	.
Cornus canadensis	X	X	X	X	X	X	.
Rubus pubescens	X	X	X	.	X	.	X
Rosa acicularis	X	X	X	X	X	X	X
Linnaea borealis	X	X	X	X	X	X	.
Mitella nuda	X	X	X	X	X	.	X
Lonicera involucrata	X	X	X	X	X	.	X
Ribes lacustre	X	X	X	X	X	.	X
Mertensia paniculata	X	X	X	X	X	.	X
Petasites palmatus	X	X	X	X	X	X	X
Maianthemum canadensis	X	X	X	X	X	X	X
Schizachne purpurascens	X	X	X	X	X	.	.
Pyrola asarifolia	.	X	X	X	X	.	.
Populus tremuloides	X	X	X	X	X	X	.
Fragaria virginiana	X	X	X	X	X	X	X
Epilobium angustifolium	X	X	X	X	X	X	X
Ribes aureum	X	X	.	.	.	.	.
Betula papyrifera	X	X	X	X	X	X	.
Lathyrus ochroleucus	X	X	X	X	X	X	.
Aster ciliolatus	X	X	X	X	.	X	.
Actea rubra	X	.	X	X	.	.	.
Alnus sinuata	X	X	X	X	X	.	.
Galium aparine	X	.	X	.	.	.	.

Species	White Spruce Sarsaparilla	White Spruce Blueberry	White Spruce Horsetail	White Spruce Feather Moss	Black Spruce Blueberry	Lodgepole Pine Bearberry	Black Spruce Peat Moss Bog Complex
Viola sp.	X	X	X	X	X	.	.
Salix sp.	X	X	X	X	X	X	X
Symphoricarpos albus	X	.	X	X	.	.	.
Vaccinium myrtilloides	X	X	.	X	X	X	.
Equisetum sylvaticum	X	X	X	X	X	.	X
Streptopus amplexifolius	X	.	.	X	.	.	.
Aralia nudicaulis	.	X	X	X	.	.	.
Amelanchier alnifolia	.	.	.	X	.	X	.
Populus balsamifera	X	X	.	X	X	.	.
Pyrola secunda	.	X	.	X	.	.	.
Lonicera dioica var. *glaucescens*	.	.	X	X	X	.	.
Achillea sibirica	X	.	.	X	X	.	.
Lycopodium annotinum	X	.	.	.	X	.	.
Equisetum arvense	X	X	.	X	X	X	X
Smilacina racemosa	X	.	X	.	.	.	.
Pinus contorta	X	X	.	X	X	X	.
Cornus stolonifera	X	.	X	X	.	.	.
Gymnocarpium dryopteris	X	.	X	.	.	.	.
Abies lasiocarpa	X	.	.	X	.	.	.
Shepherdia canadensis	X	X	X	X	X	.	.
Vaccinium vitis-idaea var. *minus*	X	X	X	X	.	X	X
Arnica cordifolia	X	X	.	X	X	.	.
Spiraea lucida	X	.	.	X	.	.	.
Osmorhiza depauperata	X	.	X	.	.	.	.

Species	Association						
	White Spruce Sarsaparilla	White Spruce Blueberry	White Spruce Horsetail	White Spruce Feather Moss	Black Spruce Blueberry	Lodgepole Pine Bearberry	Black Spruce Peat Moss Bog Complex
Ledum groenlandicum	.	X	X	X	X	X	.
Equisetum scirpoides	X	X	.	.	X	.	X
Goodiera repens	X	X	.	X	X	.	.
Vicia americana	X	X	.	.	.	.	.
Oryzopsis asperifolia	X	X	.	X	X	.	.
Moneses uniflora	X	X	X	.	X	.	.
Sorbus scopulina	X	.	.	X	.	.	.
Castillea miniata	.	X	.	.	.	X	.
Thalictrum venulosum	X	X	X	X	X	.	.
Geocaulon lividum	X	X	X	X	X	.	X
Orchis rotundifolia	X	.	.	X	.	.	.
Dryopteris filix-mas	X	.	X	.	.	.	.
Lycopodium complanatum	X	X	.	.	.	.	.
Arctostaphylos uva-ursi	.	X	.	.	.	.	.
Picea mariana	.	X	X	.	X	X	X
Elymus innovatus	.	.	.	.	X	.	.

APPENDIX C

SPECIES LIST

Trees	Common Names
Abies lasiocarpa (Hook.) Nutt.	Alpine Fir
Betula papyrifera Marsh.	Paper Birch
Larix laricina (Du Roi) K. Koch	Tamarack
Picea glauca (Moench) Voss	White Spruce
Picea mariana (Mill.) BSP.	Black Spruce
Pinus contorta Loudon var. *latifolia* Engelm.	Lodgepole Pine
Populus balsamifera L.	Balsam Poplar
Populus tremuloides Michx.	Aspen

Shrubs	
Alnus sinuata (Regel) Rydb.	Green Alder
Alnus tenuifolia Nutt.	River Alder
Amelanchier alnifolia Nutt.	Saskatoon-berry
Arctostaphylos uva-ursi (L.) Spreng.	Common Bearberry
Betula pumila L. var. *glandulifera* Regel	Swamp Birch
Cornus stolonifera Michx.	Dogwood
Corylus cornuta Marsh.	Beaked Hazelnut
Elaeagnus commutata Bernh.	Silverberry
Ledum groenlandicum Oeder	Labrador Tea
Lonicera involucrata (Richards.) Banks	Bracted Honeysuckle
Lonicera dioica L. var. *glaucescens* (Rydb.) Butters	Twining Honeysuckle
Prunus virginiana L.	Choke Cherry
Ribes aureum Pursh	Golden Current
Ribes hirtellum Michx.	Wild Gooseberry
Ribes lacustre (Pers.) Poir.	Bristly Black Current
Rosa acicularis Lindl.	Prickly Rose
Rubus strigosus Michx.	Wild Red Raspberry

Shrubs	Common Names
Salix myrtillifolia Anderss.	Willow
Salix spp.	Willow
Shepherdia canadensis (L.) Nutt.	Canadian Buffalo-berry
Spiraea lucida Dougl.	White Meadowsweet
Sorbus scopulina Greene	Mountain Ash
Symphoricarpos albus (L.) Blake	Snow Berry
Vaccinium membranaceum Dougl.	Tall Bilberry
Vaccinium myrtilloides Michx.	Blueberry
Vaccinium myrtillus L.	Low Bilberry
Vaccinium scoparium Leiberg	Grouse-berry
Viburnum edule (Michx.) Raf.	Low-bush Cranberry

Herbs

Achillea sibirica Ledeb.	Yarrow
Actaea rubra (Ait.) Willd.	Red and White Baneberry
Aconitum delphinifolium DC.	Monkshood
Aralia nudicaulis L.	Wild Sarsaparilla
Arnica cordifolia Hook.	Arnica
Aster ciliolatus Lindl.	Lindley's Aster
Athyrium filix-femina (L.) Roth	Lady Fern
Botrychium virginianum (L.) Sw.	Grape Fern
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint-Marsh Reed Grass
Calamagrostis rubescens Buckl.	Pine Grass
Caltha palustris L.	Marsh Marigold
Calypso bulbosa (L.) Oakes	Venus'-slipper
Campanula rotundifolia L.	Bluebell Harebell
Cardamine pensylvanica Muhl.	Bitter Cress
Carex capillaris L.	Sedge
Carex concinna R.Br.	Sedge
Carex disperma Dewey	Sedge
Carex douglasii Boott	Sedge

Herbs	Common Names
Carex media R.Br.	Sedge
Carex sprengelii Dewey	Sedge
Castilleja miniata Dougl.	Common Red Paint Brush
Circaea alpina L.	Enchanter's Nightshade
Clematis verticillaris DC. var. *columbiana* (Nutt.) A. Gray	Purple Clematis
Corallorhiza trifida Chatelain	Pale Coral-root
Cornus canadensis L.	Bunchberry
Cystopteris fragilis (L.) Bernh.	Bladder Fern
Dryopteris dilatata (Hoffm.) A. Gray	Broad Spinulose Shield Fern
Elymus glaucus Buckl.	Smooth Wild Rye
Elymus innovatus Beal.	Hairy Wild Rye
Epilobium angustifolium L.	Fireweed Great Willow-hero
Equisetum arvense L.	Common or Field Horsetail
Equisetum hyemale L.	Scouring Rush
Equisetum scirpoides Michx.	Horsetail
Equisetum sylvaticum L.	Woodland Horsetail
Fragaria virginiana Duchesne	Wild Strawberry
Galium aparine L.	Cleavers
Galium boreale L.	Northern Bedstraw
Geocaulon lividum (Richards.) Fern.	Toad-flax
Geranium richardsonii Fisch. & Trautv.	Crane's-bill
Geum rivale L.	Purple or Water Avens
Goodyera repens (L.) R.Br.	Rattlesnake Plantain
Gymnocarpium dryopteris (L.) Newm.	Oak Fern
Habenaria hyperborea (L.) R.Br.	Northern Green Orchid
Hedysarium alpinum L. var. *americanum* Michx.	Hedysarium
Heracleum lanatum Michx.	Cow Parsnip
Hieracium albertinum Farr	Woolly Hawkweed
Juncus sp.	Rush
Lathyrus ochroleucus Hook.	Pea Vine

Herbs	Common Names
Lilium philadelphicum L. var. *andinum* (Nutt.) Ker. ..	Western Wood Lily
Linnaea borealis L. var. *americana* (Forbes) Rehd. ...	Twin-flower
Lycopodium annotinum L.	Stiff Club-moss
Lycopodium clavatum L.	Common or Running Club-moss
Lycopodium complanatum L.	Ground Cedar
Lycopodium obscurum L.	Tree Club-moss Ground Pine
Maianthemum canadense Desf. var. *interius* Fern.	Wild Lily-of-the-Valley Two-leaved Solomon's Seal
Melilotus alba Desr.	White Sweet Clover
Mertensia paniculata (Ait.) G. Don.	Tall Mertansia
Mitella nuda L.	Bishop's-cap
Mitella trifida Grah.	Bishop's-cap
Moneses uniflora (L.) A. Gray	One-flowered Wintergreen
Orchis rotundifolia Banks	Round Leaved Orchid
Oryzopsis asperifolia Michx.	Rice Grass
Osmorhiza depauperata Phil.	Sweet Cicely
Oxycoccus microcarpus Turcz.	Small Bog Cranberry
Petasites palmatus (Ait.) A. Gray	Palmate-Leaved Coltsfoot
Petasites sagittatus (Pursh) A. Gray	Arrow-Leaved Coltsfoot
Poa glaucifolia Scribn. & Will.	Bluegrass
Pyrola asarifolia Michx.	Common Pink Wintergreen
Pyrola bracteata Hook.	Large Wintergreen
Pyrola picta J.E. Smith	White-veined Wintergreen
Pyrola secunda L.	One-sided Wintergreen
Pyrola virens Schweigg.	Greenish-flowered Wintergreen
Ranunculus sp.	Buttercup
Rubus chamaemorus L.	Cloudberry Baked-Apple Berry
Rubus pedatus J.E. Smith	Creeping Raspberry
Rubus pubescens Raf.	Dewberry Running Raspberry
Schizachne purpurascens (Torr.) Swallen	False Melic
Smilacina racemosa (L.) Desf. var. *amplexicaulis* (Nutt.) S. Wats.	False Solomon's-seal

Herbs

Smilacina stellata (L.) Desf. .... Star-flowered Solomon's-seal
Stellaria sp. .... Chickweed
Streptopus amplexifolius (L.) DC. .... Twisted-stalk
Thalictrum venulosum Trel. .... Veiny Meadow Rue
Urtica gracilis Ait. .... Common Nettle
Vaccinium vitis-idaea L. var. *minus* Lodd. .... Bog Cranberry Cow-berry
Valeriana sitchensis Bong. ....
Vicia americana Muhl. .... Wild Vetch
Viola rugulosa Greene .... Western Canada Violet

Mosses and Lichens

Abietinella abietina (Hedw.) Fleisch.
Aulacomnium palustre (Hedw.) Schwaegr.
Bryum pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb.
Campylium radicale (P. Beauv.) Grout
Cladonia cornuta (L.) Hoffm.
Cladonia digitata (L.) Schaer
Cladonia ecmocyna (Ach.) Nyl.
Cladonia mitis Sandst.
Climacium dendroides (Hedw.) Web. & Mohr.
Dicranum fragilifolium Lindb.
Dicranum fuscescens Turn.
Dicranum polysetum Sw.
Dicranum tauricum Sapeh.
Dicranum undulatum Enrh.
Distichum capillaceum (Hedw.) B.S.G.
Drepanocladus aduncus (Hedw.) Warnst. var. *polycarpus* f. *gracilescens* (B.S.G.) Mönk
Drepanocladus uncinatus (Hedw.) Warnst.
Eurhynchium pulchellum (Hedw.) Warnst.
Helodium blandowii (Web. & Mohr.) Warnst.
Hylocomium splendens (Hedw.) B.S.G.

Mosses and Lichens

Mnium marginatum (With.) Brid. ex. P. Beauv.

Peltigera aphthosa (L.) Willd.

Plagiomnium drummondii (Bruch & Schimp.) Koponen

Plagiomnium medium (B.S.G.) Koponen

Plagiomnium rugicum (Laur.) Koponen

Pleurozium schreberi (Brid.) Mitt.

Polytrichum juniperinum Hedw.

Ptilidium pulcherrimum (Web.) Hampe

Ptilium crista-castrensis (Hedw.) De Not.

Rhacomitrium sp.

Rhytidiadelphus triquetrus (Hedw.) Warnst.

Rhytidium rugosum (Hedw.) Kindb.

Sphagnum fuscum (Schimp.) Klinggr.

Stereocaulon tomentosum Fr.

Tomenthypnum nitens (Hedw.) Loesk.

APPENDIX D

GLOSSARY OF COMMON TERMS

Soil drainage classes

1) *Rapidly drained.* The soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions. Soils are free of any evidence of gleying throughout the profile. Rapidly drained soils are commonly soils of coarse texture or soils on steep slopes.

2) *Well drained.* The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year. Soils are usually free of mottling in the upper 3 feet, but may be mottled below this depth. B horizons, if present, are reddish, brownish, or yellowish.

3) *Moderately well drained.* The soil moisture in excess of field capacity remains for a small but significant period of the year. Soils are commonly mottled in the lower B and C horizons or below a depth of 2 feet. The Ae horizon, if present, may be faintly mottled in fine-textured soils and in medium-textured soils that have a slowly permeable layer below the solum.

4) *Imperfectly drained.* The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year. Soils are commonly mottled in the B and C horizons; the Ae horizon, if present, may be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

5) *Poorly drained.* The soil moisture in excess of field capacity remains in all horizons for a large part of the year. The soils are usually very strongly gleyed. Except in high-chroma parent materials the B, if present, and upper C horizons usually have matrix colors of low chroma. Faint mottling may occur throughout.

6) *Very poorly drained.* Free water remains at or within 12 inches of the surface most of the year. The soils are usually very strongly gleyed. Subsurface horizons usually are of low chroma and yellowish to bluish hues. Mottling may be present at depth in the profile. Very poorly drained soils usually have a mucky or peaty surface horizon.

Soil texture

The textural classes are defined wholly in terms of size distribution of the primary particles. These are as follows:

Name of Separate	Diameter (millimeters)
very coarse sand	2.0 - 1.0
coarse sand	1.0 - 0.5
medium sand	0.5 - 0.25
fine sand	0.25 - 0.10
very fine sand	0.10 - 0.05
silt	0.05 - 0.002
clay	less than 0.002

The gravelly class names are added to the textural class names according to the following rule:

Gravel volume (percent)	
less than 20	- use textural class name only.
20 - 50	- gravelly and texture.
50 - 90	- very gravelly and texture.

Aeolian deposit - material deposited by wind.

Alluvial deposit - material deposited by moving water.

Aspect - the direction faced by a slope.

Association (plant) - a plant community with a definite floristic composition.

Available water - water that plants can use from the soil. The water in the soil which is held by the soil particle with forces between 1/3 and 15 bars.

Character species

Exclusive species - species completely or almost completely confined to one community.

Selective species - species found most frequently in a certain community but also, though rarely, in other communities.

Preferential species - species present in several communities more or less abundantly, but predominantly or with better vitality in one certain community.

Carbon-nitrogen ratio (C/N) - the ratio of organic carbon to total nitrogen in the soil.

Companion species - species without pronounced affinities for any community.

Constant species - a plant species which occurs in more than 80 percent of the sample plots within an association.

Dune, sand - a mound or ridge of sand deposited by wind.

Eluviation - the removal of material in suspension or in solution from a soil layer.

Erosion - the wearing away of the land surface by water, wind, or other agents.

Floodplain - the land bordering a stream which may be subject to periodic inundation.

<u>Gley</u> - a soil condition produced by reduction in soils that are saturated with water for long periods of time.

<u>Illuviation</u> - the process of depositing material in the soil from suspension or from solution derived from the upper horizons of the soil.

<u>Lacustrine deposit</u> - material deposited in lake water.

<u>Organic matter</u> - decomposed plant residue found in or on the surface of the soil.

<u>Outwash</u> - a stratified sediment deposited by the melting waters of a glacier.

<u>Peat</u> - partially decomposed organic matter accumulated under wet conditions.

<u>Permanent wilting percentage</u> - the water content of the soil at which the plants permanently wilt. Usually given as the amount of water in the soil in percent which is held by forces corresponding to 15 bars tension or more.

<u>pH</u> - the activity of hydrogen ions in the soil; used to indicate acidity or alkalinity of the soil. A pH of 7.0 is neutral, lower values are acid, and higher values are alkaline.

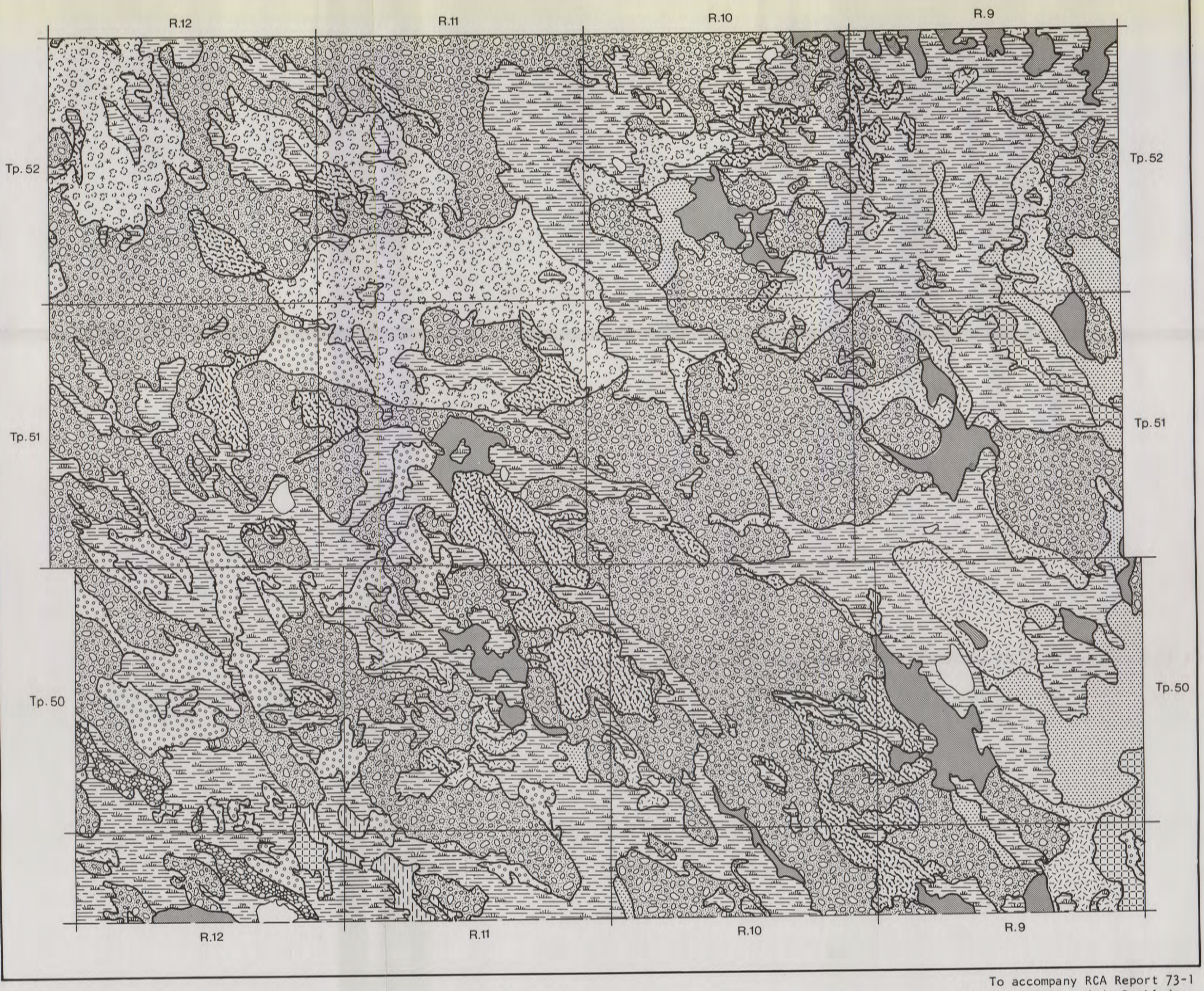
<u>Soil parent material</u> - material from which the soil has developed.

<u>Soil profile</u> - a vertical section through all the soil horizons extending into the parent material.

<u>Stand</u> - a definite forest area which has a uniform floristic composition.

<u>Till</u> - unstratified glacial drift deposited by ice.

<u>Water-holding capacity</u> - the maximum amount of water that a unit volume of soil can hold against the force of gravity.



To accompany RCA Report 73-1
by G. L. Lesko and J. D. Lindsay

FIGURE 5. SOIL MANAGEMENT AREAS

SCALE:
1 0 1 2 3 4 5 MILES

- Hubalta – Bremay – Codesa
- Hubalta – Kenzie – Eaglesham
- Newbrook – Hubalta – Onoway
- Maywood – Evansburg – Bigoray
- Tolman – Eta – Hubalta
- Raven – Evansburg
- Hubalta – Maywood
- Horburg – Clouston
- Heart – Kenzie
- Kenzie – Eaglesham
- Alluvial