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Mixedwood Section in an Ecological Perspective

Saskatchewan






Mixedwood Section in an Ecological Perspective Saskatchewan

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ABSTRACT

A forest is more than trees alone; it encompasses a complex interacting relationship between living and non-living components. The term "ecosystem" has been used in this publication to identify and describe single forest entities. Twenty-three ecosystems have been described, and their implications in forest management have been identified.

Forest lands (excluding water) occupy about 326,506 km^2 or 50.1 percent of Saskatchewan's total area. Provincial Forests and Park Lands within the Mixedwood Section represent 64,503 km^2 or 19.7 percent of the total forest land area. About 57.6 percent of this land is productive, and contains 196 million cubic metres of merchantable softwood and 206 million cubic metres of merchantable hardwood volume. Although 4.0 million cubic metres of merchantable wood (softwoods) are produced annually, the potential productive capacity of this land is 13.6 million cubic metres of softwoods per annum.

The source of most forest-related employment and the largest supplier of raw materials for forest products is the Mixedwood Section. However, an escalating demand for land by other factions and large scale forest utilization threaten to reduce the land area or weaken the natural ability for species regeneration. It is the authors' belief that maximum forest production, continuous natural forest succession and the maintenance of an ecological balance may be achieved by intelligent forest management within the context of forest ecosystems.

In this edition, advanced mapping, statistics and ecological knowledge have refined the information published in the first (1976) edition.

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PREFACE

Statistics are pointing to the broadening gap between the increased consumption and limited supply of resources. Among those deficiencies, a global shortage of wood has been predicted by the year 2000 (Manning and Grinnel, 1971). This is a particular concern of the Forestry profession and woodland managers, as they are at least morally responsible for introducing proper and timely corrective measures.

Although Saskatchewan will probably not be faced with a wood fibre shortage (in a broader sense) in the next 20 or 30 years, we cannot advocate an abundance of merchantable wood of all species at the present time. Since climatic and economic factors will, in all likelihood, prevent the efficient utilization of northern areas for an unpredictable time, any speculation concerning the possibility of increasing the land area of the present commercial forest is without firm foundation. Moreover, the steady encroachment by other land-use sectors such as agriculture, parks, roads, etc. will continue to reduce the present wood-producing areas of the south. It is not hard, therefore, to predict that in the future more wood volume will be expected from a smaller area.

Saskatchewan can face this challenge with intensive forest management policies and methods. The forest land capability survey, completed in 1972, convincingly demonstrated that the productive capacity of the survey area of 14.6 million hectares including the Mixedwood Section, is about 2.6 times the actual production (Kabzems et al., 1972). Recent calculations for the Mixedwood Section alone indicate a potential of 2.94 times the present production.

In this publication an attempt has been made to introduce an ecological approach to forest management whereby short-term forest stand inventories would be replaced by permanent land-based ecological forest units or ecosystems.

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1.1 THE STUDY AREA

The Mixedwood Forest Section extends in a 35 to 285 kilometre wide band across the Province in a northwest to southeast direction between approximately 52° and 56° North latitude (Figure 1). It is a composite of the Mixedwood and Mixedwood-Parkland Transition Ecodistricts (Harris et al., 1983).

Administratively, the area is composed of the following:

(a)	Settlement or agricultural area	35,579 km^2
(b)	Provincial Forests and Parks	70,355 km^2
(c)	Indian Reserves	1,755 km^2
(d)	Prince Albert National Park	3,875 km^2
	TOTAL	111,564 km^2

This survey is limited to the portion occupied by Provincial Forests and Parks. Table 4 shows the land distribution by forest associations and other land categories.

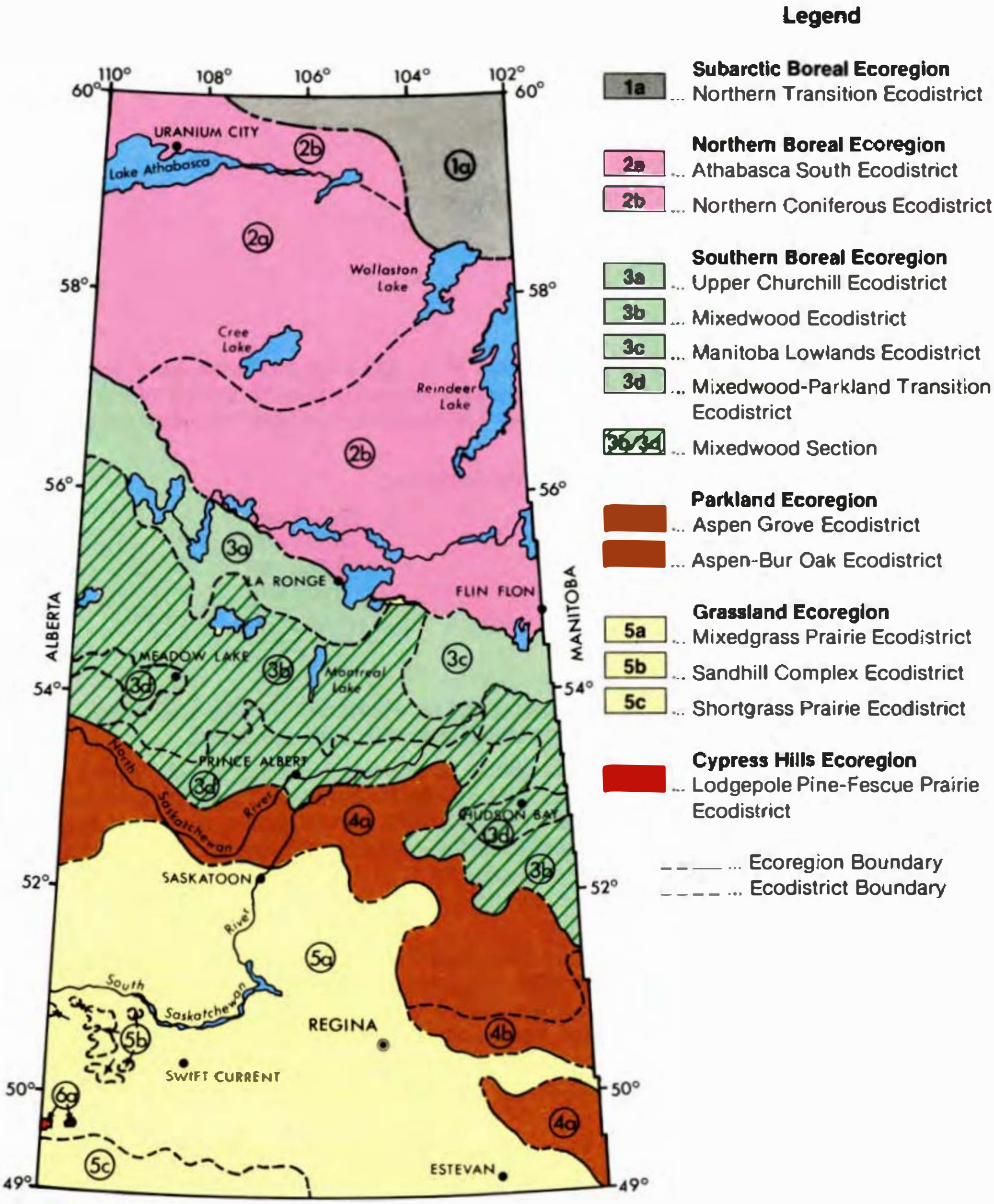
Generally, the Mixedwood Section is a gently to moderately rolling glaciated plain, with elevations ranging from about 305 metres a.s.l. in the Carrot River Lowland to about 815 metres a.s.l. on the Pasquia Hills Plateau. The Churchill and Saskatchewan River systems are major waterways which drain this Section to the northeast (Figure 4). A more detailed description of the physiography is given in Chapter 1.1.1.

1.1.1 PHYSIOGRAPHY

The Mixedwood Section of the Northern Provincial Forest occurs within the physiographic area known as the Interior Plains of North America which comprise a vast area of relatively low relief extending east and north from the Rocky Mountains to the Precambrian Shield. In Saskatchewan, the Mixedwood Section occurs mainly within three Physiographic Regions within the Interior Plains: the Manitoba-Saskatchewan Lowlands, the Saskatchewan Plains and the Alberta High Plains. A minor proportion occurs within the Manitoba Lowlands and the Athabasca River Lowlands.

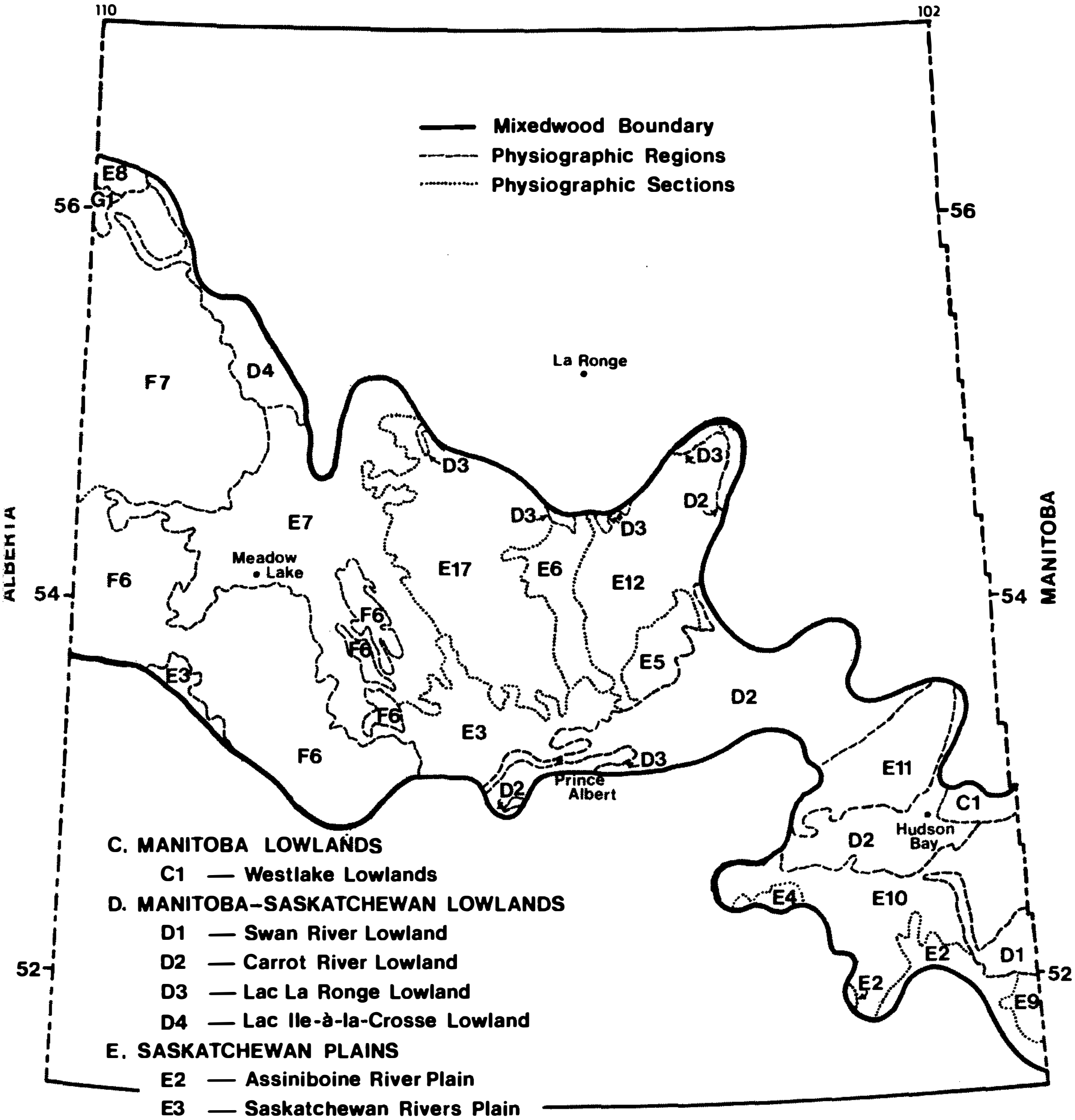
Within each Region a number of Physiographic Sections have been identified (Figure 2). The following is a brief description of the Physiographic Sections which occur within the Mixedwood Section of the Northern Provincial Forest.

Figure 1. Aerial extent of the Mixedwood Section - a composite of the Mixedwood and Mixedwood-Parkland Transition Ecodistricts



Published and unpublished maps and reports by the Saskatchewan Institute of Pedology, as well as the Geologic and Physiographic maps of Saskatchewan, were consulted in this Section and in Sections 1.1.2 and 1.1.3.

Figure 2. Physiographic divisions of the Mixedwood Section



C. MANITOBA LOWLANDS
- C1 — Westlake Lowlands

D. MANITOBA–SASKATCHEWAN LOWLANDS
- D1 — Swan River Lowland
- D2 — Carrot River Lowland
- D3 — Lac La Ronge Lowland
- D4 — Lac Ile-à-la-Crosse Lowland

E. SASKATCHEWAN PLAINS
- E2 — Assiniboine River Plain
- E3 — Saskatchewan Rivers Plain
- E4 — Quill Lake Plain
- E5 — White Gull Creek Plain
- E6 — Montreal Lake Plain
- E7 — Beaver River Plain
- E8 — Methy Portage Plain
- E9 — Duck Mountain Upland
- E10 — Porcupine Hills Upland
- E11 — Pasquia Hills Upland
- E12 — Wapawekka Hills Upland
- E17 — Waskesiu Hills Upland

F. ALBERTA HIGH PLAINS
- F6 — Thickwood Hills Upland
- F7 — Mostoos Hills Upland

G. ATHABASCA RIVER LOWLANDS
- G1 — Clearwater River Plains

C. Manitoba Lowlands Region:

C 1 Westlake Lowland:

Occurring at elevations between 320 and 370 m, this level to gently undulating Section occupies a small area within the Mixedwood Section.

Surficial deposits within the Provincial Forest portion of the Mixedwood Section consist predominantly of organic materials (peat). The thickness of peat varies from approximately 0.5 to 3 m. The mineral substratum includes alluvial, beach, resorted till and lacustrine deposits. Dark Grey Chernozemic and Luvisolic are the dominant mineral soils.

D. Manitoba-Saskatchewan Lowlands Region:

D 1 Swan River Lowland:

The elevation of this gently undulating to rolling Lowland varies from 425 to 455 m.

Luvisolic profiles developed in glacial till are the dominant soils within the Provincial Forest portion of the Mixedwood Section. Soils of recent origin may be found along the Swan River. Some Dark Grey Chernozemic soils developed on glacial till also occur within the forest fringe.

D 2 Carrot River Lowland:

This gently undulating Section borders the Manitoba Lowlands and Saskatchewan Plains Regions. Elevations range between 305 and 455 m.

The surficial glacial deposits consist mainly of glaciofluvial, glaciolacustrine and fluvial-lacustrine sediments.

Luvisolic, Brunisolic, Gleysolic and Organic soils dominate within the Provincial Forest portion of this Section. Dark Grey Chernozemic soils also occur. Many of these Chernozemic soils are very productive for both agriculture and forestry.

D 3 Lac La Ronge Lowland:

This undulating to gently rolling Section borders the Canadian Shield. It ranges in elevation from 365 to 455 m. Preglacial sands underlie most of the area, and consequently sandy glacial tills are of common occurrence. Sandy fluvial-lacustrine deposits also occupy fairly extensive areas.

Luvisolic, Brunisolic, Gleysolic and Organic soils dominate this Section.

D 4 Lac Ile-à-la Crosse Lowland:

This gently undulating Section, which also lies adjacent to the Canadian Shield, varies in elevation from 395 to 455 m. The orientation of lakes and presence of material in the drift, whose source is northwest of this Section, suggest a southeast movement of the glacial ice sheet in this area.

Brunisolic, Luvisolic, Gleysolic and Organic soils occur within this Section. The Brunisolic soils are developed mainly in sandy fluvial and fluvial-lacustrine deposits, whereas the Luvisolic soils are developed in finer textured deposits.

E. Saskatchewan Plains Region:

E 2 Assiniboine River Plain:

This Section occurs entirely within the agricultural area, and for purposes of this report, no further description is provided.

E 3 Saskatchewan Rivers Plain:

This gently undulating to rolling Section is located at elevations ranging from 455 m to 595 m.

Meltwater sorting of the glacial deposits has formed areas of sandy deposits which are very prevalent in the Provincial Forest portion of this Section. In some areas these sandy deposits have been reworked by wind to form dunes.

Regosolic, Brunisolic, Dark Grey Chernozemic, Gleysolic and Organic soils commonly occur within the forest areas. Some Black Chernozemic soils also occur.

E 4 Quill Lake Plain:

This Section occurs entirely within the agricultural area, and for the purposes of this report, the description has been deleted.

E 5 White Gull Creek Plain:

The elevation of this gently undulating to rolling Section is between 455 to 550 m.

Soils of this Section are developed mainly in fluvial-lacustrine, glacial till or glaciofluvial deposits.

Luvisolic, Brunisolic, Regosolic, Gleysolic and Organic soils commonly occur within this Section.

E 7 Beaver River Plain:

This gently undulating to rolling Section, whose northern extremity borders the Canadian Shield, ranges in elevation from 455 to 550 m.

Modification of the drift by glacial meltwater has resulted in numerous outwash deposits, as well as banded deposits which contain thin layers of fine textured material within an otherwise coarse or moderately coarse textured fluvial-lacustrine deposit. Relatively shallow fluvial-lacustrine materials overlying glacial till also occupy fairly extensive areas. Glacial till and glaciolacustrine deposits also occur.

Luvisolic, Chernozemic, Brunisolic, Organic and Gleysolic are the dominant soil profiles within this Section. Productive Black Chernozemic soils developed from sediments deposited by glacial Meadow Lake are found in the agricultural area near the town of Meadow Lake.

E 8 Methy Portage Plain:

Located at the northwest extremity of the Mixedwood Section, this gently undulating to rolling plain borders the Canadian Shield, and occurs at an elevation between 455 and 550 m.

Soils are mainly Luvisolic, Brunisolic, Organic and Gleysolic. The parent material of the mineral soils consists predominantly of glaciofluvial, fluvial-lacustrine and glacial till deposits.

E 10 Porcupine Hills Upland:

This gently to strongly rolling Section ranges in elevation between 550 and 760 m.

Luvisolic profiles developed in glacial till are the dominant soils.

E 11 Pasquia Hills Upland:

The Pasquia Hills Upland is located to the north and separated from the Porcupine Hills by the Manitoba-Saskatchewan Lowlands. The topography is gently to strongly rolling with elevations ranging from 550 to 815 m.

Bedrock deposits which include calcareous and non-calcareous silts and clays, and calcareous shales containing thin beds of clayey limestone, may be encountered at shallow depths. Hence, soils developed in shale-modified glacial till may be found.

Luvisolic, Organic and Gleysolic are the dominant soil profiles.

E 12 Wapawekka Hills:

This gently to strongly rolling Section varies in elevation from 550 to 760 m.

The bedrock geology indicates that preglacial sands occur in the northern part of this Section. As a result, sandy glacial tills commonly occur in this area. Extensive areas of shallow fluvial-lacustrine material overlying glacial till occur within the western half and southern parts of this Section. The east-central part of this Section consists dominantly of soils developed in glacial till. Glaciofluvial and fluvial-lacustrine deposits also commonly occur in this Section.

Luvisolic, Brunisolic, Gleysolic and Organic are the dominant soil profiles.

E 17 Waskesiu Hills Upland:

This gently to strongly rolling Section includes most of the Prince Albert National Park, and extends northward slightly past Doré Lake. Elevations range from 520 to 760 m.

Luvisolic profiles developed in glacial till are the dominant soils occurring in this Section. Brunisolic soils of fluvial-lacustrine origin commonly occur in the northern part of this Section. Overlays of fluvial-lacustrine material on glacial till occupy a fairly extensive area. In addition, this Section also contains significant areas of Gleysolic and Organic soils.

F. Alberta High Plains Region:

F 6 Thickwood Hills Upland:

This gently to strongly rolling Section occurs at an elevation between 550 and 760 m.

Within the Provincial Forest part of this Section, Luvisolic profiles developed in glacial till are the dominant soils.

F 7 Mostoos Hills Upland:

This upland occurs at elevations ranging from 395 to 670 m. The dominant landscape consists of a gently to strongly rolling glacial till plain and eroded escarpments.

Luvisolic profiles developed in glacial till are the dominant soils in this Upland. Brunisolic soils developed in glaciofluvial deposits as well as Organic and Gleysolic soils are common.

G. Athabasca River Lowlands Region:

G 1 Clearwater River Plains:

Elevations range from 305 to 610 m.

The portion of this section occurring in the study area is relatively level terrain which is dominated by Organic soils.

1.1.2 SURFICIAL DEPOSITS

Within the past two million years, Saskatchewan has been subjected to four glaciations. The most recent, known as the Wisconsin, progressed in a southwesterly direction, and is believed to have covered all of Saskatchewan with the exception of the southwest corner. It receded about 10,000 years ago.

As the glacier advanced, it picked up material from the underlying bedrock and previous glacial deposits, and re-deposited it to form the parent material of our soils. Within the Mixedwood Section, the following types of glacial deposits occur:

Glacial till:	A variable mixture of boulders, sand, silt and clay deposited by glacial ice.
Glaciolacustrine:	Stratified sediments (silt, clay, sand and minor coarser material) deposited on the bottom of glacial lakes.
Glaciofluvial:	Coarse textured materials (sands, gravels) deposited by streams flowing from melting glacial ice.
Fluvial-lacustrine:	Sediments deposited under alternating or overlapping glaciolacustrine and glaciofluvial conditions. Generally sands, loamy sands or coarse, medium or fine sandy loams.

Post-glacial modification of the glacial drift has resulted in the formation of the following deposits.

Alluvial:	Material deposited as a sorted or semi-sorted sediment in the bed of a stream, or on its flood plain or delta. Usually sands, silts or clays.
Aeolian:	Sand and silt transported and deposited by wind.
Colluvial:	Material redeposited at lower elevations as a result of gravitational forces. Commonly occurring along steep slopes.

The Organic terrain may be differentiated into three broad categories, namely:

Bog: An area in which the dominant peat materials are sphagnum and forest peat. The groundwater is usually acidic and nutrient deficient.

Fen: An area in which the peat is derived from sedges, grasses and reeds. The groundwater is usually near neutral and nutrient rich.

Swamp: An area in which the primary peat materials are forest and fen peat. The groundwater is usually neutral or slightly acid.

1.1.3 BEDROCK GEOLOGY

Beneath the glacial drift, bedrock deposits are found. Their origin is the result of a sequence of events that occurred many millions of years ago. The oldest bedrock deposits which presently outcrop in the Canadian Shield, were formed during the Precambrian Era, approximately 3,000 million years ago (Richards and Fung, 1969).

Approximately 500 million years ago, the Precambrian rocks sloped southward in a basin-like fashion. The rim of this basin occurs at the present south edge of the Canadian Shield. Subsequent to this, a series of marine and non-marine deposits and erosional events have occured within the basin area.

The uppermost bedrock deposits beneath the Mixedwood Section consist of materials deposited during the Cretaceous Period, dating back approximately 135 million years. Generally, these consist of silts, clays and shales. Sandy bedrock deposits occur along the northern part of the Mixedwood Section, and have contributed to the sandy glacial till found in that area.

1.1.4 CLIMATE

Saskatchewan's location in interior North America at mid-northern latitudes confers on it a continental climate, with short, warm summers and long, cold winters. The seasonal weather variations are determined by three different air masses that invade the province: cold and dry air from the continental polar region especially in winter, cool and moist air from the Pacific, and occasionally warm and moist air from the Atlantic and the Gulf of Mexico. Most precipitation falls during the summer months.

Regionally, the climate varies from humid and cold in the Subarctic Boreal Ecoregion to very dry and warm in portions of the Grassland Ecoregion. The Mixedwood Section occurs within a subhumid and cool climate. Table 1 summarizes climatic data as it relates to the various ecodistricts within Saskatchewan; whereas Table 2 presents climatic information by the various Physiographic Sections which occur within the study area.

1.1.5 VEGETATION

The long term interaction of such environmental factors as climate, soil and topography is well reflected in the natural forest cover in Saskatchewan. The Ecoregions and Ecodistricts described by W.C. Harris, A. Kabzems, A.L. Kosowan, G.A. Padbury and J.S. Rowe for Saskatchewan are outlined in Figure 1, and their land areas with major cover types are listed in Table 3.

Photographs of typical landscapes of each Ecodistrict are presented in Figure 3.

Table 1. Climate of Ecodistricts[1]

Ecoregion	Ecodistrict	Precip. (mm) Total Annual	Precip. (mm) May-Sept.	Temp. (°C) Mean January	Temp. (°C) Mean July	Degree Days	Representative Climate
1. Subarctic Boreal	a) Northern Transition	369	208	-27.4	+15.0	1,020	humid-cold
2. Northern Boreal	a) Athabasca South	390	249	-24.0	+16.2	1,090	humid-cold
	b) Northern Coniferous	450	270	-23.7	+16.9	1,135	humid-cold
3. Southern Boreal	a) Upper Churchill	457	300	-21.4	+16.8	1,275	subhumid-cool
	b) Mixedwood	417	270	-20.5	+17.0	1,375	subhumid-cool
	c) Manitoba Lowlands	472	285	-21.9	+18.3	1,480	subhumid-cool
	d) Mixedwood-Parkland Transition	420	270	-20.0	+17.0	1,450	subhumid-cool
4. Parkland	a) Aspen Grove	410	265	-19.2	+18.0	1,525	dry-warm
	b) Aspen-Bur Oak	430	270	-17.3	+19.0	1,575	dry-warm
5. Grassland	a) Mixedgrass Prairie	375	240	-16.9	+18.7	1,665	dry-warm
	b) Sandhill Complex	330	210	-14.6	+19.2	1,680	very dry-warm
	c) Shortgrass Prairie	310	205	-14.5	+19.1	1,655	very dry-warm
6. Cypress Hills	a) Lodgepole Pine-Fescue Prairie	494	280	-11.3	+17.1	1,330	subhumid-cool

1. Taken from Harris et al., *Ecological Regions of Saskatchewan*, 1983.

Table 2. Climatic data for the Mixedwood Section within the Provincial Forest[1]

Physiographic Section	Mean Temperature °C		Growing Season						Precipitation (cm)	
						Frost				
	January	July	Start	End	Length (Days)	Frost-Free Days	Last Spring	First Fall	Annual	May-Sept
C1 Westlake Lowland	-18.9 to -20.0	17.2 to 18.3	April 30-May 5	Oct. 6-11	154-165	80- 90	June 10-20	Aug. 20-Sept. 2	40.64-45.72	25.40-27.94
D1 Swan River Lowland	-18.9 to -20.0	17.2 to 17.8	April 25-30	Oct. 6-11	159-169	70- 80	June 10-20	Aug. 25-30	40.64-45.72	25.40-27.94
D2 Carrot River Lowland	-18.9 to -20.0	17.8 to 18.9	April 25-30	Oct. 6-11	159-169	90-100	June 1-10	Aug. 20-Sept. 10	38.10-40.64	25.40-27.94
D3 Lac La Ronge Lowland	-21.1 to -23.3	16.7 to 17.2	April 30-May 5	Oct. 1-6	148-160	80-90	—	—	40.64-45.72	27.94
D4 Lac Ile-à-la Crosse Lowland	-21.1 to -23.3	16.7 to 17.2	April 30-May 5	Oct. 1-6	148-160	70- 80	—	—	40.64-45.72	—
E3 Saskatchewan Rivers Plain	-17.8 to -18.9	18.3 to 18.9	April 25-30	Oct. 6-11	160-169	90-110	June 1-10	Sept. 1-10	33.02-38.10	22.86-27.94
E5 White Gull Creek Plain	-18.9 to -20.0	16.7 to 18.3	April 30-May 5	Oct. 1-6	148-160	80- 90	June 1-10	Aug. 20-Sept. 1	40.64-45.72	25.40-27.94
E6 Montreal Lake Plain	-18.9 to -21.2	16.7 to 17.2	April 30-May 5	Oct. 1-6	148-160	80- 90	June 10-20	Aug. 20-Sept. 1	40.64-45.72	25.40-27.94
E7 Beaver Ridge Plain	-18.9 to -20.0	16.7 to 17.2	April 25-30	Oct. 1-6	154-164	70- 80	June 10-20	Aug. 20-Sept. 1	35.56-40.64	22.86-25.40
E8 Methy Portage Plain	-20.0 to -21.1	16.7 to 17.2	April 30-May 5	Oct. 1-6	148-160	70- 80	—	—	40.64-50.80	—
E10 Porcupine Hills Upland	-18.9 to -20.0	15.6 to 16.7	April 30-May 5	Oct. 6-11	154-165	70- 80	June 20+	Aug. 10	45.72-50.80	27.94-33.02
E11 Pasquia Hills Upland	-18.9 to -20.0	15.6 to 16.7	April 30-May 5	Oct. 6-11	154-165	70- 80	June 20+	Aug. 10-20	45.72-50.80	27.94-33.02
E12 Wapawekka Hills Upland	-20.0 to 23.3	15.6 to 16.7	April 30-May 5	Oct. 1-6	148-160	70- 80	June 20+	Aug. 20	45.72-50.80	27.94
E17 Waskesiu Hills Upland	-18.9 to -21.1	15.6 to 16.7	April 30-May 5	Oct. 1-6	148-160	70- 80	June 20+	Aug. 20	40.64-50.80	27.94-33.02
F6 Thickwood Hills Upland	-17.8 to -20.0	16.1 to 16.7	April 25-May 5	Oct. 1-11	148-169	70	June 20	Aug. 10	35.56-40.64	25.40-30.48
F7 Moostoos Hills Upland	-20.0 to -21.1	15.6 to 16.7	April 30-May 5	—	130+	60- 70	—	—	45.72-60.96	25.40-40.64
G1 Clearwater River Plains	-21.1 to -23.3	16.7 to 17.2	April 30+	—	—	60	—	—	40.64-45.72	25.40-27.94

1. Taken from Ellis et al., "The Physiographic Divisions of the Northern Provincial Forest in Saskatchewan", 1970.

Table 3. Forest cover types in Saskatchewan

Ecodistrict[1]	Total Area (km^2)	Presence of Tree Species[2]	Common Cover Types[3]
Northern Transition (1a)	28,142	bS-jP-wB-(tA+bPo) +wS+tL[4]	Black Spruce Jack Pine Jack Pine-Black Spruce Black Spruce-Tamarack White Birch Aspen + Balsam Poplar White Spruce
Athabasca South (2a)	89,245	jP-bS+(wB+tA+wS+tL)	Jack Pine Jack Pine-Black Spruce Black Spruce Black Spruce-Tamarack
Northern Coniferous (2b)	120,387	bS-jP-tA-wS-wB-bPo-bF-tL	Jack Pine Black Spruce Aspen Jack Pine-Aspen + (wB+bPo) Aspen-Jack Pine Aspen-Spruce Spruce-Aspen Jack Pine-Black Spruce White Spruce Tamarack
Upper Churchill (3a)	28,700	jP-tA-bS-bPo-tL-bF	Jack Pine Aspen+(wB+bPo) Black Spruce Aspen-Spruce Jack Pine-Aspen White Spruce Tamarack Jack Pine-Black Spruce Black Spruce-Tamarack
Mixedwood (3b)	85,096	tA-jP-wS-bS-bPo-wB-bF-tL-(wE+gAs+mM)	Aspen + (bPo+wB) Jack Pine Black Spruce Aspen-White Spruce White Spruce-Aspen White Spruce Jack Pine-Aspen Jack Pine-Black Spruce Tamarack Black Spruce-Tamarack White Birch Elm-Ash-Manitoba Maple

Table 3. continued

Ecodistrict[1]	Total Area (km²)	Presence of Tree Species[2]	Common Cover Types[3]
Manitoba Lowlands (3c)	18,775	bS-bPo-tA-wS-jP-(mM+wE+gAs)-wB-bF-tL	Black Spruce Balsam Poplar-Aspen Jack Pine White Spruce + (bF+bS) White Spruce-Aspen+ (bPo+wB) Jack Pine-Aspen Balsam Poplar Tamarack Elm-Ash-Manitoba Maple
Mixedwood-Parkland Transition (3d)	26,468	tA-jP-bPo-wS-bS-wB-tL-bF-(wE+gAs+mM)	Aspen + (bPo + wB) Jack Pine Black Spruce Aspen-White Spruce White Spruce-Aspen White Spruce Jack Pine-Aspen Jack Pine-Black Spruce Tamarack Black Spruce-Tamarack White Birch Elm-Ash-Manitoba Maple
Aspen Grove (4a)	72,256	tA-bPo-(wB+wS+jP+bS)+gAs+mM+wE	Aspen+ (bPo+wB) Balsam Poplar
Aspen-Bur Oak (4b)	8,713	tA-bPo-bO[5]+(wE+gAs+mM)	Aspen+ (bPo+bO+wE+gAs+mM) Aspen-Oak
Grassland (5a,b,c)	173,988		
Cypress Hills (6a)	183	lP[6]-wS-tA+bPo	Lodgepole Pine Aspen Lodgepole Pine-Aspen White Spruce Lodgepole Pine-White Spruce

1. Taken from Harris et al., *Ecological Regions of Saskatchewan*, 1983.
2. Tree species are listed in order of decreasing merchantable volume. Abbreviations for tree species occurring in the Mixedwood Section are found in Appendix 1.
3. Recognized cover types have been listed according to their prevalence by land area, as ascertained by the forest inventory survey.
4. +outside parenthesis indicates a trace amount of species present by volume (less than one percent).
   +within parenthesis indicates volume accumulation.
   -indicates species present are greater than one percent by volume.
5. bO symbolizes Bur Oak.
6. lP symbolizes Lodgepole Pine.

Figure 3. Typical Ecodistrict landscapes in Saskatchewan

1a. Northern Transition

Open black spruce-lichen forest is the dominating forest cover type.

2a. Athabasca South

Sandstone till with open jack pine cover dominates, but prominent eskers with limited tree growth are also typical features of this Ecodistrict.

2a. Athabasca South

Active sand dunes are unique features.

2b. Northern Coniferous

Numerous lakes, irregular topography and diverse forest cover make this a fascinating Ecodistrict.

Figure 3. continued

3a. Upper Churchill

Undulating to rolling topography, sandy and gravelly ridges with jack pine and aspen, and peaty lowlands with black spruce characterize this Ecodistrict.

3b. Mixedwood

Invasion of spruce seedlings under young aspen initiates the sequence of species typical of this Ecodistrict.

3c. Manitoba Lowlands

Patchy stands of black spruce and tamarack occupy poorly drained lowlands.

3d. Mixedwood - Parkland Transition

Cultivated farmland and isolated patches of forest characterize this Ecodistrict.

Figure 3. continued

4a. Aspen Grove

Small tracts of clonal aspen patches dispersed in cultivated fields and pastures are typical.

4b. Aspen-Bur Oak

Bur oak mixed with aspen, balsam poplar and shrub vegetation are found in the Qu'Appelle River Valley and its tributaries.

5a. Mixedgrass Prairie

Grassland (prairie) was once a major natural vegetation unit in the province; now it is reduced to fragmentary areas.

5b. Sandhill Complex

Sand dunes partially stablized by vegetation are the result of semi-arid climatic and xeric physiographic conditions.

Figure 3. continued

5c. Shortgrass Prairie

The very dry and warm regional climate has influenced and promoted the occurrence of typical grassland vegetation.

6a. Lodgepole Pine-Fescue Prairie

Cypress Hills are a beautiful, highly elevated, dissected plateau with grasslands, lodgepole pine, aspen, balsam poplar and white spruce.

The existing forest, excellent accessibility and superior land potential for forest production contribute to the recognition of the Mixedwood Section as the "backbone" of Saskatchewan's forest industry. Table 4 illustrates the distribution of presently recognized and inventoried species associations or cover types. Thirteen major species associations are recognized in the provincial inventory survey, neglecting a number of minor ones which are less common or have no commercial value at the present time. Dominating in area over the other groups of cover types are three "fire" associations - trembling aspen, black spruce and jack pine.

Table 4. Forest Associations in the Mixedwood Section (in hectares)

Species Association	Stocking[1] (crown closure)	Over-mature	Mature	Immature	Young	Total	Percent
White Spruce	A	2,068	4,897	812	123	7,900	
	B	8,404	17,788	1,796	129	28,117	
	C	7,694	33,230	3,454	222	44,600	
	D	501	7,668	1,265	206	9,640	
Subtotal		18,667	63,583	7,327	680	90,257	2.48
Black Spruce	A	495	2,110	6,602	1,707	10,914	
	B	3,394	25,495	42,998	21,997	93,884	
	C	7,208	75,928	159,916	35,683	278,735	
	D	1,214	36,341	225,788	27,028	290,371	
Subtotal		12,311	139,874	435,304	86,415	673,904	18.53
Jack Pine	A	870	6,403	28,520	11,654	47,447	
	B	4,371	22,486	72,505	30,190	129,552	
	C	7,902	40,707	149,943	34,380	232,932	
	D	1,903	22,260	155,311	14,694	194,168	
Subtotal		15,046	91,856	406,279	90,918	604,099	16.61
Tamarack	A	2	75	122	31	230	
	B	116	1,410	1,990	390	3,906	
	C	77	4,650	9,626	922	15,275	
	D	21	649	1,868	610	3,148	
Subtotal		216	6,784	13,606	1,953	22,559	0.62
Jack Pine-Black Spruce	A	653	1,503	4,145	370	6,671	
	B	2,598	10,898	23,596	1,151	38,243	
	C	6,794	35,115	71,923	2,118	115,950	
	D	3,162	31,373	44,706	1,380	80,621	
Subtotal		13,207	78,889	144,370	5,019	241,485	6.64
Mixedwood (Spruce-Aspen)	A	2,033	3,040	1,670	503	7,246	
	B	16,823	20,162	6,569	2,594	46,148	
	C	21,340	57,649	14,231	1,717	94,937	
	D	1,207	15,976	5,069	660	22,912	
Subtotal		41,403	96,827	27,539	5,474	171,243	4.71
Mixedwood (Jack Pine-Aspen)	A	564	1,468	4,012	5,336	11,380	
	B	3,383	4,671	10,330	8,621	27,005	
	C	8,607	7,316	18,074	6,571	40,568	
	D	3,124	2,552	7,760	1,141	14,577	
Subtotal		15,678	16,007	40,176	21,669	93,530	2.57
Mixedwood (Aspen-Spruce)	A	4,320	2,262	2,299	1,138	10,019	
	B	25,728	12,503	7,061	1,757	47,049	
	C	85,514	51,846	18,966	4,134	160,460	
	D	25,579	26,138	9,506	1,266	62,489	
Subtotal		141,141	92,749	37,832	8,295	280,017	7.69
Mixedwood (Aspen-Jack Pine)	A	309	907	2,866	5,721	9,803	
	B	2,249	3,947	9,005	6,460	21,661	
	C	6,327	9,996	16,551	4,235	37,109	
	D	3,539	4,167	11,545	2,110	21,361	
Subtotal		12,424	19,107	39,967	18,526	89,934	2.47

Table 4. **continued**

Species Association	Stocking[1] (crown closure)	Over-mature	Mature	Immature	Young	Total	Percent
	A	852	221	24	—	1,097	
Mixedwood	B	4,382	611	202	6	5,201	
(Balsam Poplar-	C	8,899	1,099	147	—	10,145	
Spruce)	D	250	227	53	7	537	
Subtotal		14,383	2,158	426	13	16,980	0.47
	A	18,583	9,256	10,533	17,088	55,460	
Hardwood	B	43,117	33,686	37,950	17,422	132,175	
(Aspen)	C	108,898	148,072	116,238	31,985	405,193	
	D	94,598	250,413	244,538	98,758	688,307	
Subtotal		265,196	441,427	409,259	165,253	1,281,135	35.24
	A	3,627	1,820	207	—	5,654	
Hardwood	B	13,714	3,898	1,709	79	19,400	
(Balsam-	C	17,081	5,521	2,297	131	25,030	
Poplar)	D	377	1,473	301	29	2,180	
Subtotal		34,799	12,712	4,514	239	52,264	1.44
Hardwood	A	743	336	664	2	1,745	
(White Birch,	B	4,613	541	1,184	16	6,354	
Manitoba Maple,	C	3,044	1,397	2,512	105	7,058	
White Elm,	D	211	1,622	2,211	175	4,219	
Green Ash)							
Subtotal		8,611	3,896	6,571	298	19,376	0.53
Total - All Associations		593,082	1,065,779	1,573,170	404,752	3,636,783	100.00
Percent		16.32	29.33	43.22	11.13	100.00	

		Percent
Total Area	7,035,524	100.00
Productive	4,050,060	57.56
Forested	3,636,783	51.69
Non-Forested	413,277	5.87
Non-Productive	2,400,261	34.12
Forested	1,625,845	23.11
Non-Forested	774,416	11.01
Water	585,203	8.32

1. A: understocked; B: inadequately stocked; C: well stocked; D: overstocked.

Beyond stand maturity, net yields decline with the rate of decline being dependent upon tree species, stand composition and environmental conditions.

Stand maturity and trends in stand deterioration are important factors in forest management (Table 5).

Table 5. Stand maturities on an average site (years)[1]

Species Association	Overmature	Mature	Immature	Young
White Spruce	120+	70 - 110	40 - 60	30
Black Spruce	130+	100 - 120	50 - 90	40
Jack Pine	100+	70 - 100	40 - 60	30
Jack Pine-Black Spruce	110+	80 - 100	50 - 70	40
Tamarack	140+	90 - 130	50 - 80	40
Mixedwood (Spruce-Aspen)	110+	70 - 100	40 - 60	30
Mixedwood (Aspen-Spruce	90+	60 - 80	40 - 50	30
Mixedwood (Jack Pine-Aspen)	80+	60 - 70	40 - 50	30
Mixedwood (Aspen-Jack Pine)	80+	60 - 70	40 - 50	30
Hardwoods (Aspen, Balsam Poplar, White Birch)	80+	60 - 70	30 - 50	20

1. Earlier maturity can be expected on better sites, and later maturity on poorer sites.

CHAPTER 2

OBJECTIVES

- To identify ecological forest units or ecosystems within the Mixedwood Forest Section in Saskatchewan, and to appraise their use in forest management.
- To provide a better understanding of the ecosystem concept in order to base forestry practices on sound and fundamental ecological principles rather than short term wood volume inventories.
- To relate consequences of various management alternatives regarding forest establishment, stand development and perpetuation.
- To emphasize the land potential for forest production.

CHAPTER 3

3.0 MODIFYING FACTORS

3.1 SETTLEMENT[1]

The European demand for furs prompted the exploration of Western Canada. From about 1670 to 1870, the Hudson's Bay Company claimed authority over lands draining into Hudson Bay, and in 1774, the first permanent settlement in Saskatchewan was established at Cumberland House by Samuel Hearne. The intense rivalry of the fur trade prompted the establishment of fur forts within the interior of Saskatchewan.

In 1821, rival fur trading companies amalgamated under the Hudson's Bay Company name. This amalgamation decreased the number of fur forts and personnel required. To offset this surplus of people, the Hudson's Bay Company commenced settling former employees in the Red River Valley.

Political unrest in the area covered by the Hudson's Bay Company charter led the British Government in 1857 to appoint a committee to study the eligibility of license renewal to the Hudson's Bay Company, and the possibility of colonization of these lands. Stemming from this, and of significance to Saskatchewan, were two separate studies to determine the feasibility of agricultural development on Hudson's Bay Company lands. One study was carried out by Captain John Palliser from Britain, and the other by Mr. S.J. Dawson and Professor H.Y. Hind from Canada. Both studies indicated lands suitable for agricultural development.

In 1868, the British Government relinquished administration of the Hudson's Bay Company lands, and the Canadian Government assumed the responsibility of this area, which it named the Northwest Territories.

Concerned with settlement, the Canadian Government passed the Dominion Lands Act in 1872, which provided a homestead of 65 hectares (160 acres) for a nominal fee of $10.00 to incoming settlers. Treaties with Indians contained provisions whereby the Government would provide agricultural supplies (tools, seed, etc.) as a further effort in agricultural development.

Several years prior to the advent of the railway, older settlements progressed favourably. In 1880, two ranchers from the Calgary area moved to the Battleford area and started ranching. The Hudson's Bay Company grist mill located at Prince Albert also went into operation in 1880. The *Prince Albert Times* and *Saskatchewan Review* began publishing in 1882.

With the advent of the railway, people tended to settle in close proximity to the newly constructed C.P.R. line. The railway to Prince Albert was completed in 1890, and in 1891 German speaking Mennonites from Russia settled along the line at Rosthern. Two years later a few French families from France settled in the Duck Lake area. Ukrainians arrived at Saskatoon in 1897 and travelled to Fish Creek. A couple of years later about 7,000 Doukhobors from Russia settled near Swan River, Yorkton and Prince Albert. Promotional efforts for settlement during this period saw the influx of many settlers of diverse origin, and for the period ending June 30, 1906, a total of 27,692 homestead entries were made in the Province of Saskatchewan.

Settlement, coupled with mechanization, rapidly altered the natural landscape. Drought during the 1930's brought about the abandonment of many farms in the southern area of the province, and hastened the encroachment of agriculture on the fringe areas of the forest.

Information provided by a 1953 survey[2], and a 1975 forest inventory indicate that within an approximate 23 year period the amount of forested land, within an area which relates to the settlement area of the Mixedwood Section, decreased by about 0.6 million hectares or 53 percent (excluding Indian Reserves). Since 1975, land development has continued.

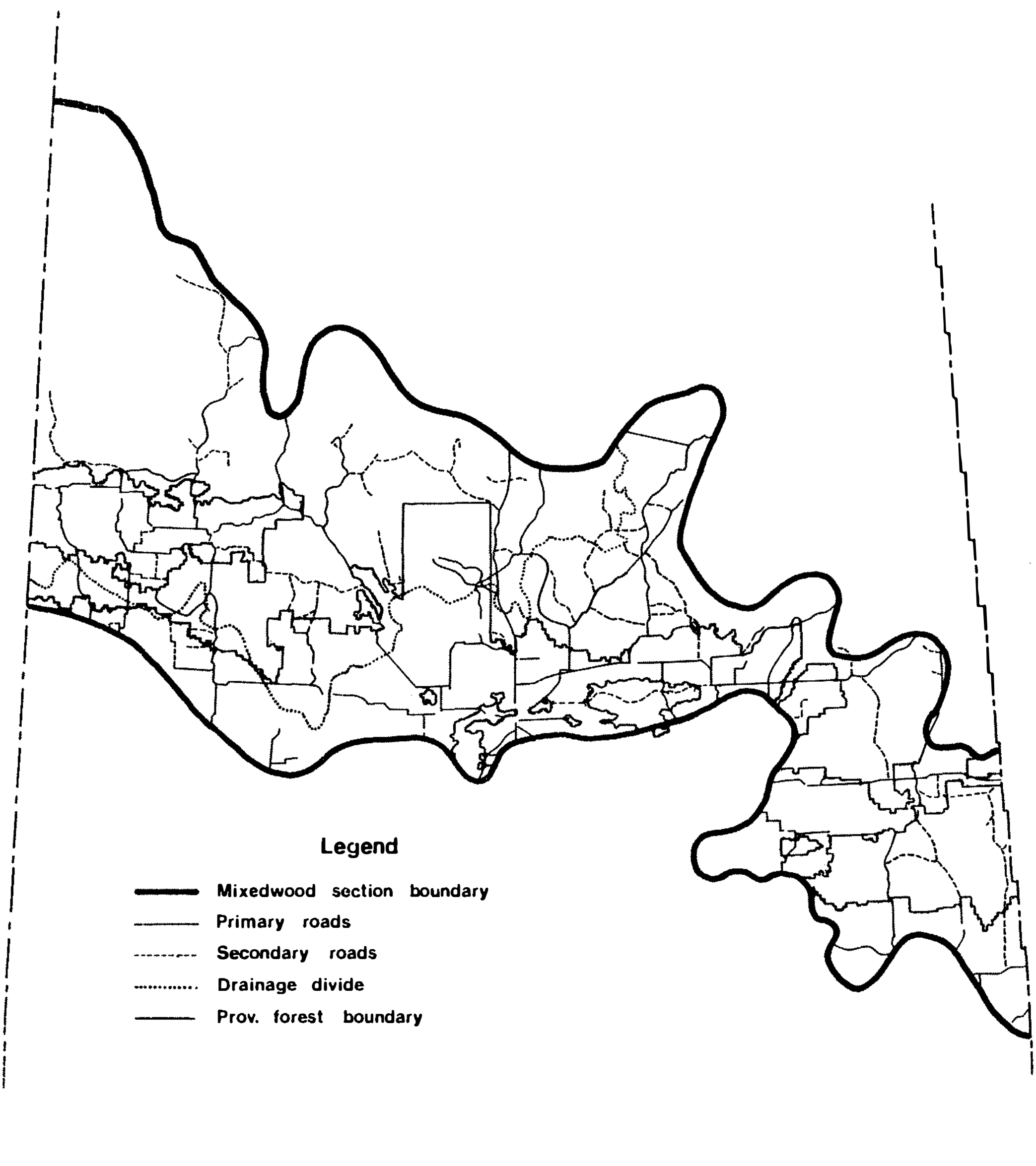
1. Adapted mainly from the publication *Saskatchewan, the History of a Province* by J. Wright

2. Unpublished report by D. G. Wyllie, "Saskatchewan Survey Report 1953".

3.2 ROADS

Approximately 1,370 km of primary highways and an equal distance of secondary all-weather roads cross the Mixedwood Section (Figure 4). Except for the northwest portion of the Section, the average distance to an all-weather road is about 40 to 50 km. Roads (Photo 1) are necessary for transporting goods, recreational purposes, communication, hunting, trapping and other public services. In forestry, they are essential for conveying timber and for fire protection. Generally roads are considered absolutely necessary, and are sometimes used as broad indicators of a regional economy, similar to the consumption of soap as an indicator of the health and hygiene of a nation.

Figure 4. Road network[1] and drainage divide



1. 1976 information.

Benefits derived from roads obscure their direct and indirect negative effects upon the environment. Whether it is an agricultural or forested area, roads remove land from production. In this Section alone, it is estimated that about 12,500 hectares of forest land are occupied by major roads, of which about 6,800 hectares or 54.4 percent, are rated as productive land. At the current rate of increment of 1.1 cubic metres of softwoods per hectare, this land could produce 7,480 cubic metres of valuable softwood products.

Roadside flooding is another direct negative effect. In order to obtain information about the magnitude of this problem, four main highways within the Provincial Forest portion of the Mixedwood Section were traversed in 1975. Locations with partially or fully blocked culverts, or the complete absence of required culverts, were marked on maps and the extent of inundation was determined from aerial photographs. Over a total distance of 483 km., 28 bridges and 425 culverts (Photo 2) were registered, with an average of 0.9 culverts per km or 1.1 km of road per culvert. Approximately 50 hectares of locally flooded areas (Photo 3) were observed. In low areas with level topography, the interference of roads and consequent flooding affected much larger areas (Photo 4) than roads constructed in hummocky terrain. Generally, in places with obstructed drainage, the negative effects of excess water are visible on the upper side of the road; on the lower side of the road vegetation has generally benefited. However, there is no doubt that the interrupted natural drainage has a much larger and far reaching impact on the forest vegetation and local environment than observed during this trial. The entire Manitoba Lowlands Ecodistrict (3c) is an example of a large area where natural flooding has been artifically controlled by the Outlook, Nipawin and Squaw Rapids hydro projects. The time elapsed is still too short to note visible changes; however, in time this area may become the largest block of the most productive forest land in the province.

Photo 1. Many kilometres of new roads are built every year.

Photo 2. Culverts and bridges accommodate natural drainage.

Photo 3. A missing culvert creates local flooding.

Photo 4. The lack of a culvert on flat terrain affects large areas.

Another popular and much debated subject has been the reserves or "leave strips" along roads, streams and lakes (Photo 5). The pros and cons as viewed by foresters, wildlife and fisheries biologists, recreation, soil and administrative people in Western Canada and the United States, have been described in the Canadian Forestry Service publication "*Leave strips: Good or Bad*" (Stevenson, 1975).

Photo 5. A disrupted leave strip.

Generally, it seems desirable to retain these green belts, especially with a multiple land use concept in mind. Nevertheless, so many variables and circumstances influence each situation that an on-the-spot assessment of each site appears to be the most realistic course of action.

In Saskatchewan leave strips are reserved along the borders of provincial highways, other roads, streams and banks of lakes, as may be designated by the Minister.

A study to determine the accelerated loss (if any) of wood volume from blow-down or breakage in leave strips along provincial highways was initiated in 1975. Some blow-down on sites with a high water table where trees were shallow rooted (Photo 6) was noted. Additional information on leave strips and their maintenance is required (Thompson, 1975).

Photo 6. Some blow-down along leave strips is unavoidable.

3.3 GRAZING

Statistics provided by the Economics Branch, Saskatchewan Department of Agriculture indicate that on July 1, 1984, the adult cattle population in Saskatchewan was 1,342,000 head. During the summer of 1984, grazing permits for about 13,892 head (1.0% of the total provincial adult cattle population) were authorized. Approximately 59 percent of the permits were issued for grazing within the Provincial Forest and the balance for grazing within the Provincial Parks.

Although the effects of grazing in the forest are not fully understood, root damage and physical breakage are obvious in some cases particularly near watering holes, corrals and other places where cattle assemble. Grazing in areas that have been logged or burned and are presently supporting a mixture of grasses and softwood seedlings should be avoided or lightly grazed, as livestock will tend to concentrate in these areas where grass is more abundant, and seedling trampling will occur.

With the exception of meadow areas, hardwood stands appear to provide the most adequate cover under which preferred understory vegetation may become established. This is probably the result of the tree canopy permitting more sunlight penetration to fulfill the requirements of the more demanding understory vegetation.

3.4 RECREATION

The Mixedwood Section is easily accessible and encompasses some of Saskatchewan's best recreational features: extensive tree cover, diverse fish and wildlife resouces, numerous navigable lakes and rivers, good quality water and beaches, reliable snow cover and reduced wind speed relative to areas further south. It is additionally important considering the somewhat limited recreational opportunities of adjacent southern areas which are primarily agricultural. The Section includes 72% (approximately 700,000 ha) of all land areas designated by statute for recreation*, and accomodates nearly 50% of the recreational use of all such designated areas.

Dispersed forms of recreation such as hunting, fishing, snowmobiling and cross-country skiing occur throughout the Section, and are particularly evident on crown lands. The aerial extent over which these recreational uses occur is largely dependent on the network of forest roads and trails.

Intensive forms of recreation are concentrated within parks (Table 6), recreation sites and cottage subdivisions. Park areas are often zoned to consolidate intensive recreation use within specific areas. These core areas encompass most of the day use and extended stay recreation facilities: picnic areas, beaches, campgrounds, fixed roof accommodation, and cottages. The remaining park area is normally zoned for low intensity recreational use.

A second objective of park areas, other than recreation, is preservation or protection of natural environment. Parks are in a unique position to be of long term benefit to the preservation of the mixedwood ecosystems. Within parks, the forest resource is generally managed for its intrinsic value rather than economic gain.

Table 6. Provincial Parks in the Mixedwood Section (1985)

Park	Area (ha)	Visitations (1985)**
Duck Mountain Provincial	26,160	242,643
Greenwater Provincial	18,653	54,156
Meadow Lake Provincial	156,970	249,699
Nipawin Provincial	65,269	41,910
Total	267,052	588,408***

Past management efforts within parks and recreation sites have protected forest resources from fire and harvesting activities. As a result, many forest stands are becoming more susceptible to fire and disease. Alternative management may be required in the future to ensure the long term vitality of these forested environments for recreation purposes.

* Including Prince Albert National Park.
** Based on 3 persons/vehicle.
*** In addition, 302,596 visitations were recorded to October, 1985 at the Prince Albert National Park.

3.5 FOREST UTILIZATION

The utilization of Saskatchewan's forests has been closely related to, and influenced by, the historical aspects of the forest industry, changes in administrative control and forest product market developments.

Commercial forest utilization can be traced back to 1870 when the Dominion of Canada acquired the responsibility of resource administration from the Hudson's Bay Company. Prime virgin stands of overmature white spruce attracted wood industries, and six large stationary sawmills were established. Railways, rivers with favourable water flow, and ice roads were the main means of conveying logs to the mills. Horses were used, both for skidding in the forest and pulling loaded sleighs for short distance hauling. Depletion of the large blocks of mature white spruce necessitated the replacement of the large stationary mills by small portable mills which could be moved to smaller, scattered stands of desirable timber. Between 300 and 500 such mills went into operation, and until about 1955, selective cutting in small patches of trees over 36 cm d.b.h. (o.b.) was a common practice.

Closely related to the spruce lumber industry was the production of railway ties. Production of ties fluctuated and was never in adequate proportion for Saskatchewan's 14,000 km of railway. In this respect, Saskatchewan has been a large consumer, but a relatively small producer. With the abandonment of less profitable branch lines, a future decline in the demand for ties can be anticipated.

Production of spruce lumber has also fluctuated, with major peaks occuring in 1912, 1920 and 1946, when annual production varied from 318,600 to 365,800 m^3 of lumber. The lowest production occurred from 1926 to 1930, with an average output of 23,600 m^3 per annum. A regulated annual output of 141,600 to 165,200 m^3 of lumber from 1950 to 1965 did not reflect a declining market, but rather an intended policy to prevent white spruce from being over-cut.

Until 1950, about 70 percent of the logging was done during the winter. Logs were sawn into planks and boards, and then hauled to piling yards for seasoning, resawing and planing. Log skidding and lumber hauling were done on frozen ground, thus cheap and primitive winter roads were utilized.

Once the logging operation was completed, equipment removed and campsites abandoned, land recovery was left to nature. As the wounds inflicted on the environment were small, natural regeneration, in most cases, was sufficient for restocking the cut-over areas, and early cut-overs could hardly be noticed after 10 or 15 years.

Today, it is unrealistic to expect nature to counterbalance man's interference. Forest utilization has increased dramatically and forest harvesting methods, then and now, are hardly comparable. Seasonal winter logging has been replaced by a continuous harvest operation, and temporary winter roads have been replaced by permanent all-weather haul and extraction passageways. Short distance (0.4 to 1.6 km) log hauling to the mill has given way to long distance (80 to 160 km) transportation of tree length logs to the mill or factory. In addition to diversified and integrated utilization, complete mechanization in tree felling, skidding and bucking is now employed.

Socio-economic changes have accompanied developments in the forest industry. Direct effects are increased revenue and permanent employment. However, pursuit of increased financial returns from forest resources must be carefully kept in balance and regulated with the actual and potential productive capacity of the resource (Table 7).

Table 7. Present volume and current increment by species (in thousands of cubic metres)

Species	Volume	Percent	Increment
White spruce	58,573	14.58	1,240
Black spruce	57,135	14.22	857
Jack pine	64,028	15.93	1,600
Balsam fir	13,178	3.28	240
Tamarack	3,102	0.77	37
Total Softwoods	196,016	48.78	4,034*
Aspen	160,301	39.89	4,588
Balsam poplar	30,431	7.57	993
White birch	14,259	3.55	268
Green ash	18	—	—
Manitoba maple	623	0.16	15
White elm	193	0.05	3
Total Hardwoods	205,825	51.22	5,867
Grand Total	401,841	100.00	9,901

*The 4,034,000 cubic metres of annual softwood increment represents the present or actual growth. The calculated potential softwood annual increment in the Mixedwood Section is 13,582,000 cubic metres.

Present utilization of softwoods in the Mixedwood Section is about 2.0 million cubic metres or 49.8 percent of its current annual increment; hardwood utilization is only 10.3 percent. This total output of softwoods does not, however, exclude over-utilization of a single species. The actual acreage of cut-over land can only be estimated because of intermingled clear-cut and selectively logged stands and delayed follow-up surveys. This creates some uncertainty as to whether or not the backlog of non-forested land as shown in Table 4 is increasing or decreasing after the completion of current reforestation programs and natural regeneration has taken place.

In many instances short-term economic considerations take precedent over silvicultural and ecological aspects of forest utilization. It is the intent of this publication to relate these aspects in a practical manner and attempt to correct this situation. Another expansion in forest utilization, similar to that in the last two decades, may be detrimental to our forest resources and should be given careful consideration. Briefly, a significant change, compatible with economic realities, would require wider understanding and acceptance of the ecosystem concept in forest resource management (Bakuzis, 1968).

3.6 FOREST FIRES

Fire suppression records for the 39 year period (1945-1983) revealed that an average of 80 fires have burned every year within the provincial forest portion of the Mixedwood Section. About 27,744 ha or 0.43 percent of the forest land has burned annually (Table 8). At this rate, and assuming evenly-spread forest fires, all forest land could be expected to burn once every 232 years. Actually, no such regularity prevails, for some areas experience two, three or more fires, while others escape fire for a long time. An interesting note is that lightning is the cause of the majority of fires when origin was determined. The cause of 39 percent of the forest fires is unknown.

Forty-six radio-equipped lookout towers, and air patrols maintain a surveillance over the forested area. In addition, close co-operation with commercial air carriers which pass over the area aids in fire detection. Specialized initial attack crews, water bombing fixed-wing aircraft and helicopters perform a vital role in the suppression of forest fires. The importance of good public relations is realized, and public co-operation and education are achieved through radio and newspaper messages, fire protection signs and other forms of communication.

Professionals agree that fires have both harmful and beneficial effects, depending on circumstances. Wildlife ecologists, hunters and prospectors may see them as advantageous to their interests; while foresters, fishermen, watershed management people and tourists may be opposed.

Forest fires are considered to be disastrous to modern forestry, with their only justification being a cheap means of forest propagation in cases of extensive management. However, there is no doubt that forest fires, in the past, have been an all-time regulating force in determining the natural regeneration and distribution of tree species in the Mixedwood Section.

Fire hazard ratings for the various forest ecosystems have been developed by members of the fire research group, Northern Forest Research Centre, Edmonton, Alberta. The ratings were based on available information about the individual ecosystem and knowledge of fire behaviour. Variations in stand age, disturbance and density could not be considered at the time because of inadequate data, and the resulting ratings were applicable primarily to standardized conditions of full stocking and stand maturity. Where necessary, final adjustments to the ratings were made during field consultations with provincial forestry officials (Chrosciewicz, 1983). Appendix III displays the ratings for each ecosystem.

The system of ratings is based on a relative scale from 1 to 10, one (1) being very low, and ten (10) very high. It provides a rating for crown and surface fires during the dormant and active seasons of forest growth (Chrosciewicz, 1983) as follows:

$$\text{C.D.S.}\ \left\{\begin{array}{c|c} \text{C.F.} & \text{C.F.} \\ \hline \text{S.F.} & \text{S.F.} \end{array}\right\}\ \text{A.G.S.}$$

Where:

C.D.S. (left) refers to the cured dormant state in early spring and late fall.
A.G.S. (right) refers to the active growth state in late spring to early fall.
C.F. (above) refers to crown fires.
S.F. (below) refers to surface fires.

Table 8. Forest fire history - Mixedwood Section (1945-1983)

Year	No. of Fires[1]	Area[2] Burned (hectares)	Causes									
			Recreation		Settlement		Industry		Lightning		Unknown	
			No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned
1945	22	3,219	—	—	2	93	2	40	2	2,857	16	229
1946	64	9,415	—	—	17	2,240	5	200	1	1	41	6,974
1947	82	7,122	—	—	13	1,673	6	1,604	6	90	57	3,755
1948	61	17,205	—	—	15	4,193	—	—	2	2	44	13,010
1949	147	177,661	—	—	39	75,753	4	53	8	308	96	101,547
1950	42	37,840	—	—	14	28,477	—	—	4	4,285	24	5,078
1951	11	1,313	—	—	2	17	—	—	2	147	7	1,149
1952	54	4,067	1	—	6	840	6	61	4	335	37	2,831
1953	53	27,116	—	—	4	134	7	17	4	30	38	26,935
1954	14	353	—	—	2	—	2	—	1	243	9	110
1955	57	15,218	—	—	5	6	4	45	13	156	35	15,011
1956	33	1,951	—	—	4	134	1	4	7	879	21	934
1957	39	2,107	—	—	6	660	—	—	12	1,367	21	80
1958	70	9,296	1	—	12	4,054	2	438	8	578	47	4,226
1959	44	641	1	—	3	121	1	1	7	27	32	692
1960	37	1,524	1	—	5	136	—	—	8	1,301	23	87
1961	129	95,144	7	251	14	1,562	5	8	52	13,251	51	80,072
1962	91	930	8	7	6	175	—	—	50	555	27	193
1963	64	9,210	3	2	7	8,423	1	—	25	347	28	438
1964	130	106,169	9	11	17	5,364	1	—	88	78,599	35	22,195
1965	23	306	2	2	1	8	—	—	9	13	11	283
1966	38	708	5	21	2	2	1	—	11	656	19	29
1967	129	10,885	18	8	25	3,832	5	2	29	6,123	52	920
1968	96	55,858	18	154	12	845	2	—	27	10,930	37	43,929
1969	110	3,231	18	8	8	18	3	49	33	108	48	3,046
1970	82	90,472	13	29	3	—	1	—	47	74,116	18	16,327

Table 8. continued

Year	No. of Fires[1]	Area[2] Burned (hectares)	Causes									
			Recreation		Settlement		Industry		Lightning		Unknown	
			No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned
1971	69	2,701	8	6	10	1,175	7	3	17	1,334	27	183
1972	149	8,091	24	6	19	37	3	—	51	7,842	52	206
1973	70	490	4	—	17	209	11	44	17	108	21	129
1974	46	103	3	—	1	—	4	3	22	8	16	92
1975	64	194	12	2	6	—	5	—	19	140	22	52
1976	137	3,576	32	166	20	587	10	54	43	2,334	32	435
1977	116	104,597	18	46	13	2,283	7	188	58	101,932	20	148
1978	102	223	27	11	12	3	2	3	53	108	8	103
1979	56	731	9	3	4	1	5	1	32	521	6	205
1980	161	251,196	19	1,226	14	223	12	792	80	94,117	36	154,828
1981	190	19,795	45	54	30	402	13	27	76	14,058	26	5,254
1982	173	1,075	35	42	12	142	4	1	68	639	54	251
1983	71	104	19	4	10	34	7	17	24	34	11	15
Total	3,126	1,082,037	360	2,059	412	143,866	149	3,655	1,000	420,474	1,205	511,983
Percent	100.00	100.00	11.52	0.19	13.18	13.29	4.77	0.34	31.99	38.86	38.55	47.32

1. Includes fires of less than 0.10 hectares in size.
2. Does not include burned-over areas of less than 0.10 hectares.

Table 8. continued

Year	No. of Fires[1]	Area[2] Burned (hectares)	Causes									
			Recreation		Settlement		Industry		Lightning		Unknown	
			No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned	No. of Fires	Area Burned
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1972	149	8,091	24	6	19	37	3	—	51	7,842	52	206
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1974	46	103	3	—	1	—	4	3	22	8	16	92
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1977	116	104,597	18	46	13	2,283	7	188	58	101,932	20	148
1978	102	223	27	11	12	3	2	3	53	108	8	103
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Total	3,126	1,082,037	360	2,059	412	143,866	149	3,655	1,000	420,474	1,205	511,983
Percent	100.00	100.00	11.52	0.19	13.18	13.29	4.77	0.34	31.99	38.86	38.55	47.32

1. Includes fires of less than 0.10 hectares in size.
2. Does not include burned-over areas of less than 0.10 hectares.

CHAPTER 4

4.0 METHODS AND SCOPE OF INVESTIGATIONS

4.1 GENERAL SYNOPSIS

Simultaneously with the interest in better forest management and maintenance of forest resources, forest ecology advanced and developed into a special field of the ecological science. As a result, a number of different forest classification systems were developed and proposed for further research and forest management purposes. It is beyond the scope of this publication to list and review all the trends and developments these scientists followed in their work and presentations; however, briefly, they have considered climate, physiographic features, forest cover and minor vegetation as the major factors contributing to the formation of forest ecosystems. In this report, emphasis is placed on forest cover, minor vegetation and soils with reference to regional climatic data (Figure 5).

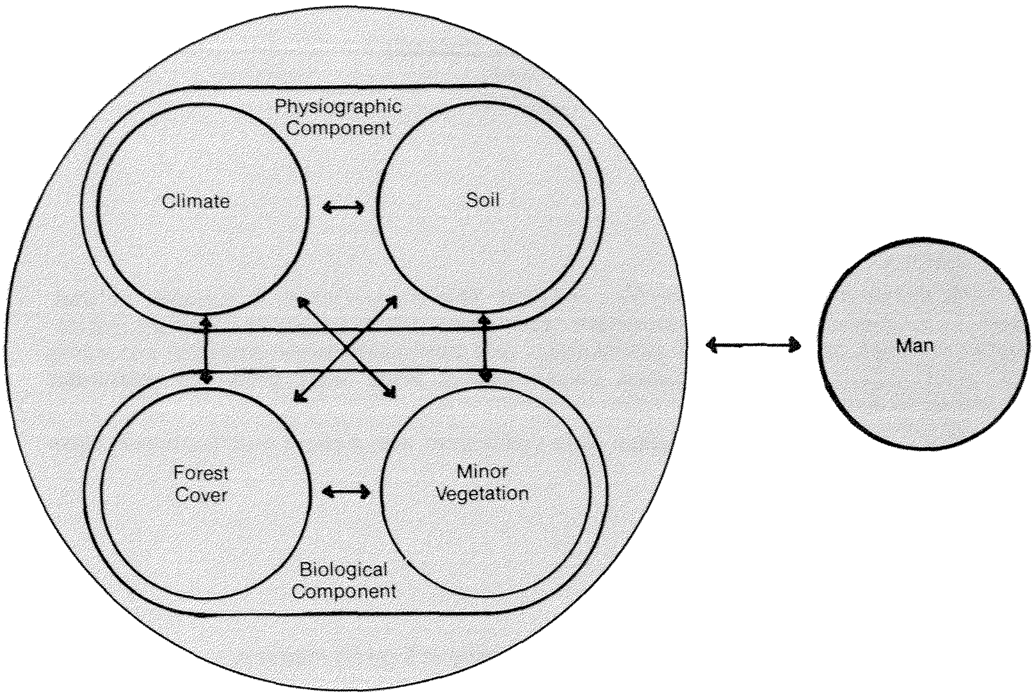


Figure 5. A simplified scheme of interrelations in a forest ecosystem

4.2 FOREST INVENTORY

The groundwork for the ecosystems described in this publication is closely related to the history and extent of related forest surveys in the last four decades in Saskatchewan, particularly in the Mixedwood Section.

The first general inventory which began in 1946 and was completed in 1956, was designed to provide information on forest land distribution and timber resources. Four forest associations, softwood (spruce), softwood (jack pine), mixedwood (spruce-aspen) and hardwood (aspen), were recognized, based on the proportion of softwoods or hardwoods by volume. The canopy or crown density was divided into four levels (A, B, C, D), and the height into four classes (1, 2, 3, 4).

From 1957 to 1975 a second inventory covering the previous 98,420 km^2 plus an additional 56,980 km^2 was undertaken. The number of species associations in this survey was increased to nine, namely: softwood (white spruce), softwood (black spruce), softwood (jack pine), softwood (tamarack), mixedwoods (spruce-aspen), (aspen-spruce), (jack pine-aspen), (aspen-jack pine) and hardwood (aspen-balsam poplar-white birch). Stands were described according to the following criteria:

Composition:[1]

Softwoods (S):	More than 75% softwoods by volume.
Softwood/hardwood (SH):	50 to 75 percent softwoods by volume.
Hardwood/softwood (HS):	50 to 74 percent hardwoods by volume.
Hardwoods (H):	More than 75 percent hardwoods by volume.

In young stands, the number of stems of each species was used as a composition criterion.

Crown Cover:

A. 1 to 30 percent crown cover (understocked).[2]
B. 31 to 50 percent crown cover (inadequately stocked).
C. 51 to 70 percent crown cover (well stocked).
D. 71 to 100 percent crown cover (overstocked).

Height Class:[3]

1. 0.3 to 9.1 m
2. 9.2 to 15.2 m
3. 15.3 to 21.3 m
4. 21.4 m+

In 1976, the third inventory survey was initiated. This survey, which is currently utilized, adopted S.I. or metric units of measurement. Jack pine - black spruce and balsam poplar-spruce were added as new species associations, and hardwoods were classified according to their primary species, namely: aspen, balsam poplar, white birch, green ash, Manitoba maple and white elm.

Four density or crown closure classes were maintained with a slight modification in class limits. The new classes include:

$10 < A \leq 30\%$
$30 < B \leq 55\%$
$55 < C \leq 80\%$
$80 < D \leq 100\%$

Stand height classes, as shown below, are designated at 5 metre intervals.

$2.5 < 5 \leq 7.5$
$7.5 < 10 \leq 12.5$
$12.5 < 15 \leq 17.5$
$17.5 < 20 \leq 22.5$
$22.5 < 25+$

1. See Appendix 1 for softwood and hardwood species nomenclature.
2. "Forest Stands" describes stocking in the glossary.
3. Average height of dominant and co-dominant trees.

A modified Three-Pee sampling technique replaced the relascope. The new method is based on the probability that a sample tree will be selected in a proportional manner to the prediction of volume in the population being sampled.

A site matrix, based on soil drainage and texture was added to the inventory. The drainage and texture classes are interpreted on aerial photographs in addition to the forest cover types.

Seven classes are utilized in the description of soil drainage and five classes (including organic) are recognized as components of soil texture. They include:

Soil Drainage:

Very rapidly drained (VRD)
Rapidly drained (RD)
Well drained (WD)
Moderately well drained (MWD)
Imperfectly drained (ID)
Poorly drained (PD)
Very poorly drained (VPD)

Soil Texture:

Coarse (C)
Moderately coarse (MC)
Moderately fine (MF)
Fine (F)
Organic soil (O)

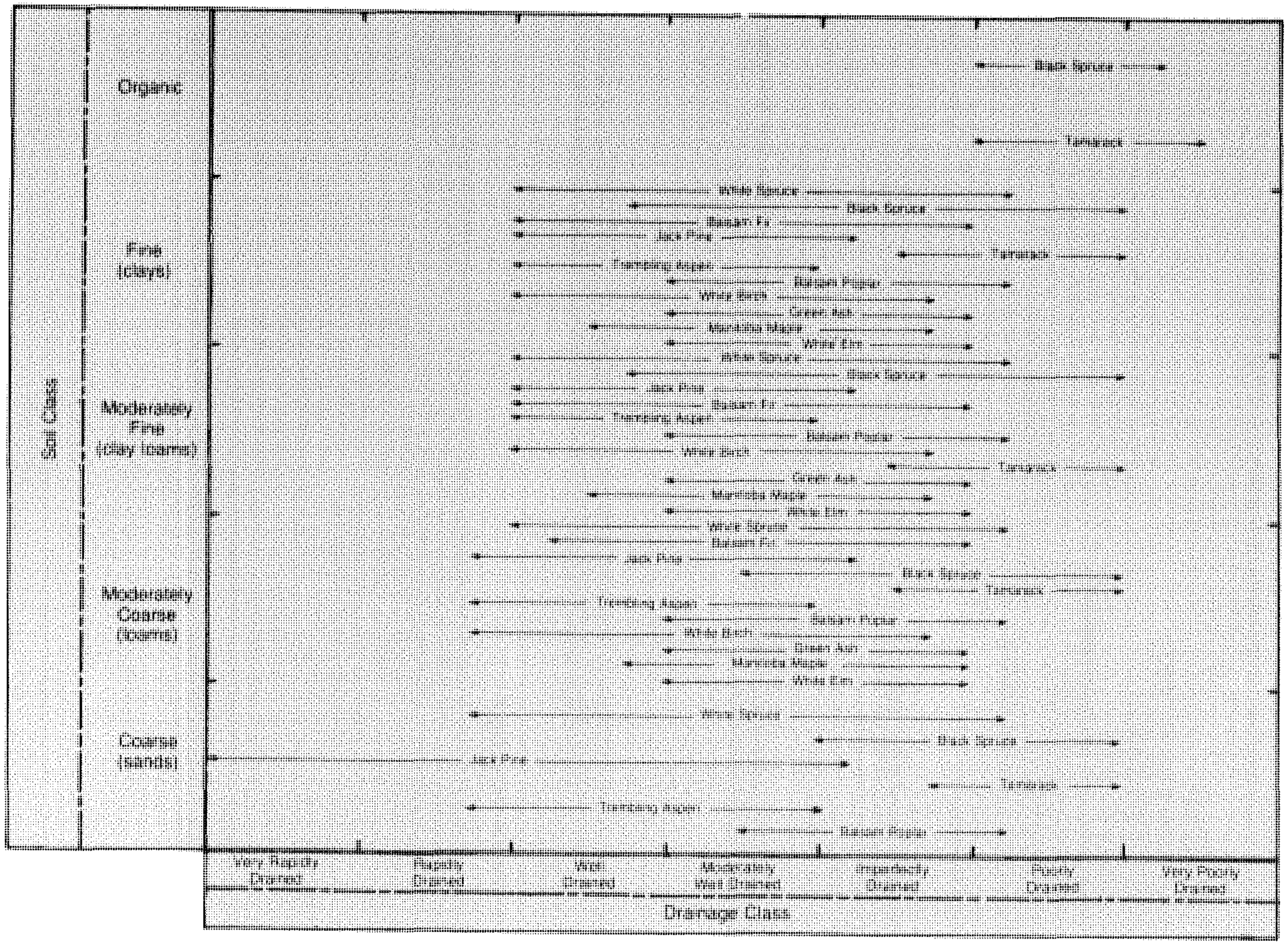
The common commercial edaphic ranges for tree species found within the Mixedwood Section are shown in Figure 6.

The assignment of ages to forest stands was also added to the inventory program. As shown in Table 9, forest stand ages are based on ten-year classes. All ages are coded according to year of origin.

Table 9. Forest stand ages

Yr. of Origin	Age	Code	Yr. of Origin	Age	Code
1976-1985	≤ 9 yrs.	98	1896-1905	80- 89 yrs	90
1966-1975	10-19 yrs.	97	1886-1895	90- 99 yrs	89
1956-1965	20-29 yrs.	96	1876-1885	100-109 yrs	88
1946-1955	30-39 yrs.	95	1866-1875	110-119 yrs	87
1936-1945	40-49 yrs.	94	1856-1865	120-129 yrs	86
1926-1935	50-59 yrs.	93	1846-1855	130-139 yrs	85
1916-1925	60-69 yrs.	92	1836-1845	140-149 yrs	84
1906-1915	70-79 yrs.	91	1826-1835	150-159 yrs	83

Figure 6. Edaphic ranges of trees for commercial production in the Mixedwood Section



4.3 GROWTH AND YIELD SURVEY

In 1949 a "growth and yield" survey was initiated to study the growth and productivity of commercial tree species in this province. Over nine hundred 809 m^2 (one-fifth acre) permanent sample plots in six major forest associations were established. Empirical growth and yield tables complemented by pertinent information on regeneration, utilization, and environmental factors affecting tree growth, were prepared and published in comprehensive reports.

Three site quality groups, derived from forest stand characteristics and implying environmental growth conditions, were used in the growth and yield survey. However, it was often realized that more site quality subdivisions are required to indicate the actual land productivity. In view of this, the information found in Appendix II has been assembled into seven site quality groups.

The growth and yield survey is continued by maintaining the remaining permanent sample plots, and by the addition of variable size plots in conjunction with the Three-Pee inventory sampling.

4.4 POTENTIAL AND ACTUAL FOREST LAND PRODUCTIVITY

The Land Capability Classification for Forestry carried out from 1964 to 1972 under the A.R.D.A. program contributed immensely to this project by providing information on potential land productivity. The area involved consisted of 146,087 km^2, of which 111,564 km^2 are within the Mixedwood Section. This study supplemented previous studies by furnishing background material on the interaction of biophysical and climatic factors on forest communities and their production.

The system consisted of three categories:

(a) Capability class: a composite expression of all environmental factors as they apply to tree growth;

(b) Capability subclass: the factors which limit tree growth;

(c) Indicator species: indigenous tree species that can be expected to yield the productivity within the limits of a particular capability class.

In assigning land to a given class, the present actual productivity of a mature, fully stocked stand in terms of mean annual increment (M.A.I.) of merchantable volume was determinative.

Seven productivity classes were recognized, ranging from greater than 7.7 m^3/ha for class 1 lands to less than 0.7m^3/ha for class 7 lands. Due to climatic limitations, class 1 lands for forestry do not occur in Saskatchewan.

The capability survey for land in the Provincial Forests revealed an average annual potential production of 2.9 m^3/ha, while actual production, at that time, was 1.1 m^3/ha. Therefore, the potential softwood species production was 2.6 times the actual.

As described in Section 4.2, the Forestry Division utilizes a site classification system which is based on edaphic (soil texture and drainage) factors. Coupling this information with results obtained from the growth and yield survey facilitates the determination of potential productivity of various tree species (Figure 7).

Edaphic classes, their distribution and potential productivity within the Mixedwood Section are listed in Table 10. The weighted potential M.A.I. for the Mixedwood Section is 3.35 m^3/ha, while the weighted actual M.A.I. of the same area is 1.14 m^3/ha. The ratio is 2.94, similar to that obtained by the A.R.D.A. forest land capability survey.

Figure 7. Potential species productivity.[1]

Soil Texture Class	VR	VR-R	R	R-W	W	W-MW	MW	MW-I	I	I-P	P	P-VP
O												bS III/0.8
F					wS II/3.1	wS II+/3.8	wS I/4.3	wS I+/5.0	wS I/4.3	wS II-/2.6	bS II/1.4	bS III/0.8
MF-F					wS II/3.1	wS II+/3.8	wS I/4.3	wS I+/5.0	wS I/4.3	wS II-/2.6	bS II/1.4	bS III/0.8
MF					wS II/3.1	wS II+/3.8	wS I/4.3	wS I+/5.0	wS I/4.3	wS II-/2.6	bS II/1.4	bS III/0.8
MC-MF				wS II-/2.6	wS II/3.1	wS II+/3.8	wS I/4.3	wS I+/5.0	wS I/4.3	wS II-/2.6	bS II/1.4	bS III/0.8
MC				jP II-/1.6	wS II/3.1	wS II+/3.8	wS II+/3.8	wS II+/3.8	wS II+/3.8	wS II-/2.6	bS II/1.4	bS III/0.8
C-MC	jP III-/0.8	jP III-/0.8	jP III/1.3	jP II-/1.6	jP II-/1.6	wS II/3.1	wS II/3.1	wS II/3.1	wS II/3.1	wS II-/2.6	bS II/1.4	bS III/0.8
C	jP III-/0.8	jP III-/0.8	jP III-/0.8	jP III-/0.8	jP III/1.3	jP III/1.3	jP III/1.3	jP III/1.3	bS III/0.8	bS III/0.8		

Drainage Class

1. Productivity expressed as M.A.I. (m^3/ha). Upper term indicates site class.

Table 10. Edaphic classes and potential forest land productivity within the Mixedwood Section

Edaphic Class	Total Area (hectares)	Potential Mean Annual Productivity (m^3)
VRD/C	138	110
VRD-RD/C	2,898	2,318
VRD-RD/C-MC	13	10
VRD-RD/MC-MF	6	8
RD/C	94,865	75,892
RD/C-MC	90	117
RD/MC	35	56
RD/MC-MF	24	48
RD-WD/C	61,865	49,492
RD-WD/C-MC	80,476	128,762
RD-WD/MC	2,073	3,317
RD-WD/MC-MF	2,129	5,535
WD/C	44,903	58,439
WD/C-MC	99,403	159,045
WD/MC	12,632	39,159
WD/MC-MF	33,187	102,880
WD/MF-F	4	12
WD/F	776	2,406
WD-MWD/C	75,062	97,581
WD-MWD/C-MC	196,505	609,320
WD-MWD/MC	40,182	152,692
WD-MWD/MC-MF	823,347	3,128,719
WD-MWD/MF	286	1,087
WD-MWD/MF-F	57,627	218,983
WD-MWD/F	8,547	32,479
MWD/C	18,317	23,812
MWD/C-MC	33,919	105,149
MWD/MC	12,552	47,698
MWD/MC-MF	325,931	1,401,718
MWD/MF	70	301
MWD/MF-F	36,054	155,032
MWD/F	50,935	219,020
MWD-ID/C	35,782	46,517
MWD-ID/C-MC	41,385	128,293
MWD-ID/MC	10,856	41,253
MWD-ID/MC-MF	626,631	3,133,655
WD-ID/MF	2,022	10,110
MWD-ID/MF-F	139,617	698,085
MWD-ID/F	85,994	429,970

Table 10. continued

Edaphic Class	Total Area (hectares)	Potential Mean Annual Productivity (m^3)
ID/C	13,690	10,952
ID/C-MC	14,607	45,282
ID/MC	7,181	27,288
ID/MC-MF	136,191	585,621
ID/MF	4,140	17,802
ID/MF-F	48,272	207,570
ID/F	18,541	79,726
ID-PD/C	27,237	21,790
ID-PD/C-MC	26,723	69,618
ID-PD/MC	8,820	22,932
ID-PD/MC-MF	269,630	701,064
ID-PD/MF	4,771	12,405
ID-PD/MF-F	15,350	39,931
ID-PD/F	5,692	14,799
PD/C-MC	25,982	36,375
PD/MC	6,916	9,682
PD/MC-MF	122,737	171,860
PD/MF	2,906	4,068
PD/MF-F	8,225	11,515
PD/F	5,700	7,980
PD/O	24,658	19,465
PD-VPD/MC	38	30
PD-VPD/MC-MF	30	24
PD-VPD/MF-F	6	5
PD-VPD/O	194,879	155,903
TOTAL	4,050,060	13,582,767*

*The weighted potential mean annual increment per hectare is 3.35 m^3.

4.5 UNDERSTORY VEGETATION

In addition to tree cover, the understory vegetation of forest ecosystems has important implications for forest management.

Vegetation on selected permanent growth and yield plots was sampled to determine dominant vegetation and composition. Sampling procedure within each plot involved 24 quadrats which were spaced two metres apart along lines placed at 90° to each other, radiating out from the centre of the plot. The quadrat size was 70.7 cm on a side (half a square metre); within quadrats the presence of plant species was checked. This is a modification of the sampling method described by Kershaw (1964).

Subsequent to the above, a complete inventory of all plant species present on the plot was tabulated, to determine the plants which were missed by the sampling because of their scarcity.* Data from the quadrats was tabulated to find the total number of quadrats in which a plant species had been found, and this in turn was divided by 24 (total number of quadrats) to give an approximate value for the overall frequency of the plant on the plot. For example, a frequency value of 10 percent means that the species was found on one out of every ten quadrats. The plant species were divided into groups according to their height (Table 11), so that one could have a dominant association within any one of the seven strata recognized, for example, tall shrubs, medium shrubs and mosses. Low shrubs and herbs, mosses and lichens attaining a frequency of over 80 percent were considered dominants. Medium shrubs, medium herbs and grasses and tall herbs and grasses which attained a frequency of greater than 70 percent were considered dominants, as were tall shrubs that were greater than 50 percent in frequency. These values were set after sampling sites which had high densities of a particular layer. Density of the tree canopy was determined from aerial photographs.

Nomenclature of the vascular plants follows Moss (1959) or Scoggan (1957); the mosses and liverworts follow Bird (1973); lichens follow Fink (1935) and Thompson (1957). Common names were obtained from various sources, with Budd and Best (1969) and Crum (1973) being the most frequently used.

Table 11. Layers of vegetation

Tall Shrub:	Includes all woody plants over 1 m in height. Species such as *Alnus* (alder) and *Salix* (willow) are found in this category.
Medium Shrub:	Includes all woody plants which are under 1 m but over 15 cm in height. Examples are *Ledum groenlandicum* (Labrador tea) and *Rosa acicularis* (prickly rose).
Tall Herb and Grass:	All herbaceous vegetation which is over 30 cm in height. Examples are *Calamagrostis* spp. (reed grass) and *Thalictrum venulosum* (Meadow Rue).
Medium Herb and Grass:	All herbaceous vegetation between 15 and 30 cm in height. This includes such species as *Mentha arvensis* (wild mint) and *Poa glauca* (meadow grass).
Low Shrub and Herb:	All vascular vegetation which is under 15 cm in height. Examples of such species are *Vaccinium vitis-idaea* (bog cranberry) and *Viola* spp. (violet).
Mosses:[1]	Includes all bryophyte vegetation, including feather mosses (i.e. *Hylocomium* spp.) and peat mosses (*Sphagnum* spp.)
Lichens:[1]	All lichen flora such as *Cladonia* (reindeer moss).

1. In the case of mosses and lichens, only the species which are growing on the ground were included with the arboreal species being excluded.

* Plant species encountered are listed in Appendix V.

4.6 SOILS

During 1975, ninety-four permanent sample plots located within the Mixedwood Section were examined. These plots were selected from the total population of sample plots by considering land features, tree species association and accessibility.

Primarily physiographic information was recorded on computer forms published by the Soil Research Institute, Ottawa. Two physiographic attributes of particular importance in forest ecosystems include soil drainage and texture. Seven drainage classes were utilized, including:

(a) Very rapidly drained: Soils developed in coarse textured sands (0.5 to 2 mm in diameter) and gravels (greater than 2 mm in diameter), which are of glaciofluvial or fluvial-lacustrine origin. These soils are dry, and precipitation is absorbed almost immediately. Groundwater and/or runoff does not influence vegetation growth.

(b) Rapidly drained: Soils developed in medium, fine or loamy sands which are generally of fluvial-lacustrine or aeolian origin. Coarse textured glacial tills also occur in this class. They may contain gravel lenses or be underlain by material of other glacial deposition. Precipitation is almost immediately absorbed; however, at a slightly lesser rate than the previous class. These soils occur in all topographic classes. Groundwater and/or runoff do not influence vegetation growth.

(c) Well drained: Profile textures and modes of origin are highly variable; however, the most common deposition is glacial till which is of a moderately coarse to moderately fine texture. At least one horizon is present which has the ability to significantly restrict water penetration. These soils are moisture deficient for short periods of time, and although they may be found on all slope positions, their most common occurrence is from the middle slope to crest positions. Coarse textured profiles are usually located on lower slopes, such that ground water and/or runoff influences vegetation growth and thus differentiates it from the previous two classes.

(d) Moderately well drained: This drainage class is characterized by soils which contain excess soil moisture for short periods of time. Moderately coarse to moderately fine textured glacial till is the most frequent parent material for soils in this category. However glaciolacustrine, glaciofluvial, fluvial-lacustrine and recent deposits also occur. These soils usually occur from the middle to the toe slope positions. Their characteristic differentiation from the well drained class is the presence of a few mottles which may occur throughout the profile.

(e) Imperfectly drained: Excess moisture for moderately long periods of time is portrayed in the soil profile by abundant mottling and/or gleying. These soils also may be developed from diverse glacial and recent deposits. Usually they are located in the lower slope and depressional positions. The soil profile may be influenced by a fluctuating water table.

(f) Poorly drained: These are soils which have developed under prolonged saturated or near saturated conditions. The mineral substratum which is gleyed and/or mottled is usually overlain by a shallow layer of peat which may be in various states of decomposition. Taxonomically, these soils are usually classified within the Gleysolic Order. Generally, these soils are found on level to undulating topography or in depressional areas.

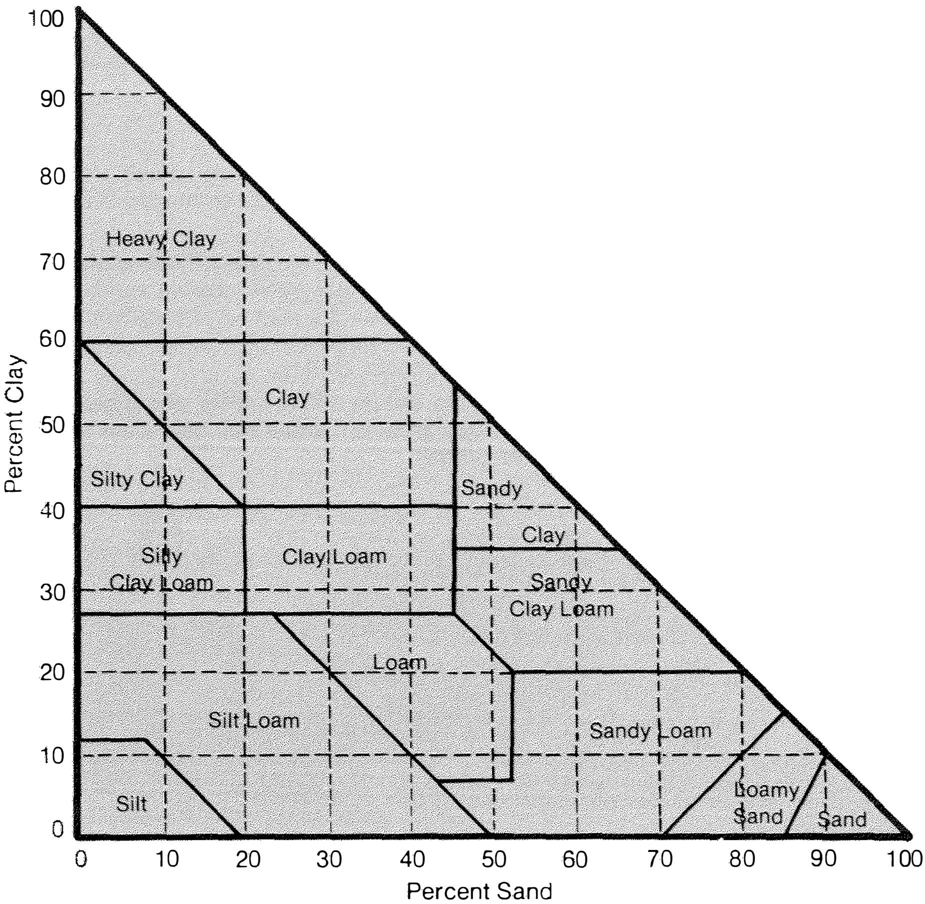
(g) Very poorly drained: Organic or Gleysolic soils which are continually saturated represent the soils occurring in this class.

Soil texture refers to the relative proportion of various size groups in a given soil (Buckman and Brady, 1964). Size groups utilized are shown below:

Very coarse sand:	2.0 - 1.0 mm
Coarse sand:	1.0 - 0.5 mm
Medium sand:	0.5 - 0.25 mm
Fine sand:	0.25- 0.10 mm
Very fine sand:	0.10- 0.05 mm
Silt:	0.05-0.002 mm
Clay:	Less than 0.002 mm

Combining the above constituents in varying degrees produces textural groups which are in common usage (Figure 8).

Figure 8. Textural triangle[1]



In the application of texture within this report, the classes shown in Figure 8 are combined into four groups. These groups and their members are shown below:

Group	
Coarse:	Sands, loamy sands
Moderately coarse:	Sandy loams, loam, silt loam
Moderately fine:	Sandy clay loams, clay loam, silty clay loam
Fine:	Sandy clays, clay, heavy clay, silty clay

1. Taken from the C.S.S.C. publication *The System of Soil Classification for Canada,* Canada Department of Agriculture, 1970.

CHAPTER 5

5.0 FOREST ECOSYSTEMS: THEIR NATURE AND IMPORTANCE IN FOREST MANAGEMENT

The major forest ecosystems recognized in this survey are grouped into series based on soil drainage. Within each series several ecosystems are described in some detail, as to its forest cover, minor vegetation and physiographic site factors. For the summary of the ecosystems described, see Appendix III.

5.1 VERY RAPIDLY AND RAPIDLY DRAINED SERIES

Jack pine is the prevalent tree species, although aspen and white spruce also form marginal merchantable stands on some of the rapidly drained sites. Terrain conditions facilitate harvesting in all seasons.

Soils are usually developed on coarse textured, moisture and nutrient deficient glaciofluvial, fluvial-lacustrine or aeolian deposits. Soil textures include sands, loamy sands and gravel. Profiles developed on coarse sands or gravels are usually very rapidly drained (Photo 7); whereas, those developed in fine textured sands are usually rapidly drained (Photo 8). These soils are usually classified in the Brunisolic or Regosolic Orders.

These soils occur on both flat and hummocky terrain. Since normal precipitation is almost immediately absorbed by the soil, and the water table is located well below the rooting zone, run-off or groundwater rarely influence tree growth.

Photo 7. Jack pine growing on a very rapidly drained gravel deposit.

5.1.1 PINUS-CLADONIA/ARCTOSTAPHYLOS ECOSYSTEM (Jack Pine-Lichen/Bearberry Type)

Pure understocked jack pine stands without tall shrubs, a dense carpet of lichens (reindeer moss) and bearberry are typical vegetation strata of this ecosystem (Photos 9 and 10).

The understory vegetation is characteristically a fruiticose lichen carpet, dominated by *Cladonia* spp. This *Cladonia* carpet may be a combination of several species with *Cladonia mitis, C. alpestris* and *C. rangiferina* comprising the majority of the ground cover. Other less frequent species on these sites are *C. coccifera, C. multiformis, C. arbuscula* and *C. deformis.*

Photo 8. Rapidly drained fine sands supporting jack pine growth.

Photo 9. 'Pinus-Cladonia' Ecosystem. Open stands with an abundance of reinder moss (lichen) on the forest floor.

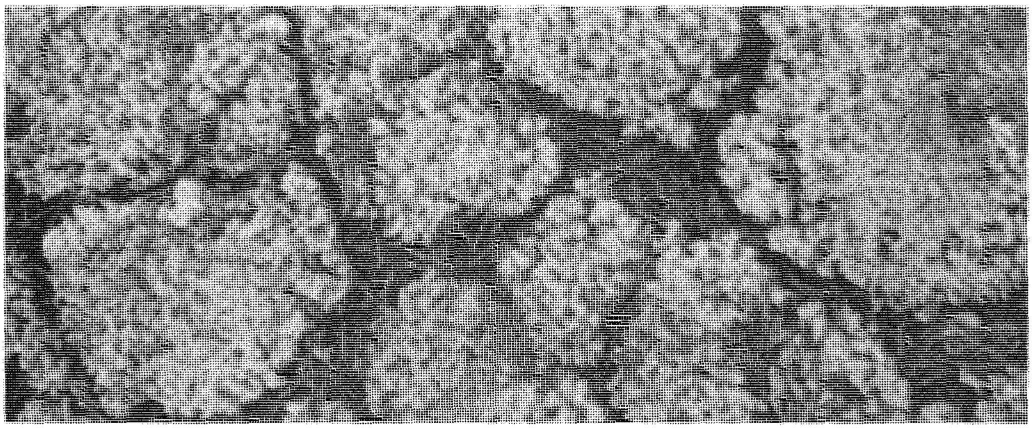


Photo 10. A dense carpet of reindeer moss (lichen) is typical ground vegetation of very rapidly drained jack pine sites.

The density of the tree canopy and the dryness of the site determine the composition of the understory. For example, a very rapidly drained site with an open jack pine canopy (total crown closure less than 45%) will have a ground cover of almost totally *Cladonia* spp. with only a sparse scattering of vascular plants, tolerant to the very dry conditions, such as *Maianthemum canadense* (two-leaved solomon's seal), *Poa interior* (blue grass), *Viola adunca* (early blue violet) and *Arctostaphylos uva-ursi* (bearberry). On a rapidly drained site with an open tree canopy or a very rapidly drained site with a denser canopy (greater than 45%), *Cladonia* spp. and *Arctostaphylos uva-ursi* combine to form the dominant ground vegetation. A slight increase in vascular plant diversity accompanies this change. A rapidly drained site with a relatively dense tree canopy comprises the moister phase of this series. Here, *Cladonia* spp. and *Alnus crispa* (green alder) form the characteristic lichen and shrub vegetation strata.

A typical very rapidly-rapidly drained soil profile has the following characteristics:

Horizon	Description
LFH	A mor humus form, usually very thin (less than 2 cm); derived predominantly from pine needles; pH approximately 4.5.
A (e) (j)	Light grey, ashy appearance; a single grain or platy structure; thickness is quite variable (2 to 10 cm); pH approximately 5.3. Textures may be sands of variable coarseness, loamy sands or gravel.
B (m) (t) (j)	Usually a brownish coloured, structureless (single grain) horizon. Thickness is variable (about 50 cm). Textures may be sands of variable coarseness, loamy sands, or gravel; pH approximately 5.5.
C	Usually a pale yellow to brownish coloured, structureless (single grain) horizon. Textures are usually loamy sands, sands or gravels; pH approximately 6.0.

Mature stands, from 80 to 100 years of age, yield about 90 m^3 of merchantable volume per hectare. Trees are limby, excessively tapered and provide logs suitable for railways ties and low grade lumber. If adequate stocking can be obtained, these sites are suitable for fence post production (a product very much in demand) at a reduced rotation (60 years). Rotation age for maximum fibre (pulpwood) production is reached at 80 years with a mean annual increment of 0.8 to 1.1 m^3 per hectare per year, and yields of 65 to 90 m^3 per hectare.

Scarification after clear-cutting promotes jack pine regeneration. An excessive exposure of mineral soil may result in wind erosion.

Table 12. Chemical and physical analysis of a very rapidly-rapidly drained profile within the Canwood Provincial Forest (analysis by W.K. Janzen 1968)

Horizon	Depth (cm)	Particle Size Distribution (Percent): Coarse & Med. Sand	Fine Sand	Very Fine Sand	Total Silt	Total Clay	pH	Organic Matter N (Percent)	NO_3-N* ppm	$NaHCO_3$-P ppm	Cation Ex. Cap.* MEQ/100gm
L-H	2.0- 0	—	—	—	—	—	4.8	—	8.0	13.0	28.9
Ae1	0 - 3.8	58.2	33.5	4.5	1.9	1.9	5.3	0.80	0.5	7.0	6.8
Ae2	3.8-10.2	54.4	33.8	6.4	3.2	2.2	5.3	0.04	0.5	19.0	4.5
Bm1	10.2-22.9	61.7	31.9	3.8	0.1	2.5	5.8	0.02	0.5	27.0	3.4
Bm2	22.9-35.6	48.7	42.5	5.1	2.1	1.6	6.4	0.02	0.5	16.0	2.9
Bm3	35.6-53.3	38.4	51.3	7.6	1.6	1.1	6.1	0.02	0.5	13.5	2.4
C1	53.3-73.7	64.5	32.2	2.6	0.2	0.5	6.4	—	1.0	4.5	0.8
C2	73.7-91.4	80.7	16.9	1.6	0.4	0.4	6.5	—	1.0	4.0	0.9
C3	91.4+	72.5	24.0	2.5	0.5	0.5	6.6	—	1.0	3.5	0.8

* The high NO_3-N and exchange capacity of the L-H horizon as opposed to the very low levels in the mineral horizons suggest the importance of the preservation of this horizon.

Due to a considerably warmer and drier ecoclimate on these sites forest fires are frequent. Deep and multiple fire scars on trees indicate short fire frequencies. Most fires are severe and very destructive on these sites. Even if all the forest cover is not totally burned, fires lower the quality of butt logs, reduce the sparse regeneration in openings, and destroy the thin organic mat, which had taken, perhaps, 100 years or more to develop.

Trees on these sites are also prone to attack by parasites and insect pests which reduce vigour and may eventually result in the death of the tree. The most common parasite of jack pine is the dwarf mistletoe or witches' broom (*Arceuthobium americanum*), while jack pine budworm (*Christoneura pinus* Free.) and pitch nodule maker (*Petrova albicapitana* Busck.) are the most common insects.

On the positive side, fairly good regeneration of jack pine species is assured following a fire. In relation to other species, jack pine has a thick, corky bark and serotinous cones, two inherent characteristics which enable it to survive the hazards of fire. Generally the succession of jack pine is certain after fires, after clear-cutting, and to a lesser extent, in natural stand openings at maturity. No other species can compete with drought-resistant jack pine on these sites. A return to the same tree cover and minor vegetation ensures a permanent or stable position to this ecosystem.

Occasionally, south and southwest facing slopes on hummocky terrain become excessively dry following a clear-cut, and natural regeneration of any tree species is precluded. Xerophytic shrubs, herbs and grasses capable of withstanding the extreme conditions occupy these areas.

Scattered clusters of *Alnus crispa* (green alder) are able to continue a precarious existence after clear-cutting, but they do not create a major hindrance to artificial reforestation.

5.1.2 PICEA GLAUCA-AGROPYRON/ARCTOSTAPHYLOS ECOSYSTEM
(White Spruce-Wheat Grass/Bearberry Type)

White spruce stands have a patchy appearance with variable size openings, commonly occupied by struggling aspen, shrubs or grass vegetation (Photo 11). Such stands are more common along the border of the Aspen Grove Ecodistrict on northly and north-easterly slopes and ridges. Although these sites appear more favourable for jack pine, white spruce likely became established under exceptionally favourable weather conditions. This transition has been considered as a natural trend or invasion of prairie by white spruce (Rowe 1956). Reduced incidence of forest fires probably promotes this invasion of parkland.

Soils commonly occurring within this ecosystem consist of Brunisolic or Regosolic profiles developed in fluvial-lacustrine deposits (fine sands) which have been modified by wind.

Photo 11. White spruce growing on a rapidly drained site.

The understory vegetation is represented by a predominance of grasses and low shrubs. The grass is a composite of several species of which *Poa interior* (blue grass) and *Agropyron subsecundum* (wheat grass) are the main species. *Arctostaphylos uva-ursi* (bearberry) is the main component of the low shrub layer. This ecosystem generally has an open tree canopy, although occasionally a closed tree canopy forms and under this condition the ground is generally bare with only a carpet of needles and cones. These sites often have a scattering of tall shrubs, predominantly *Amelanchier alnifolia* (Saskatoon).

A variety of grasses and low herb vegetation including *Festuca scabrella* (rough fescue), *Koeleria cristata* (June grass), *Stipa richardsonii* (Richardson needle grass) and *Viola adunca* (early blue violet), typical of prairie vegetation, also accompany this association.

Average productivity (M.A.I.) is about 1.0 to 1.7 m^3 per hectare, depending on stand density. Yields of 105 to 119 m^3 per hectare occur at the rotation age of 90 years. Seldom do yields exceed 140 m^3 per hectare at stand maturity of 130 to 140 years of age. These trees which are generally limby and faulty and of poor form, have low commercial value and should be managed exclusively for fibre production.

As the disturbance of mineral soil increases the moisture deficiency, and may increase the susceptibility of the soil to wind erosion, land use decisions should be scrutinized.

Once established, white spruce seems to be able to survive on these sites due largely to the lack of competition from other tree species and ground vegetation. Artificial regeneration of these sites should involve the introduction of jack pine.

5.1.3 POPULUS-ROSA/ELYMUS ECOSYSTEM (Aspen-Rose/Rye Grass Type)

Aspen is the third species capable of forming marginal commercial stands on these coarse sands and gravelly deposits. These sparse stands consist of short, often fire-scarred trees (Photo 12). As these sites are subject to repeated forest fires, jack pine and white spruce have been eliminated in most areas. Aspen has been able to survive because of its unique ability to reproduce vegetatively from root sprouts or suckers.

Dry leaves and grass create a high fire hazard in the cured dormant state of this ecosystem (see Appendix III).

The competition of shrub and grass vegetation on these arid sites practically excludes any natural regeneration of other tree species, and provides a stiff competition even to aspen seedlings.

Characteristic ground vegetation of this site is a scattered tall shrub layer consisting of *Corylus cornuta* (beaked hazelnut) and/or *Amelanchier alnifolia* (Saskatoon). The *Corylus cornuta* is usually the most prevalent, but occasionally a pure layer of *Amelanchier alnifolia* occurs. Underneath this scattered tall shrub layer a variety of vascular plants are encountered, most prevalent being *Rosa acicularis* (prickly rose), *Elymus innovatus* (hairy wild rye) and *Arctostaphylos uva-ursi* (bearberry), which frequently form the dominants. *Epilobium angustifolium* (fireweed) is the common tall herb, though seldom dominant.

Other species typically found on these sites include *Lathyrus ochroleucus* (cream-coloured vetchling), *Bromus anomalus* (nodding brome), *Fragaria virginianum* (wild strawberry), *Rubus pubescens* (dewberry), *Arctostaphylos uva-ursi* (bearberry) and *Cornus canadensis* (bunchberry).

Stand composition usually is pure aspen, with a few remnants of jack pine, white spruce or birch (10tA + jP + wS + wB).[1] Average height of stands seldom exceeds 15 m at the rotation age of 80 to 85 years with a mean annual increment slightly below 1.5 m^3 per hectare. Total yield is about 100 m^3 per hectare at the rotation age, and 140 m^3 per hectare at stand maturity. The quality and soundness of the wood are poor because of fire scars and excessive rot. For these reasons, utilization of aspen on these sites is limited, except for a small amount of fuelwood. No form of logging other than clear-cutting can be suggested. A logical step toward proper management of these sites would be the introduction of jack pine, creating a mixed aspen-jack pine association. Presently these sites are grazed extensively. They also provide favourable wildlife habitat. Without intentional changes of tree species, aspen will occupy these sites permanently.

1. Based on a scale of 10, almost complete domination by aspen with insignificant amounts of jack pine, white spruce and white birch.

Photo 12. Aspen growing on a rapidly drained site.

Photo 13. Mixed white spruce-aspen stand growing on a rapidly drained site.

5.1.4 PICEA GLAUCA/POPULUS-CORYLUS ECOSYSTEM (Spruce/Aspen-Hazelnut Type)

Mixed stands of aspen and white spruce (Photo 13) on these arid sites are relatively uncommon, as it appears as though their biological requirements create a rigorous competition or conflict. Spruce tends to occupy northerly slopes and local hollows, while aspen occurs around openings and on southerly exposures. Economically this type offers very little.

Soils usually consist of coarse sandy and gravelly fluvial-lacustrine deposits. The understory vegetation consists of a tall shrub layer with a low herb/shrub layer underneath. *Corylus cornuta* (beaked hazelnut) is the main constituent of the tall shrub layer with *Linnaea borealis* (twinflower) and *Cornus canadensis* (bunchberry) comprising the low shrub/herb layer. Other species typical of these dry sites include *Elymus innovatus* (hairy wild rye), *Arctostaphylos uva-ursi* (bearberry) and *Amelanchier alnifolia* (Saskatoon).

These stands usually reach only 15 to 17 m in height. The mean annual increment is between 1.7 to 2.0 m^3 per hectare (both species). At the rotation age of 80 to 85 years, the yield is about 140 m^3 per hectare and increases to 175 m^3 per hectare at stand maturity.

The introduction of jack pine in artificial reforestation programs appears appropriate.

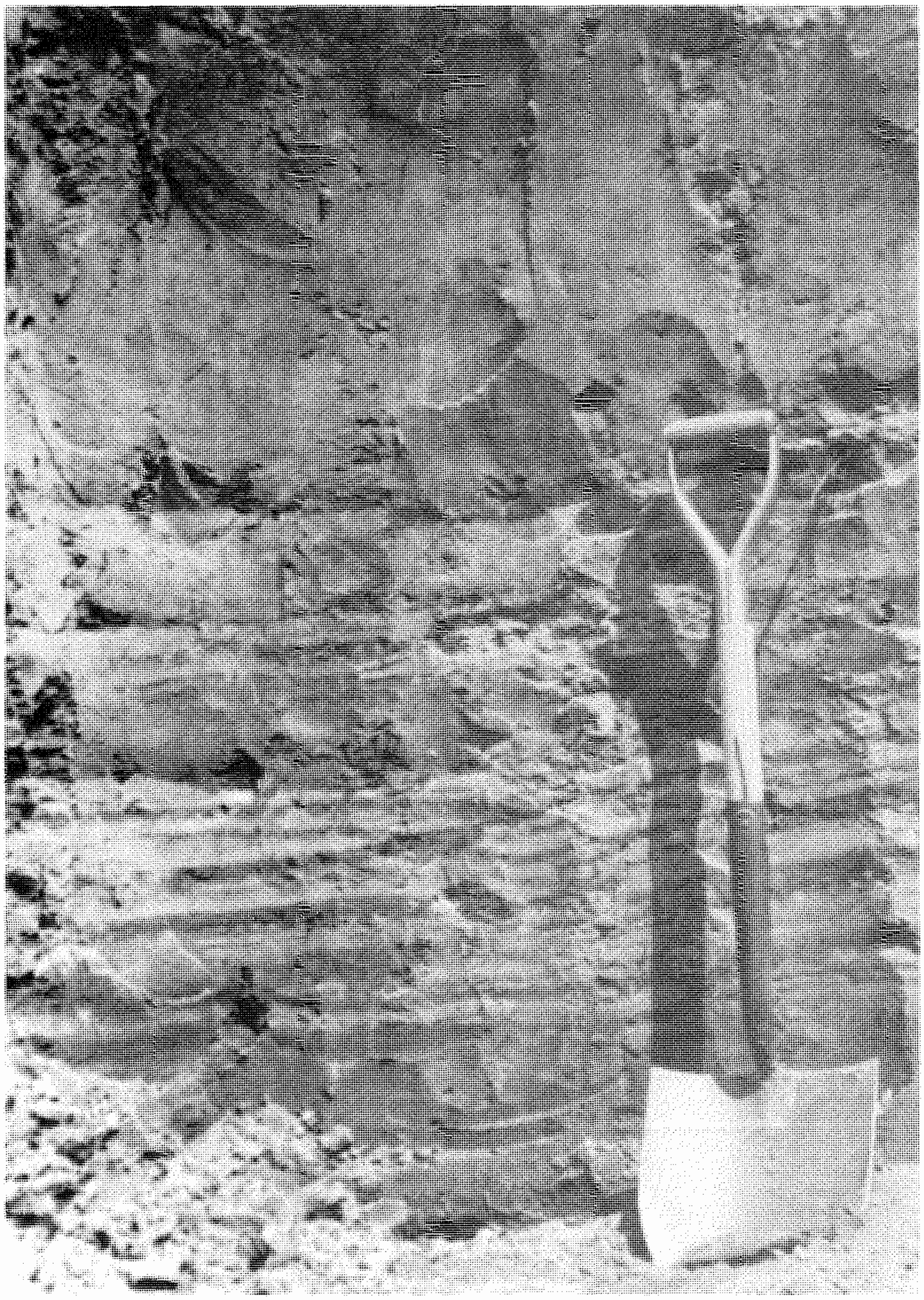


Photo 14. A well drained, banded soil profile. The coarser (light coloured) and finer (dark coloured) materials are deposited under alternating conditions of sedimentation.

5.2 WELL DRAINED SERIES

In terms of vegetation, further species diversity and improved growth segregate this series from the previous one. Jack pine and white spruce still maintain their leading role as recommended species; however, aspen, black spruce, and mixed stands also reach present standards for merchantable stands. Generally, periodic or seasonal deficiency of moisture is experienced within this series.

Soils in this series are usually classified in the Luvisolic Order and occur mainly on glacial till deposits and to a lesser extent, on glaciolacustrine and fluvial-lacustrine deposits. Within a particular textural class, the mode of origin does not appear to significantly alter growth of any particular species. For example, growth on a clay loam glacial till is similar to that on a clay loam glaciolacustrine deposit. Within the wide variation of profile textures the well drained moisture regime encompasses, the optimum texture appears to be moderately fine to fine in range. Soils do not exhibit any mottling.

These soils are found on level to hummocky topography. The coarse textured profiles are usually located in the lower slope or depressional position where they are influenced by ground water or run-off. However, banded profiles (Photo 14) of coarse texture may be located in topographical positions where groundwater or run-off have no influence. Profiles of moderately coarse, moderately fine and fine texture occur most commonly on the upper slopes.

Timber harvesting and site preparation for reforestation can be carried out during the summer and winter seasons.

5.2.1 PINUS-VACCINIUM VITIS-IDAEA/PLEUROZIUM ECOSYSTEM (Jack Pine-Bog Cranberry/Feather Moss Type)

This ecosystem is dominated by jack pine (Photo 15), with some aspen, white birch and white and black spruce on moister slopes and in local depressions. On a decimal scale the stand composition could be described as follows: 9jP 1tA+wB+wS+bS.

Photo 15. 'Pinus-Vaccinium vitis-idaea/Pleurozium' forest ecosystem.

The characteristic understory vegetation is a feather moss carpet in combination with one or more lichen or vascular plant species. This feather moss carpet is composed predominantly of *Pleurozium schreberi* with lesser amounts of *Hylocomium splendens* (stair step moss) and *Ptilium crista-castrensis* (knight's plume). The presence of *Vaccinium vitis-idaea* (bog cranberry) as part of the dominant association indicates the driest phase of this ecosystem, while *Alnus crispa* (green alder) indicates the moistest.

The density of the tree canopy, in combination with the relative dryness of the site, dictates which other species will be present. An open canopy on a well drained site generally supports a *Vaccinium myrtilloides* (blueberry) - *Vaccinium vitis-idaea* (bog cranberry) - *Pleurozium schreberi* - *Cladonia* spp. association, with the *Cladonia* spp. being a combination of *Cladonia mitis, C. alpestris* and *C. rangiferina*. Moister types with a closed canopy support an *Alnus crispa* (green alder) - *Cornus canadensis* (bunchberry) - *Trientalis borealis* (starflower) - *Pleurozium schreberi* association. Also present with the latter is *Vaccinium vitis-idaea* in fairly high frequency but not as a dominant. Intermediate types exist with these only representing the two extremes.

Other species commonly encountered on these sites include *Lycopodium complanatum* (ground cedar) and *Goodyera repens* (rattlesnake plantain).

Glacial till or glaciolacustrine deposits overlain by coarse to moderately coarse textured fluvial-lacustrine deposits commonly support jack pine in the well drained ecosystem (Photo 16).

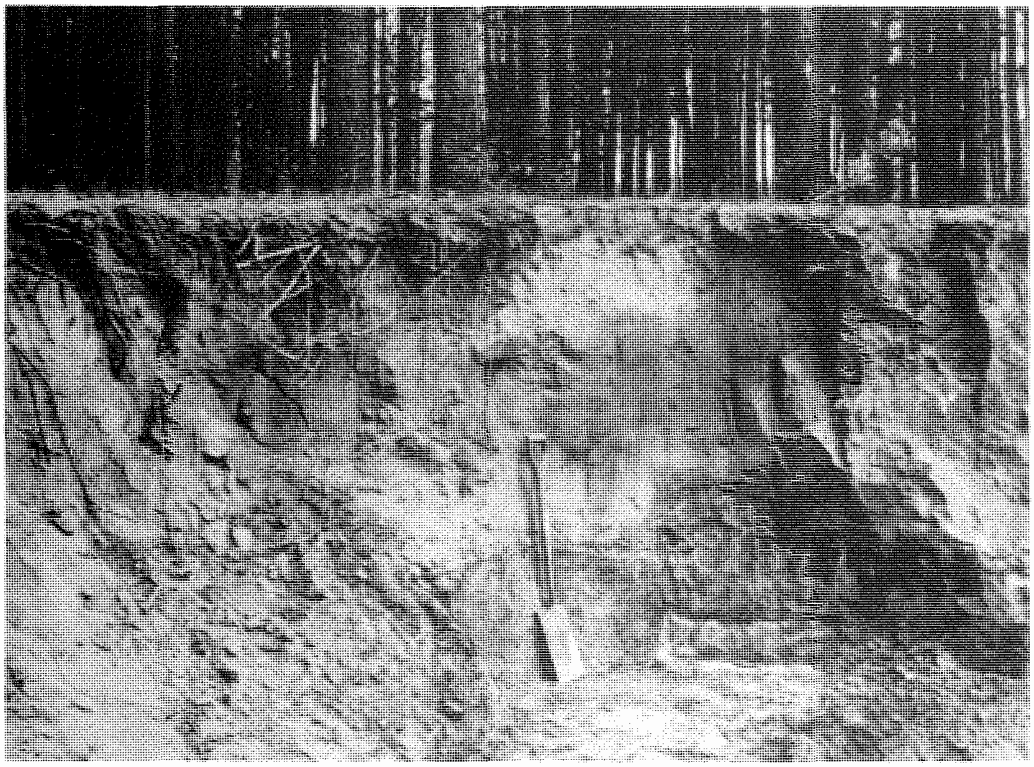


Photo 16. Moderately fine textured materials overlain by coarse to moderately coarse textured fluvial-lacustrine sands.

An example of a well drained Luvisolic profile supporting an average jack pine stand is shown below.

Horizon	Description
LFH	A mor humus form, approximately 3 cm thick. Derived predominantly from pine needles, with feather moss present on the surface; pH approximately 4.7.
Ae	A weak platy, ashy coloured horizon of fluvial-lacustrine origin; fine sand texture with a few pebbles present; thickness about 4 cm; pH approximately 4.8.
Bm1	A reddish-brown coloured horizon of fluvial-lacustrine origin; fine sand texture with a few pebbles present; thickness about 12 cm; pH approximately 4.8; weak platy structure.
Bm2	A pale brown coloured horizon of fluvial-lacustrine origin; loamy sand texture with pebbles present; thickness about 23 cm; pH approximately 5.5; very weak platy structure.
IIBt1	A brownish coloured horizon of glacial till origin; subangular blocky structure with sands washed into some cleavages; sandy clay loam texture; thickness about 39 cm; pH approximately 5.4.
IIBt2	A brownish coloured horizon of glacial till origin; weak platy structure; sandy clay loam texture; thickness about 52 cm; pH approximately 6.2.
IICk	A brownish coloured horizon of glacial till origin; lime concentrated in streaks; general lime content is very low; strong platy structure; sandy clay loam texture; pH about 7.2.

Table 13. Chemical and physical analysis of a well drained profile supporting a jack pine stand near Montreal Lake (analysis by W.K. Janzen 1971)

		Particle Size Distribution (Percent)								
Horizon	Depth (cm)	Coarse & Med. Sand	Fine Sand	Very Fine Sand	Total Silt	Total Clay	pH	Organic Matter N (Percent)	$NaHCO_3$-P ppm	Cation Ex. Cap. MEQ/100gm
LFH	7.6- 0	—	—	—	—	—	4.5	0.72	207.5	78.5
Ae	0 - 7.6	24.3	24.7	14.0	34.4	2.4	4.3	0.04	26.0	4.5
AB	7.6- 20.3	31.5	21.3	10.3	32.6	4.1	5.4	0.2	13.0	4.7
IIAe	20.3- 33.0	27.1	21.6	15.1	25.7	10.2	5.7	0.02	6.5	3.4
IIBt1	33.0- 43.2	27.7	19.2	14.2	22.8	15.8	5.5	—	8.5	5.5
IIBtj2	43.2- 61.0	36.0	10.5	23.8	17.2	12.3	5.9	—	6.0	8.9
IIBt3	61.0- 76.2	25.6	19.0	12.8	24.5	17.9	6.0	—	6.0	6.4
IIBt4	76.2- 91.4	27.2	18.5	12.6	24.3	17.2	6.6	—	3.5	11.1
IIBt5	91.4-104.1	26.0	20.2	13.3	24.6	15.7	7.3	—	3.0	10.5
IICk1	104.1-121.9	30.5	20.0	12.5	23.9	12.8	7.6	—	1.5	7.1
IICk2	121.9+	30.0	20.4	13.9	21.9	13.5	7.6	—	2.0	6.7

Jack pine stands are predominantly of the second or average site quality, with an average height of 18 m, mean annual increment of 2.0 m^3 per hectare and a merchantable volume of 130 to 140 m^3 per hectare at the rotation age of 70 years. Stand maturity is reached between 70 and 100 years, with an average yield of 180 m^3 per hectare. Until this crucial age, stands retain a good density. Natural thinning, and pruning help to develop well-formed trees of adequate diameters for pole, tie and lumber production. It is necessary to extend the rotation age by 10 years if forest stands are to be utilized for dimension or piece products.

Advance regeneration is common in openings which provide sufficient light, although present observations confirm that these seedlings seldom create a future stand. At an early age, the parent stand provides some beneficial shelter, but later it deprives the young trees of moisture, nutrients and light.

Following clear-cutting or fire, jack pine regeneration is certain; no other species are able to take over this site. Therefore, it can be regarded as a stable ecosystem. Regeneration subsequent to clear-cutting, although assured, is not always of adequate density and scarification is a helpful site treatment. Fires, on the other hand, usually cause overstocking.

Recent surveys indicate that scarified areas have an average of 12 to 18 thousand saplings per hectare at 10 years of age, while fire origin stands display 30 to 78 thousand or more. As growth of such stands is very slow, stand thinning appears to be a realistic solution. By reducing tree numbers, the remaining stems are spaced such that healthier stands, higher yields and a shorter rotation may be expected. The amount of thinning depends on stand age and vigour, site quality and other factors such as expected losses due to rabbits, wet snow, etc.

Both, manual (including power saws) and mechanical stand thinnings have been carried out in Saskatchewan. To date, a considerable area has been manually thinned with brushsaws (Photo 17) on provincial forest lands.

Photo 17. Brushsaws are used in juvenile stand thinnings.

In 1952, the Forestry Division thinned 103 hectares of dense, young jack pine stands with an Athens plough (Photos 18 and 19). A similar trial was carried out by the Prince Albert Pulpwood in 1973 on 43 hectares with a drumchopper (Photo 20). Both areas are slightly better than average forest sites.

Photo 18. The 12 year old jack pine stand after strip thinning (1952).

Photo 19. The same stand twenty-seven years later (1979).

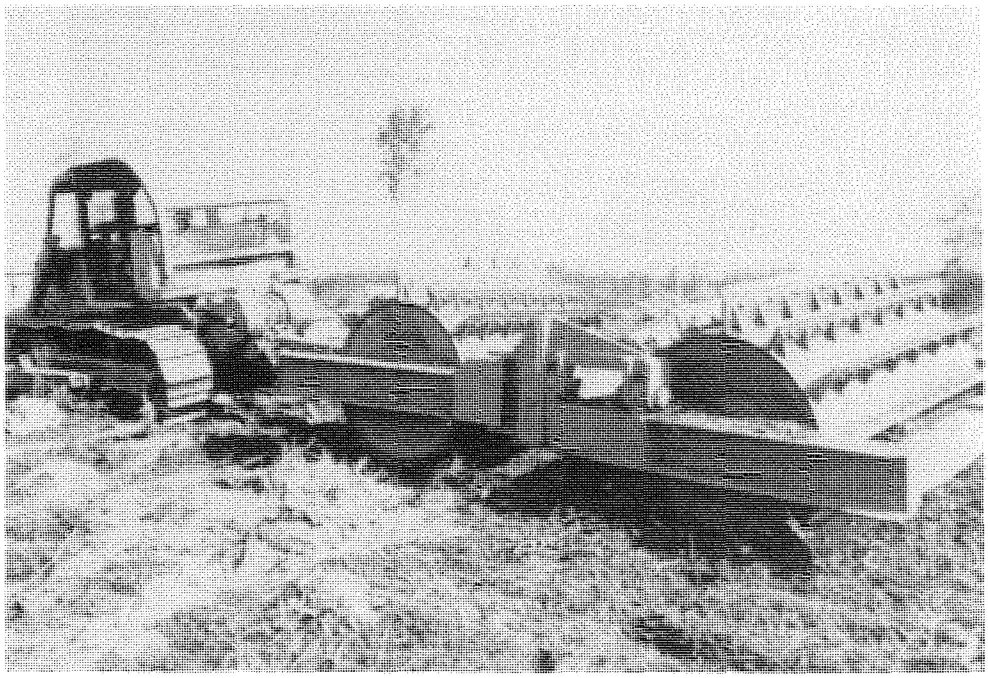


Photo 20. The Marden drumchopper is suited for mechanical strip thinning of overstocked fire stands.

Results from the 1952 strip thinning carried out by the Forestry Division are shown in Table 14.

Table 14. Distribution of mean and periodic[1] volume increment[2] in cubic metres in relation to the distance from the treated edge

Plot[3] Location From Treated Edge(m)	M.A.I. Total Volume[4]	M.A.I. Merchantable Volume[5] 7.6 cm Top	M.A.I. Merchantable Volume[5] 5.1 cm Top	P.A.I. Total Volume[4]	P.A.I. Merchantable Volume[5] 7.6 cm Top	P.A.I. Merchantable Volume[5] 5.1 cm Top
0.0-0.6	8.4	5.3	6.1	8.9	8.4	9.7
0.6-1.2	6.9	4.1	4.7	5.9	6.7	7.8
1.2-1.8	5.7	3.1	3.6	4.4	5.4	6.2
1.8-2.4	4.9	2.4	2.8	3.3	4.2	4.9
2.4-3.0	4.0	2.0	2.3	2.3	3.1	3.6
3.0+	3.1	1.6	1.9	1.4	2.0	2.5

1. 22 year period between 17 and 39 years of age.
2. Curved values.
3. Plot size 3.0 m x 0.6 m.
4. Includes stump and top.
5. Stump height - 30.5 cm.

The performance and costs associated with various forms of thinning in scarified and fire origin stands are shown in Table 15.

Table 15. Thinning performance and costs

Stand Type	Average No. of Stems/ha (in thousands) Before Thinning	After Thinning	Performance (hectares/man/day)	Cost[1] (per ha)	Thinning Method
Scarified	12-18	2.2-2.4	1.0-1.2	$210.00	brushsaw
Fire origin	38-78	3.15	0.5-0.6	$400.00	brushsaw
Fire origin	38-78	15-39	12 - 15	$150.00	drumchopper (strip thinning)

1. 1983 cost data.

Observations indicate that the optimium width of cleared and leave strips in a mechanical strip thinning program is 3.0 and 3.6 m respectively. Where it is possible to remove selected individual trees, it appears desirable to retain about 1600 to 2000 saplings per hectare (2.50m x 2.50m to 2.24m x 2.24m spacings) at 10 to 15 years of age (Photo 21). Site should be at least of average quality.

Photo 21. A thinned 16 year old jack pine stand. Remaining are 1,900 stems per hectare (2.29m x 2.29m spacing).

From 1977 to 1983, approximately 217,454 hectares of productive forest land were burned within the Mixedwood Section. A large portion of the burned area is regenerating naturally to overstocked jack pine stands. Considering the magnitude of the area, mechancial strip thinning becomes a realistic consideration.

5.2.2 PICEA GLAUCA-PLEUROZIUM ECOSYSTEM
(White Spruce-Feather Moss Type)

Impressive size, high yield and valuable wood make white spruce the most useful and desirable species in Saskatchewan. In the Mixedwood Section white spruce ranks third (preceded by aspen and jack pine) by volume and eighth by land area. Opinions differ as to whether or not it will retain the same ranking in the future. However, some decline may be expected because of the extent and fashion of harvesting this species.

The data from one hundred and thirty 809 m^2 permanent growth and yield sample plots in white spruce stands is one of the sources of information for this report. They have been deliberately established in well stocked (34.5 m^2 of basal area per ha), even-aged stands. The composition of white spruce in these stands was 67% (Newman 1969). As a result of this survey, it is obvious that we are dealing with stands which have originated from severe forest fires.

White spruce stands of this ecosystem are commonly found on well drained hummocky glacial till. At an early age they form fairly dense stands with some aspen present, but at maturity and beyond, stand appearance becomes more patchy, with balsam fir and shrub vegetation in the understory and openings (Photo 22).

Photo 22. Mature white spruce on a well drained site

Ground vegetation is characterized by a feather moss ground cover combined with a low shrub/herb layer. The feather moss carpet is comprised predominantly of *Pleurozium schreberi* and *Hylocomium splendens* (stair step moss) with small amounts of *Dicranum polysetum*, *Dicranum undulatum* and *Thuidium recognitum* (fern moss). The low shrub/herb layer is comprised of *Linnaea borealis* (twinflower) and *Cornus canadensis* (bunchberry) mainly, with other common species including *Mitella nuda* (bishop's-cap), *Equisetum arvense* (common horsetail), *Rubus pubescens* (dewberry), *Petasites palmatus* (palmate-leaved coltsfoot) and *Bromus anomalus* (nodding brome).

Forest stands are representative of the second site quality, with an average height of 20 m and a mean annual increment of 3.1 m^3 per hectare at the rotation age of 75 years. The total yield at the rotation age is between 225 to 230 m^3 per hectare, and increases to about 280 m^3 at maturity (110 years). The composition of these stands can be described as: 8wS 1(tA-bPo) 1(jP-bS-bF) + wB (Table 16).

In cut-over areas the regeneration of softwoods is often precluded by shrub and grass vegetation. Aspen suckering is comparatively scant because of the small proportion of aspen trees in the mother stand. Scarification and planting, or seeding immediately after logging appears to be the best and most dependable method of bringing the land back into softwood production. Natural regeneration of white spruce is usually favoured along the northern periphery of the mother stand.

5.2.3 POPULUS-CORYLUS ECOSYSTEM (Aspen-Hazelnut Type)

Within the Mixedwood Section, this ecosystem contains approximately 8,000 km^2. These stands are well stocked, and consist of usually healthy aspen (Photo 23 and Table 17) which mature at about 65 to 70 years of age. Ten or twenty years thereafter, the aspen rots and breaks, leaving a stand consisting of a sparse aspen and spruce cover. The remaining stand might be pleasant to look at, but is disappointing from the forest management and economic point of view.

Characteristic understory vegetation is a dense tall shrub layer, and a low herb and/or shrub layer. These sites support a wide variety of understory. The driest sites in this ecosystem support a *Corylus cornuta* (beaked hazelnut), *Elymus innovatus* (hairy wild rye), *Aralia nudicaulis* (Sarsaparilla) association. The common understory vegetation on the well-drained series is a dense layer of *Corylus cornuta* (beaked hazelnut). Under this is a layer composed of a combination of *Linnaea borealis* (twinflower), *Cornus canadensis* (bunchberry), *Aralia nudicaulis* (sarsaparilla), *Lathyrus ochroleucus* (cream-coloured vetchling), *Rubus pubescens* (dewberry) and *Epilobium angustifolium* (fireweed).The actual species compostion of the low herb and/ or shrub layer is dependent upon the density of the overstory and in particular that of the tall shrub layer. Where light is poor, there is a dominance of short herbs; in instances where light conditions are more favourable, tall herbs become dominant.

Occasionally other species are found as dominants in these complexes, but when this happens, two, three or more of the listed species are also dominant. Some of these other species include *Petasites palmatus* (palmate-leaved coltsfoot), *Mitella nuda* (bishop's-cap), *Vaccinium vitis-idaea* (bog cranberry), *Rosa acicularis* (prickly rose) and *Fragaria virginianum* (wild strawberry).

These aspen stands are found on soils similar to those supporting white spruce and mixedwoods. Aspen growth of an average or second site quality attains a height between 20 to 21 m at the rotation age of 65 years. Mean annual increment is approximately 2.8 m^3 per hectare with yields between 175 to 196 m^3. At stand maturity, between 60 and 70 years, the gross yield exceeds 185 m^3/ha. Beyond maturity, the amount of rot in aspen increases rapidly, exceeding the current increment.

Logging of aspen, for products other than pulpwood and chipboard bolts, is highly selective. This promotes some sprouting, and tends to create many-aged aspen stands. Many-aged stand structures do not agree with the autecology of this species. Under natural conditions, it might take more than one rotation to convert these sites from a hardwood to a mixed association. Only clear-cutting and forest fires promise good and healthy regeneration, which will maintain practically pure even-aged aspen.

A regeneration survey, consisting of one hundred 4.05 m^2 sample plots in a seven-year-old clear-cut area revealed a stocking of 85/20,757* aspen, 12/1,483 balsam poplar, 85/22,239 aspen and balsam poplar combined, and 3/- white spruce. The average height of aspen saplings was 2.7 m. As the seed source of softwood species was further than 1.5 km, it is reasonable to assume that the aspen and balsam poplar (in moister depressions) association will control the site for another rotation.

*The numerator of the fraction indicates the percentage of sample plots stocked, and the denominator the average number of stems per ha. A large number of seedlings per ha associated with a low percent stocking indicates that regeneration has a poor distribution, being patchy or clumpy in appearance.

Table 16. Stand and stock table[1] (white spruce stand on a well drained site)

D.B.H.-o.b. (cm)	Stand Frequency (Number of Trees, by Species/ha)								Total No. of Trees	Volume Distribution (m³/ha)								Volume (m³)	Basal Area (m²)
	wS	bS	jP	bF	tL	tA	bPo	wB		wS	bS	jP	bF	tL	tA	bPo	wB		
10.2	30	—	—	—	—	7	—	—	37	.91	—	—	—	—	.21		—	1.12	.2
12.7	27	—	5	2	—	2	2	5	43	1.40	—	.35	.14	—	.21	.14	.42	2.66	.5
15.2	57	2	5	5	—	2	2	2	75	5.46	.21	.63	.56	—	.35	.14	.49	7.84	1.4
17.8	37	2	7	2	—	5	5	—	58	6.30	.42	1.12	.35	—	1.12	.56	—	9.87	1.4
20.3	40	+	2	2	—	7	+	—	51	9.17	.28	.70	.63	—	2.03	.21	—	13.02	1.8
22.9	30	2	5	+	—	7	2	—	46	9.94	.56	1.54	.28	—	2.52	.70	—	15.54	2.1
25.4	35	+	5	2	—	5	+	—	47	14.76	.28	1.96	.49	—	1.68	.21	—	19.38	2.3
27.9	32	+	2	+	—	2	+	—	36	16.58	.56	.98	.56	—	1.61	.49	—	20.78	2.5
30.5	25	—	—	—	—	5	2	+	32	15.95	—	—	—	—	2.66	1.47	.21	20.29	2.3
33.0	25	—	—	—	—	+	2	—	27	19.94	—	—	—	—	.91	1.96	—	22.81	2.5
35.6	20	—	—	+	—	—	2	—	22	17.28	—	—	.21	—	—	1.61	—	19.10	2.1
38.1	15	—	—	+	—	+	+	—	15	15.60	—	—	.35	—	.84	.70	—	17.49	1.8
40.6	10	—	—	—	—	+	+	—	10	11.41	—	—	—	—	.35	.49	—	12.25	1.4
43.2	5	—	—	—	—	+	+	+	5	8.33	—	—	—	—	1.61	.98	.21	11.13	1.1
45.7	2	—	—	+	—	+	+	—	2	5.60	—	—	.35	—	.35	.49	—	6.79	.7
48.3	5	—	—	—	—	—	+	—	5	8.96	—	—	—	—	—	.56	—	9.52	.9
50.8	2	—	—	—	—	—	—	—	2	5.25	—	—	—	—	—	—	—	5.25	.5
53.3	+	—	—	—	—	+	+	—	+	2.59	—	—	—	—	.35	.14	—	3.08	.2
55.9	+	—	—	—	—	+	+	—	+	2.24	—	—	—	—	.28	.28	—	2.80	.2
58.4	+	—	—	—	—	—	—	—	+	1.89	—	—	—	—	—	—	—	1.89	.2
61.0	+	—	—	—	—	—	+	—	+	1.26	—	—	—	—	—	.21	—	1.47	.2
Total	397	6	31	13	—	42	17	7	513	180.82	2.31	7.28	3.92	—	17.08	11.34	1.33	224.08	26.3
Percent	77.4	1.2	6.0	2.5	—	8.2	3.3	1.4	100.0	80.7	1.0	3.2	1.8	—	7.6	5.1	0.6	100.0	

1. Basis 68 sample plots.
\+ Denotes a fraction of a tree (a frequency of less than 0.5 tree per plot).

Table 17. Stand and stock table[1] (aspen stand on a well drained site)

D.B.H.-o.b. (cm)	Stand Frequency (Number of Trees, by Species/ha)							Total No. of Trees	Volume Distribution (m³/ha)							Total	
	wS	bS	jP	bF	tA	bPo	wB		wS	bS	jP	bF	tA	bPo	wB	Volume (m³)	Basal Area (m²)
10.2	42	7	—	2	12	2	7	72	1.12	.07	—	.07	.35	.07	.28	1.96	.5
12.7	25	—	—	2	37	5	7	76	1.19	—	—	.07	2.80	.28	.49	4.83	.7
15.2	27	7	—	2	74	22	12	144	2.45	.56	—	.21	9.59	2.10	1.40	16.31	2.8
17.8	12	+	—	—	74	12	2	100	1.82	.14	—	—	15.53	1.96	.56	20.01	2.3
20.3	12	—	+	2	77	17	2	110	2.52	—	.21	.28	22.74	3.99	.56	30.30	3.7
22.9	5	—	—	—	69	10	+	84	1.47	—	—	—	25.89	2.94	.21	30.51	3.4
25.4	5	—	+	—	57	7	2	71	1.82	—	.21	—	25.54	2.45	.56	30.58	3.7
27.9	2	—	+	—	44	5	—	51	.98	—	.42	—	25.68	2.31	—	29.39	3.2
30.5	2	—	+	—	44	5	—	51	1.89	—	.21	—	14.34	1.26	—	17.70	2.1
33.0	+	—	+	—	12	2	+	14	.42	—	.21	—	10.36	.91	.14	12.04	1.1
35.6	+	—	—	+	7	2	—	9	.70	—	—	.21	7.42	1.12	—	9.45	4.4
38.1	+	—	—	+	2	+	+	2	.21	—	—	.63	3.85	.56	.14	5.39	2.8
40.6	—	—	—	—	2	+	—	2	—	—	—	—	1.75	.35	—	2.10	.2
43.2	—	—	—	—	+	—	—	—	—	—	—	—	.70	—	—	.70	—
45.7	—	—	—	—	+	—	+	—	—	—	—	—	.49	—	.21	.70	—
48.3	—	—	—	—	+	+	+	—	—	—	—	—	.21	.21	.35	.77	—
50.8	—	—	—	—	—	+	—	—	—	—	—	—	—	.21	—	.21	—
53.3	—	—	—	—	—	—	+	—	—	—	—	—	—	—	.35	.35	—
55.9	—	—	—	—	—	2	—	2	—	—	—	—	—	.84	—	.84	.7
Total	132	14	—	8	511	91	32	788	16.59	.77	1.26	1.47	167.24	21.56	5.25	214.14	31.6
Percent	16.8	1.8	—	1.0	64.8	11.5	4.1	100.0	7.7	0.4	.6	0.7	78.1	10.1	2.4	100.0	

1. Basis 98 sample plots.
+ Denotes a fraction of a tree.

Photo 23. A typical aspen stand growing on well drained till.

Another regeneration survey of one hundred 4.05 m^2 plots in a seven-year-old clear-cut area of a drier phase of this type indicated a good stocking of aspen 94/25,205, but no other species was present. Although a few white spruce "seed" trees remained from the original stand, no white spruce seedlings could be found in the area of approximately 80 hectares. The dense brush, mainly *Corylus cornuta* (beaked hazelnut), possibly prevented the seeding-in of softwood species. It was also noted that the white spruce trees left standing were of intermediate and suppressed crown classes. the potential for trees of these crown classes to produce seed is doubtful, and further study is recommended to determine their ability to propagate.

5.2.4 PICEA GLAUCA/POPULUS - CORNUS ECOSYSTEM (White Spruce/Aspen - Bunchberry Type)

Although this ecosystem occupies only about 451,000 ha or 7% of the land area within the Provincial Forests of the Mixedwood Section, it forms one of the more characteristic and noticeable stands in this Section, as evidenced by the fact that the Mixedwood Section has been named after this cover type.

The general trend on all sites is that, following a hot (severe) fire, both tree species start to grow at the same time, providing even-aged stands (Photo 24). The basic assumption is that white spruce seed is available either from the previous stand or nearby forests. Light or surface fires which do not burn all the duff on the forest floor and do not expose mineral soil, stimulate aspen regeneration. Aspen sprouts quickly the same year, while regeneration of white spruce occurs on an additive basis (Photo 25).

Photo 24. Following a severe fire, both species start to grow at the same time and are the same age.

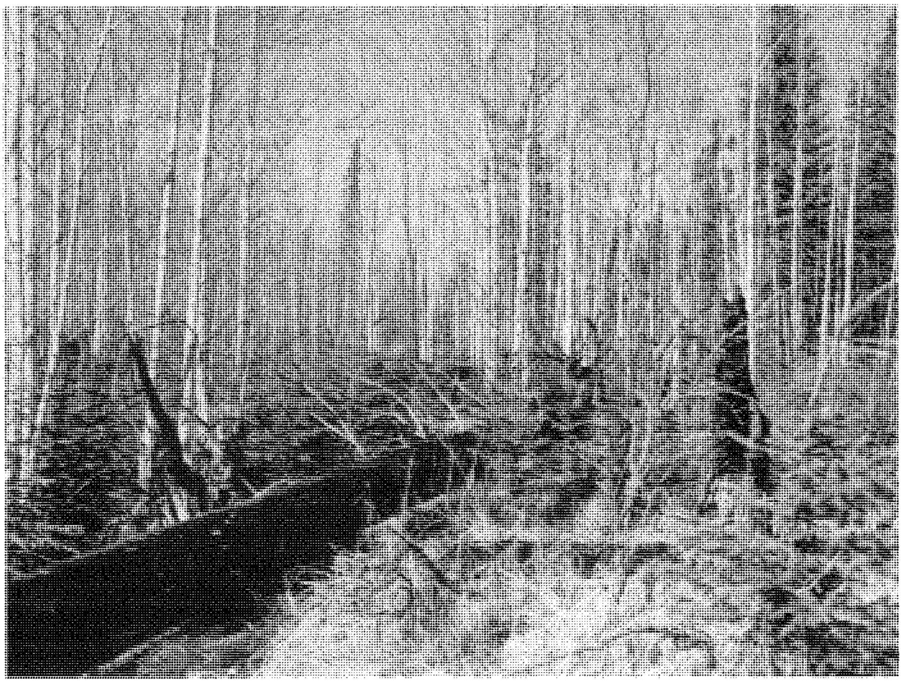


Photo 25. Following a light fire, spruce regeneration takes place under the aspen which established itself immediately after the fire.

Photo 26. Approximately only 50 to 60 percent of the white spruce break through the aspen canopy.

It takes 15 to 17 years for spruce seedlings on well drained sites to reach a height of about 1.37 m, and advance from the critical stage of being suppressed by the aspen leaf litter and understory vegetation. At that time the aspen overstory is 9.1 to 10.7 m high. A period of 50 to 60 years of intense competition for light and nutrients begins. The last major competition involves white spruce breaking through the aspen canopy (Photo 26). It is at this time that approximately 40-50 percent[1] of the white spruce is "whipped" and inhibited from further growth.

At 70 to 75 years of age, the spruce emerges as an equal partner in the overstory, and later at 100 to 110 years of age, it becomes the major species. The aspen has been steadily succumbing to old age, disease, or a combination of both, since its maturity of 60 to 70 years. The outcome of this long struggle is that only a small number (15.6%) of the original white spruce seedlings reach merchantable sawtimber size (over 25 cm at breast height) at maturity. In terms of management, therefore, it appears beneficial to release the young softwood seedlings from the heavy aspen competition at an early age, as practised in European countries with intensive forest management. By employing the practice of releasing white spruce, the province would fully capitalize on natural regeneration and increased production of white spruce.

Black spruce, jack pine and balsam fir are also commonly intermingled with aspen and white spruce in this ecosystem (Photo 27). Stand composition, depending on softwood and hardwood components, can be described as: 2wS 1(bS-jP-bF) 6tA 1(bPo-wB) as in Table 18 or 6wS 4tA+bS+bPo+wB+bF (Table 19).

Photo 27. Mature mixedwood stand on a well drained site.

The majority of these stands reach an average height of 20 m at the rotation age of 75 years. Mean annual increment at this rotation age is 3.1 m^3 per hectare, and the total yield is 210 m^3 per hectare. At stand maturity (70-100 years), the total yield is about 240 m^3 per hectare.

In general, a high percentage of white spruce and a relatively closed canopy results in a low species diversity and a high moss cover, while a high deciduous component and a more open canopy results in greater species diversity, an abundance of vascular species

1. Forestry Branch, Growth and Yield Survey.

and a discontinuous moss layer. Typical of these sites is the presence of *Cornus canadensis* (bunchberry) and *Mitella nuda* (bishop's-cap). Other species also commonly found as dominants include: *Linnaea borealis* (twinflower), *Petasites palmatus* (palmate-leaved coltsfoot), *Rubus pubescens* (dewberry), *Aralia nudicaulis* (sarsaparilla), *Mertensia paniculata* (tall mertensia) and *Epilobium angustifolium* (fireweed). A high percentage of deciduous trees in the overstory results in an increased presence of shrubs, including *Alnus crispa* (green alder), *Viburnum edule* (low-bush cranberry) and *Rosa acicularis* (prickly rose).

Hummocky glacial till of moderately coarse to moderately fine texture commonly supports the vegetation of this ecosystem.

The lack of demand for aspen wood sometimes leads to the practice of selectively removing the softwoods (Photo 28), leaving a semi-open stand of mature and decadent aspen trees to continue their growth or to yield a new aspen stand. Neither occurs. Instead, the opposite trend takes place. The aspen, because of its age, does not add any increment, and the canopy of standing trees eliminates the bulk of the sun's radiation which is required to promote root sprouting. Wind breakage (aspen is seldom uprooted) is hastened by exposure, overmaturity and damage incurred during harvest. This process continues for approximately 10 to 15 years, until the stand is destroyed. During this period of time, neither species has had an opportunity to regenerate and become re-established.

Photo 28. Originally this was a mixed stand from which softwoods have been logged.

Thus a seemingly practical method of logging, without consideration of consequences, has taken valuable land out of production for many years. Immediate planting to white spruce appears to be the most suitable corrective measure. This example again illustrates that forest cover is a component of an ecosystem, and it should be handled in the concept of the total system.

Table 18. Stand and stock table[1] (mixed aspen-spruce stand on a well drained site)

D.B.H.-o.b. (cm)	Stand Frequency (Number of Trees, by Species/ha)							Total No. of Trees	Total Volume Distribution (m³/ha)							Total	
	wS	bS	jP	bF	tA	bPo	wB		wS	bS	jP	bF	tA	bPo	wB	Volume (m³)	Basal Area (m²)
10.2	116	—	—	5	79	20	5	225	3.57	—	—	.14	2.45	.42	.14	6.72	1.8
12.7	136	12	5	—	128	12	5	298	8.19	.63	.42	—	8.96	.56	.35	19.11	3.9
15.2	72	15	5	5	109	15	12	233	7.00	1.28	.49	.35	13.44	1.12	1.40	25.08	4.1
17.8	42	12	2	2	126	5	2	191	5.81	1.68	.49	.49	22.74	.70	.42	32.33	4.6
20.3	22	7	+	+	77	12	+	118	4.78	1.47	.21	.28	19.03	2.45	.28	28.48	3.9
22.9	15	+	2	+	49	10	—	76	3.85	.28	.49	.21	15.46	2.59	—	22.88	3.0
25.4	12	—	2	2	35	5	+	56	4.27	—	.56	.63	13.57	1.82	.28	21.13	2.3
27.9	2	—	+	—	20	5	—	27	1.68	—	.35	—	9.80	2.17	—	14.00	1.6
30.5	2	—	—	—	10	+	—	12	1.05	—	—	—	6.16	.56	—	7.77	.9
33.0	10	—	—	—	5	2	—	17	4.41	—	—	—	2.87	1.40	—	8.68	1.1
35.6	2	—	—	+	5	—	+	7	1.33	—	—	.35	3.36	—	.35	5.39	.7
38.1	—	—	—	—	2	+	+	2	—	—	—	—	1.54	.14	.35	2.03	.2
Total	431	46	16	14	645	86	24	1,262	45.92	5.32	3.01	2.45	119.38	13.93	3.57	193.58	28.1
Percent	34.1	3.7	1.3	1.1	51.1	6.8	1.9	100.0	23.7	2.7	1.6	1.3	61.7	7.2	1.8	100.0	

1. Basis 235 sample plots.
\+ Denotes a fraction of a tree.

Table 19. Stand and stock table[1] (mixed spruce-aspen stand on a well drained site)

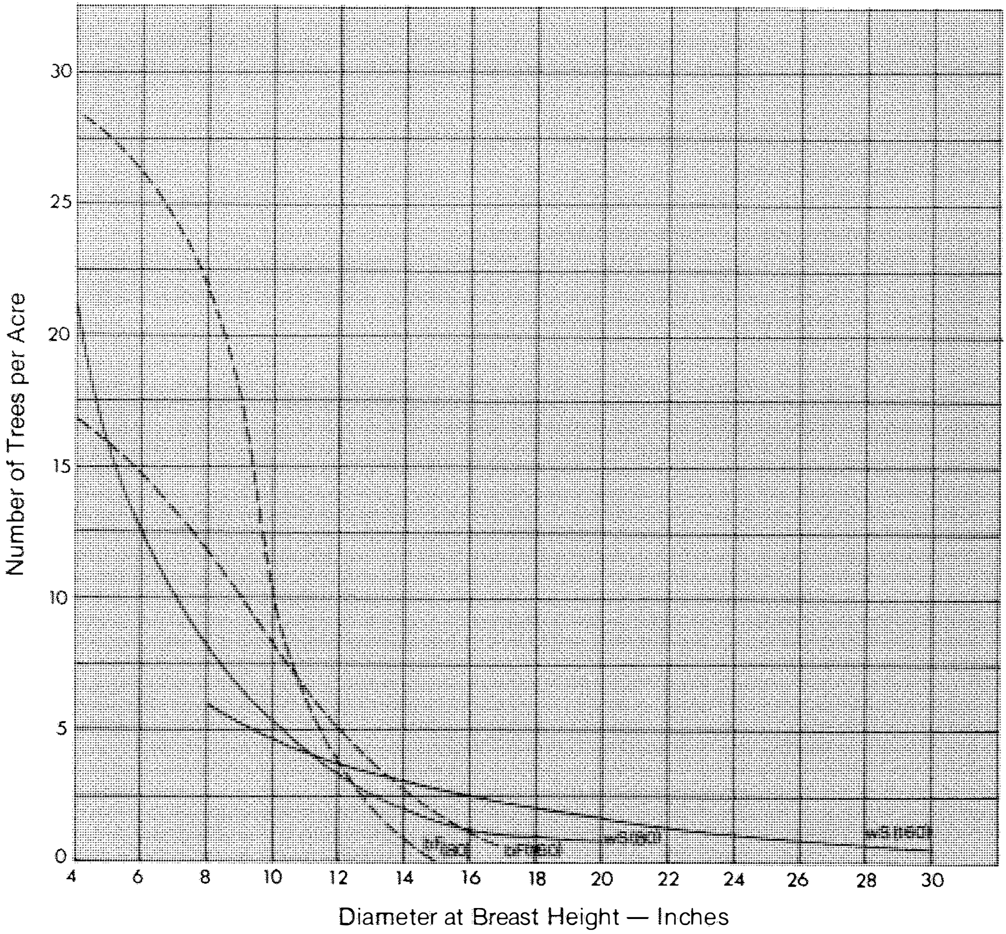
D.B.H.-o.b. (cm)	Stand Frequency (Number of Trees, by Species/ha)							Total No. of Trees	Volume Distribution (m^3/ha)							Total	
	wS	bS	jP	bF	tA	bPo	wB		wS	bS	jP	bF	tA	bPo	wB	Volume (m^3)	Basal Area (m^2)
10.2	193	2	—	+	79	15	—	289	5.81	.07	—	—	2.45	.35	—	8.68	2.3
12.7	180	—	—	—	86	25	2	293	10.64	—	—	—	5.67	1.12	.07	17.50	3.7
15.2	161	2	+	+	104	25	2	294	15.32	.14	—	—	10.85	2.03	.21	28.55	5.3
17.8	114	2	—	—	91	17	—	224	17.21	.28	—	—	15.18	2.03	—	34.70	5.5
20.3	89	2	—	—	69	7	—	167	18.82	.21	—	—	15.88	1.40	—	36.31	5.5
22.9	57	2	+	—	44	7	2	112	16.51	.28	—	—	13.30	1.68	.28	32.05	4.6
25.4	42	—	—	—	30	2	—	74	15.32	—	—	—	11.62	1.05	—	27.99	3.7
27.9	10	2	—	—	10	—	—	22	4.83	.49	—	—	4.62	—	—	9.94	1.4
30.5	10	—	—	—	2	2	—	14	5.32	—	—	—	1.40	1.12	—	7.84	1.1
33.0	2	—	—	—	2	—	—	4	1.33	—	—	—	2.31	—	—	3.64	.5
35.6	2	—	—	—	—	—	—	2	2.73	—	—	—	—	—	—	2.73	.2
38.1	2	—	—	—	—	—	—	2	2.94	—	—	—	—	—	—	2.94	.2
40.6	2	—	—	—	—	—	—	2	3.43	—	—	—	—	—	—	3.43	.2
Total	864	12	—	—	517	100	6	1,499	120.21	1.47	—	—	83.28	10.78	.56	216.30	34.2
Percent	57.6	0.8	—	—	34.5	6.7	0.4	100.0	55.6	0.7	—	—	38.5	5.0	0.2	100.0	

1. Basis 196 sample plots.
\+ Denotes a fraction of a tree.

A more proper logging operation would be to remove the aspen along with softwoods. Should a lack of demand make this unfeasible, then the aspen should be felled and left on the ground. This intentional clear-cut would promote ample regeneration of aspen and the natural succession of aspen - (aspen-spruce) - (spruce-aspen) - spruce - (spruce-balsam fir) would occur. The spruce-balsam fir association is sometimes considered as the climax stage in stand succession. Interference by man and/or nature in the form of logging, fires and wind has prevented further succession.

Figure 9 illustrates the stand frequency of the climax stage at 80 and 160 years of age. This is respectively based on 54 and 9 random relascope sample plots for each stand age. Overmature stands of this type are becoming scarce. It would be well in order to select a few hectares of such stands and declare them as ecological reserves.

Figure 9. Frequency distribution - white spruce-balsam fir cover type



A regeneration survey, consisting of two hundred 4.05 m² sample plots, was carried out in a larger seven-year-old clear-cut of this ecosystem. The plots were spaced 121 m apart along a compass line.

The following regeneration results were obtained:

White spruce	31/3,459
Jack pine	4/247
Balsam fir	1/247
All softwoods	32/3,707 (24% of composition)
Aspen	52/4,201
Balsam poplar	5/494
White birch	39/6,919
All hardwoods	72/11,614 (76% of composition)
All species	79/15,320

Advance growth of softwoods, which is sometimes common in logged areas, amounted to 2.0 percent. All indications (seedbed conditions and seed availability from the surrounding area) are that additional natural regeneration can be expected in the next 3 to 5 years. As an item of interest, the same area had only 1.5 percent coniferous stocking of new seedlings four years after logging (personal communication with S.M. Smith, Chief Forester, Prince Albert Pulpwood Limited)

5.3 MODERATELY WELL DRAINED SERIES

Apart from black spruce, all forest communities or ecosystems in this moisture series have a common occurrence and excellent forest growth. Generally adequate moisture can be expected throughout the growing season.

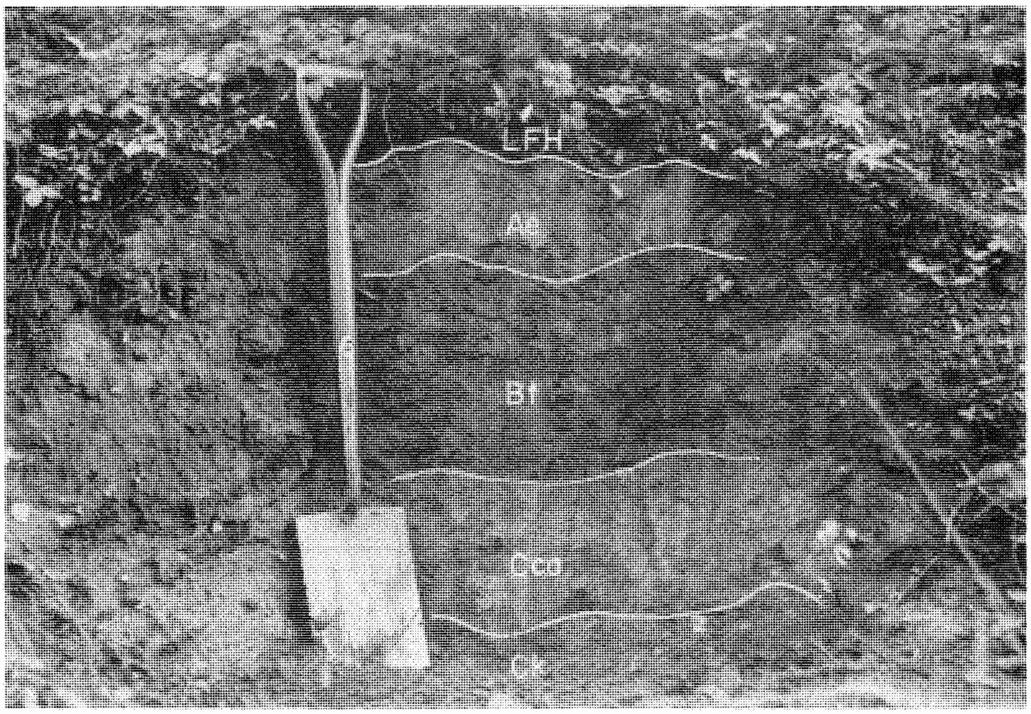


Photo 29. Moderately well drained glacial till provides a favourable rooting medium for jack pine, white spruce and mixedwood stands.

As in the well drained moisture regime, soils in the moderately well drained series also occur on a wide spectrum of parent materials, i.e., glacial till (Photo 29), glaciofluvial, glaciolacustrine, fluvial-lacustrine and recent deposits. Within a specific textural class, the mode of origin does not appear to significantly influence the productivity of any particular tree species.

Soils in this class exhibit some mottling, indicative of impeded drainage for short periods of time. The topography on which these soils occur is variable; however, they are commonly located in the lower slope positions. These soils are usually classified within the Luvisolic Order. However, Brunisolic and Chernozemic soils also occur.

Site conditions generally permit normal forest operations in summer and winter.

5.3.1 PINUS-PLEUROZIUM/LYCOPODIUM ECOSYSTEM (Jack Pine-Feather Moss/Club Moss Type)

This site supports the best jack pine growth in Saskatchewan (Photo 30). Stand composition consists of 7jP 3(tA-wS-bS)+bPo+wB. This co-existence with other minor species appears

Photo 30. Jackpine on a moderately well drained site.

beneficial for jack pine to develop optimum form under natural conditions. The dominance of jack pine is not threatened by the minor species during the current rotation, but under prolonged undisturbed conditions it will be replaced by either one or both of the spruce species. Fire or clear-cutting maintains the dominance of jack pine.

The characteristic understory is a feather moss carpet in combination with one or more vascular plant species. This feather moss carpet is composed predominantly of *Pleurozium schreberi* with lesser amounts of *Hylocomium splendens* (stair step moss) and *Ptilium crista-castrensis* (knight's plume).

The density of the tree canopy is the main factor determining the species composition of the understory. An open canopy on a moderately well drained site is similar to a closed canopy on a well drained site with an *Alnus crispa* (green alder) - *Cornus canadensis* (bunchberry) - *Trientalis borealis* (starflower) - *Pleurozium schreberi* association dominating. A closed canopy commonly supports an *Alnus Crispa* - *Pleurozium schreberi* association with very few other vascular plants being present. On the moister phases *Lycopodium annotinum* (stiff club moss) forms a third co-dominant along with *Alnus crispa* and *Pleurozium schreberi* (Photo 31).

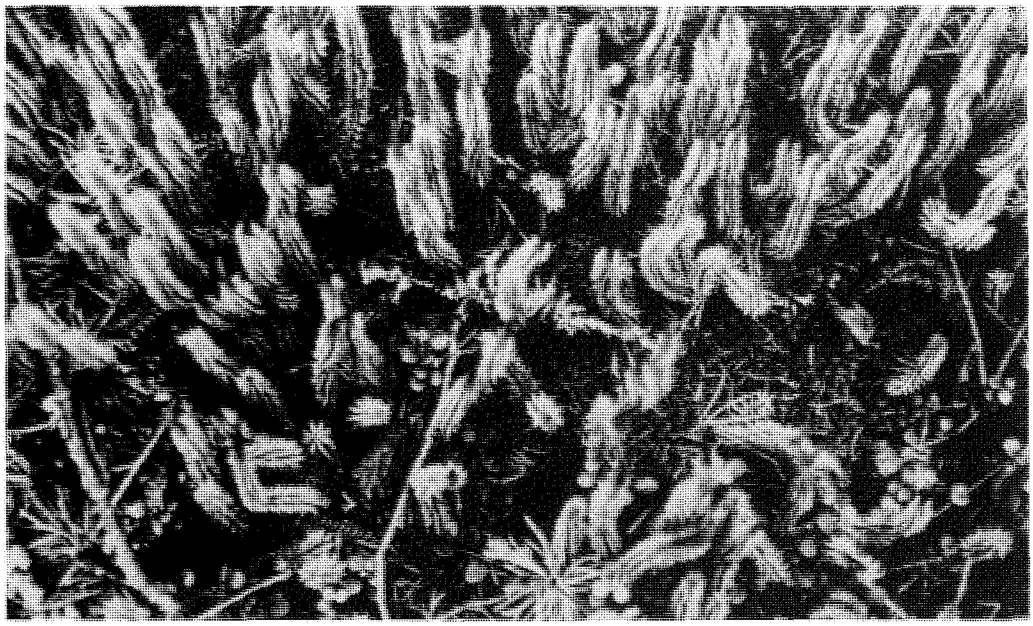


Photo 31. 'Lycopodium annotinum' (stiff club moss) is common and an indicator of highly productive jack pine sites. It becomes very noticeable in older stands.

Other species commonly found on this specific site include *Goodyera repens* (Rattlesnake Plantain), *Ledum groenlandicum* (Labrador tea), *Petasites palmatus* (palmate-leaved coltsfoot) and *Dicranum polysetum*. *Alnus crispa* (green alder) grows more vigorously in this ecosystem, and attains more height than within drier sites.

A moderately well drained Luvisolic soil profile supporting a good stand of jack pine may have characteristics shown below:

Horizon	Description
LFH	Usually a mor humus form, approximately 7 cm thick; derived predominantly from feather moss; pH approximately 4.5.
Ae	A platy, ashy coloured horizon; platiness may be better developed or more prominent than in the well drained equivalent. Texture may be sandy loam or loamy sand. Few mottles may be present; thickness about 20 cm; pH approximately 4.8.
Bt	Usually a dark brown horizon with a subangular blocky structure; texture is usually a clay loam or sandy clay loam; thickness about 50 cm; pH approximately 5.0; few mottles may be present.
Ck	A yellowish brown horizon which contains a variable lime content; textures are usually sandy loams, clay loam or sandy clay loam; few mottles may be present; pH approximately 7.0.

Table 20. Chemical and physical analysis of a moderately well- imperfectly drained profile supporting a jack pine stand near Glaslyn (analysis by W.K. Janzen, 1968)

		Particle Size Distribution (Percent)									
Horizon	Depth (cm)	Coarse & Med. Sand	Fine Sand	Very Fine Sand	Total Silt	Total Clay	pH	Organic Matter N (Percent)	No_3-N ppm	$NaHCO_3$-P ppm	Cation Ex. Cap. MEQ/100gm
L	8.9- 2.5	—	—	—	—	—	4.8	0.81	48.0	—	67.5
H	2.5- 0	—	—	—	—	—	4.9	1.01	22.0	24.0	81.7
Ae	0- 12.7	19.7	17.3	12.1	43.1	7.8	5.1	0.03	0.5	1.5	5.6
AB	12.7- 22.9	24.0	21.3	12.9	23.1	18.7	5.3	0.03	0.5	2.0	9.2
Bt1	22.9- 38.1	22.7	19.0	9.9	20.7	27.7	5.1	—	0.5	8.0	15.2
Bt2	38.1- 53.3	27.8	16.0	9.7	19.2	28.4	5.2	—	0.5	7.5	18.8
Bt3	53.3- 66.0	23.1	17.4	10.3	21.7	27.5	5.6	—	0.5	7.5	17.2
Bt4	66.0- 78.7	23.0	17.8	9.2	22.2	27.8	6.7	—	0.5	3.0	15.9
BC	78.7- 91.4	24.2	17.9	10.7	22.2	25.0	7.7	—	0.5	1.0	13.8
Ck1	91.4-106.7	23.4	17.5	10.8	23.7	24.6	8.1	—	0.5	1.0	12.5
Ck2	106.7+	19.9	18.7	11.1	26.0	24.3	8.1	—	0.5	1.0	10.7

Commercially, this is the most productive jack pine site (Figure 10). At a rotation age of 60 to 65 years, these stands average 20 to 23m in height and produce 175 to 190 m^3 of merchantable volume per hectare, which provides for a mean annual increment of 2.7 to 3.2 m^3 per hectare. At stand maturity (approximately 70 to 100 years of age) the total yield increases to between 260 and 275 m^3 per hectare (Table 21).

Generally, the present stand management will also determine the nature and composition of the future stand. Selective cutting favours the invasion of shade-enduring conifers. Clearcutting with scarification will promote and prolong jack pine as the dominant species. Summer logging also frequently promotes adequate jack pine regeneration. Following a fire, shrubs and pioneer hardwood species are more evident than jack pine. Their competition, however, is neither very intense nor persistent. Grass and willows are the first to be eliminated. Later white birch and most of the aspen saplings disappear. In time, jack pine becomes re-established and gradually gains ascendancy. At the age of 20 to 30 years it assumes a dominant role.

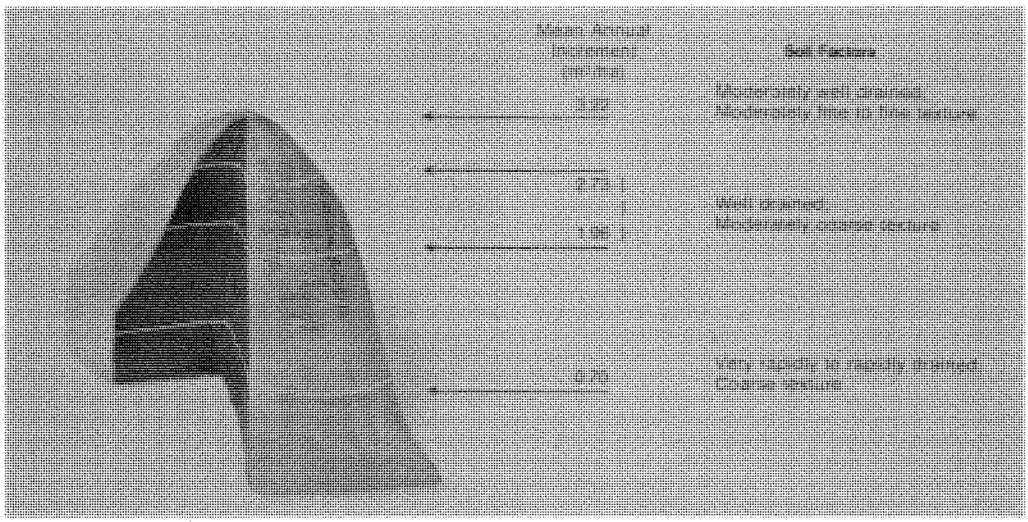
The response of jack pine to thinning is favourable in this ecosystem. Proper stand thinnings stimulate remarkable merchantable volume increments of up to 300%, and also make it feasible to grow valuable piece products such as power poles.

Table 21. Stand and stock table[1] (jack pine stand on a moderately well drained site)

D.B.H.-o.b. (cm)	Stand Frequency (Number of Trees, by Species/ha)						Total No. of Trees	Volume Distribution (m^3/ha)						Total	
	wS	bS	jP	tA	bPo	wB		wS	bS	jP	tA	bPo	wB	Volume (m^3)	Basal Area (m^2)
10.2	37	25	12	12	—	—	86	1.19	.77	.49	.35	—	—	2.80	.5
12.7	32	94	15	47	—	—	188	1.68	6.02	1.19	2.87	—	—	11.76	2.5
15.2	22	32	44	27	—	5	130	2.17	3.57	5.74	3.15	—	.49	15.12	2.3
17.8	17	40	72	20	—	5	154	2.73	6.44	13.71	3.64	—	.77	27.29	3.7
20.3	25	25	101	25	5	—	181	5.95	5.25	26.73	6.09	1.33	—	45.35	5.5
22.9	12	25	57	15	2	2	113	3.82	7.56	19.45	5.32	.63	.84	37.72	4.4
25.4	7	2	74	10	—	—	93	3.08	.84	32.12	3.71	—	—	39.75	4.8
27.9	7	—	52	2	—	—	61	3.36	—	27.50	1.68	—	—	32.54	3.9
30.5	—	—	40	—	—	—	40	—	—	24.70	—	—	—	24.70	2.8
33.0	+	—	15	—	—	—	15	.84	—	11.97	—	—	—	12.81	1.4
35.6	—	—	5	2	—	—	7	—	—	5.39	2.45	—	—	7.84	.9
38.1	—	—	2	—	—	—	2	—	—	3.29	—	—	—	3.29	.5
40.6	7	—	—	—	—	—	7	3.01	—	—	—	—	—	3.01	.9
43.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
45.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
48.3	5	—	—	—	—	—	5	2.10	—	—	—	—	—	2.10	.9
Total	171	243	489	160	7	12	1,082	30.03	30.45	172.28	29.26	1.96	2.10	266.08	35.0
Percent	15.8	22.5	45.1	14.8	0.7	1.1	100.0	11.3	11.4	64.6	11.0	0.7	0.8	100.0	

1. Basis — 15 sample plots.
\+ Denotes a fraction of a tree.

Figure 10. Jack pine productivity as a function of soil texture and moisture



In 1959, the Forestry Division established plots in 35 to 40 year old jack pine stands on three different sites within the Mixedwood Section to determine the feasibility of power pole production. Two levels of thinning and the retention of 1186 to 1236 of the most vigorous future trees per hectare from dominant and co-dominant crown classes were set as objectives. In the heavily thinned plots, only the selected future trees were left (Photo 32). On the lightly thinned plots, only those trees were removed which were likely to affect the growth of selected future trees. Hence, the lightly thinned plots contained both selected and non-interfering trees.

Photo 32. Heavily thinned jack pine on a good site in the Hudson Bay area (1984).

Table 22. Feasibility of power pole production[1]

Pole Class		Length of Pole (feet) 20	25	30	35	40	45	Top 50	Top Diameter[4]
1	Ht.[2]	60	65	70	70	75	80	85	9.4
	D.B.H.[3]	12.7	13.3	14.0	14.7	15.5	16.3	17.2	
2	Ht.	60	65	65	70	70	75	80	8.7
	D.B.H.	11.8	12.5	13.2	13.9	14.6	15.4	6.1	
3	Ht.	50	60	65	65	70	75	80	8.1
	D.B.H.	11.0	11.6	12.3	13.0	13.7	14.4	15.1	
4	Ht.	50	50	60	60	75	75	80	7.5
	D.B.H.	10.3	10.9	11.6	12.2	12.9	13.6	14.2	
5	Ht.	50	50	50	60	70	70	75	6.8
	D.B.H.	9.5	10.1	10.7	11.3	12.0	12.6	13.2	
6	Ht.	40	50	50	60	70	70	75	6.2
	D.B.H.	8.9	9.5	10.1	10.7	11.3	11.9	12.4	
7	Ht.	40	40	50	60	60	70	70	5.6
	D.B.H.	8.2	8.8	9.4	10.0	10.6	11.5	11.8	
			Poor Site		Medium Site		Good Site		

1. Heavy thinning; data projected to 70 year old stands. Imperial units currently utilized for power pole standards.
2. Ht. -tree height in feet.
3. D.B.H.- diameter at breast height in inches (outside bark).
4. Top diameter of pole in inches (outside bark).

Analysis of remeasurement data indicates that trees suitable for medium and some larger (class 4) poles may be grown on good jack pine sites in Saskatchewan (Table 22). Although Table 22 refers to projected 70 year old stands, perhaps 80 or 90 years should be considered as the practical rotation age for power pole production. Site quality appeared to impact primarily upon tree height, whereas level of thinning appeared to impact primarily on tree diameter.

The first thinning (juvenile spacing) is recommended at 10 to 15 years of age; the second (commercial) at 40 years, and the third (also commercial) at about 60 years of age.

As slender, well-formed trees with long, clear boles form these stands, making them suitable for special forest products, the stands warrant particular consideration and integrated utilization.

5.3.2 PICEA GLAUCA-PLEUROZIUM ECOSYSTEM
(White Spruce-Feather Moss Type)

This ecosystem contains the best white spruce growth in the Mixedwood Section, with trees exceeding 24 m in height and in some cases reaching 38 m in height and 90 to 100 cm in diameter at breast height.

Due to similarity of soils, lesser vegetation and growth characteristics, the moderately well drained and imperfectly drained series have been combined in this type. Reference to wetter phases suggests imperfect drainage.

Ground vegetation is characterized by a feather moss ground cover with a low shrub/herb layer. The feather moss is comprised predominantly of *Pleurozium schreberi* and *Hylocomium spledens* (stair step moss) with small amounts of *Dicranum polysetum, Dicranum undulatum* and *Thuidium recognitum* (fern moss).

The low herb/shrub layer is comprised dominantly of *Linnaea borealis* (twinflower) and *Cornus canadensis* (bunchberry). Other common species include *Mitella nuda* (bishop's-cap), *Equisetum arvense* (common horsetail), *Rubus pubescens* (dewberry), *Petasites palmatus* (palmate-leaved coltsfoot) and *Bromus anomalus* (nodding brome).

The above association remains relatively constant throughout this series with the exception of the moister phases where the low shrub/herb layer becomes less abundant, and the *Pleurozium schreberi-Hylocomium splendens* association is the remaining dominant with lesser amounts of the low shrubs and herbs. *Petasites frigidus* (vine-leaved coltsfoot) is characteristically common of these sites.

The best white spruce stands within the Mixedwood Section occur on Dark Grey Chernozemic soils, which are developed on water modified glacial till or glaciolacustrine deposits. The topography of these areas is level to gently undulating. Equally productive alluvial deposits on level topography also occur, but to a lesser extent.

Very slight elevations in the micro relief and an abundance of rotten trunks provide reasonable seedbeds for spruce. Lush vegetation and brush, together with shoots of balsam poplar offer strong competition to the establishment of white spruce seedlings. Patch/and

Photo 33. Excellent growth of white spruce on a moderately well drained silty clay loam soil.

or selective logging is recommended for natural regeneration. To minimize windthrow, the prevailing winds, surrounding forests, and topography should be considered prior to harvesting.

The magnificent canopy display and opulent vegetation give this ecosystem a fascinating appearance (Photo 33).

A mean annual increment of 4.5 m^3 and a total yield of 315 m^3 per hectare are attained at the rotation age of 65 to 70 years. At stand maturity, between 70 and 110 years, the total yield increases to 455 m^3 per hectare. On imperfectly drained sites, the mean annual increment and yields are slightly reduced.

The stand composition (Table 23) of 8wS 2(bPo-tA-bF-wB)+bS suggests that it possibly originated as a mixedwood stand. A higher proportion of balsam poplar than aspen indicates that there is excess soil moisture, in early spring, in most years.

In order to determine the regeneration potential of this ecosystem, three regeneration surveys were carried out. The survey consisted of one hundred 4.05 m^2 samples per site.

Pertinent information concerning each area sampled is shown below:

(a) An eight-year old clear-cut:

White spruce	62/1,483
Balsam fir	1/____
All softwoods	62/1,483
Aspen	69/1,483
Balsam poplar	11/____
All hardwoods	71/1,483
All species	95/2,965

The average height of the aspen saplings was 4.57m, and the white spruce seedlings varied in height between 10.2 and 38.1 cm.

(b) A ten-year old clear-cut:

White spruce	27/1,483
Aspen	54/5,930
Balsam poplar	8/494
All hardwoods	60/6,425
All species	68/7,907

The height of the aspen saplings varied between 3.5 and 4.88 m; whereas, the height of the spruce seedlings was between 20.7 and 26.5 cm.

Total regeneration in this clear-cut is acceptable. However, even assuming that further white spruce regeneration will occur, the stocking of white spruce is insufficient to produce a future softwood stand. Regeneration beyond 20 years after cutting, will create an undesirable stand age structure. It becomes obvious here that these prime sites should receive initial consideration for silvicultural treatments.

(c) A ten-year old burn near a softwood seed source:

White spruce	71/13,838
Aspen	86/36,571
Balsam poplar	2/1,977
All hardwoods	86/38,548
All species	88/52,386

Since this ecosystem occupies a considerable area within the Mixedwood Section, and is a prime producer of dimension lumber, building and plywood material, it seems well in order to invest additional time and effort to fully utilize it.

Table 23. Stand and stock table[1] (white spruce on a moderately well drained site)

D.B.H.-o.b. (cm)	Stand Frequency (Number of Trees, by Species/ha)								Total No. of Trees	Volume Distribution (m³/ha)								Volume	Basal Area
	wS	bS	jP	bF	tL	tA	bPo	wB		wS	bS	jP	bF	tL	tA	bPo	wB	(m³)	(m²)
10.2	25	—	—	10	—	—	—	7	42	.63	—	—	.35	—	—	—	.21	1.19	.2
12.7	54	—	—	10	—	—	5	—	69	3.15	—	—	.56	—	—	.21	—	3.92	.9
15.2	27	—	—	—	—	—	—	2	29	2.73	—	—	—	—	—	—	.28	3.01	.5
17.8	40	—	—	5	—	2	—	2	49	6.23	—	—	.77	—	.42	—	.35	7.77	1.1
20.3	57	—	—	—	—	2	—	5	64	12.67	—	—	—	—	.63	—	1.05	14.35	2.1
22.9	54	—	—	—	—	5	—	5	64	16.44	—	—	—	—	1.61	—	1.33	19.38	2.5
25.4	40	—	—	5	—	5	—	5	55	15.46	—	—	1.96	—	2.10	—	1.68	21.20	2.8
27.9	40	5	—	—	—	2	10	2	59	19.31	2.17	—	—	—	1.26	4.27	.98	27.99	3.7
30.5	35	—	—	—	—	12	—	—	47	20.71	—	—	—	—	7.77	—	—	28.48	3.4
33.0	42	—	—	—	—	2	10	2	56	30.51	—	—	—	—	1.89	5.32	1.40	39.12	4.6
35.6	44	—	—	—	—	—	10	—	54	38.21	—	—	—	—	—	6.16	—	44.37	5.5
38.1	44	—	—	—	—	2	—	—	46	44.57	—	—	—	—	2.66	—	—	47.23	5.3
40.6	17	—	—	—	—	—	5	—	22	20.08	—	—	—	—	—	4.13	—	24.21	3.0
43.2	12	—	—	—	—	—	—	—	12	16.51	—	—	—	—	—	—	—	16.51	1.8
45.7	5	—	—	—	—	—	5	—	10	7.49	—	—	—	—	—	5.32	—	12.81	1.6
48.3	5	—	—	—	—	—	—	—	5	8.47	—	—	—	—	—	—	—	8.47	.9
50.8	2	—	—	—	—	—	—	—	5	9.45	—	—	—	—	—	—	—	9.45	.9
53.3	2	—	—	—	—	—	—	—	2	5.25	—	—	—	—	—	—	—	5.25	.5
55.9	2	—	—	—	—	—	—	—	2	5.81	—	—	—	—	—	—	—	5.81	.7
Total	550	5	—	30	—	32	45	30	692	283.68	2.17	—	3.64	—	18.34	25.41	7.28	340.52	42.2
Percent	79.5	0.7	—	4.4	—	4.6	6.5	4.3	100.0	83.3	0.6	—	1.1	—	5.4	7.5	2.1	100.0	

1. Basis 6 sample plots.

Photo 34. Aspen attains the best growth on moderately well drained soil.

5.3.3 POPULUS-ARALIA/LINNAEA ECOSYSTEM
(Aspen-Sarsaparilla/Twinflower Type)

Aspen obtains its optimum growth (Photo 34) within the moderately well drained series. Within the imperfectly drained series, aspen declines in vigour (Photo 35).

Photo 35. On imperfectly drained sites, the vigour of aspen is reduced. The invasion by spruce is evident.

These sites support a variety of understory species. The most common include *Linnaea borealis* (twinflower), *Cornus canadensis* (bunchberry), *Aralia nudicaulis* (sarsaparilla), *Lathyrus ochroleucus* (cream-coloured vetchling), *Rubus pubescens* (dewberry), *Epilobium angustifolium* (fireweed), *Rosa acicularis* (prickly rose), *Viburnum edule* (low-bush cranberry) and *Ribes triste* (red currant). Seldom does one species assume total dominance. Other less common species include *Petasites palmatus* (palmate-leaved coltsfoot), *Mitella nuda* (bishop's-cap), *Vaccinium vitis-idaea* (bog cranberry), and *Fragaria virginianum* (wild strawberry).

Within the moister phase of this series, *Calamagrostis canadensis* (marsh reed grass) forms a dominant in combination with the above species.

Soils commonly supporting aspen growth within this ecosystem consist of moderately coarse to moderately fine textured glacial till on hummocky topography.

On moderately well drained sites, aspen stands often reach an average height of 23 m and higher at a very early rotation age of 60 years. At the rotation age, the mean annual increment is between 3.5 to 3.8 m^3 per hectare, and the total yield is 210 to 245 m^3 per hectare. At stand maturity, 60 to 70 years of age, the gross yields often exceed 315 m^3 per hectare.

Excellent regeneration is obtained after fires (Photo 36) and also by clear-cutting (Photo 37).

A regeneration survey, consisting of one hundred 4.05 m^2 sample plots within a 809 ha clear-cut area nine years after logging, showed a stocking of 93/10,378 aspen and 7/7,907 balsam poplar. The average height of saplings ranged between 4.0 and 4.6 m. As a result of the size of the area, and the lack of a softwood seed source, it is certain that the present ecosystem will be maintained.

Photo 36. Vigorous aspen and balsam poplar sprouts, two years after a fire.

Photo 37. Abundant aspen regeneration three years after a clear-cut on a well to moderately well drained site.

The stocking and frequency (7/7,907) of balsam poplar sprouts in the above cut-over is undesirably high. This hardy species is a prolific and vigorous producer of sprouts, especially on moister sites, thus offering undesirable competition to the aspen saplings.

At present, the demand for balsam popar is low. MacMillan Bloedel at Hudson Bay, the largest user of hardwoods, does not exceed 17 percent balsam poplar in their total volume.[1] Therefore, within aspen clear-cuts, localized areas of balsam poplar serves several useful functions, namely: shelter for wildlife, regulation of water flow, and the avoidance of excessive balsam poplar sprouting.

5.3.4 PICEA GLAUCA/POPULUS-CORNUS/MITELLA ECOSYSTEM (White spruce/Aspen-Bunchberry/Bishop's-cap Type)

This is the most productive mixedwood type (Photo 38) found usually on moderately fine to fine textured soils. Stand composition depends very much on the stand history. Without the interference of man or fire the mixedwood stage is prolonged in this ecosystem (Photo 39).

Photo 38. A mixed white spruce-aspen stand 65 years of age on a moderately well drained site.

1. Personal communication with B. Brooks, Woodlands Supervisor, MacMillan Bloedel, Hudson Bay.

Photo 39. A white spruce-aspen stand at an extended mixedwood stage.

Typical of these sites is *Cornus canadensis* (bunchberry) and *Mitella nuda* (bishop's-cap) dominants or near dominants. The sites with a high proportion of coniferous trees tend to have a feather moss component, while sites with a high proportion of deciduous tree species have herb layers and a few or no mosses. Species commonly found as dominants in combination with these two are *Linnaea borealis* (twinflower), *Petasites palmatus* (palmate-leaved coltsfoot), *Rubus pubescens* (dewberry), *Aralia nudicaulis* (sarsaparilla) and *Mertensia paniculata* (tall mertensia). A high percentage of conifer component results in less species diversity and an increase in the moss dominance. The diversity is great, generally being a mixture of the types found under pure stands of the coniferous and deciduous components; hence, assigning of a dominant is difficult.

Stands reach an average height of 23 to 24 m at the rotation age of 65-70 years, and over 27 m at maturity, which is between 70 to 100 years. The mean annual increment of all species at the rotation age is 4.2 to 4.5 m^3 per hectare per year; total yields of 270 to 295 m^3 and 315 to 350 m^3 per hectare are obtained at rotation age and maturity, respectively.

Stand development, utilization methods and regeneration problems are similar but greater in magnitude than those discussed for the well drained series. Since these are very productive and sensitive sites, prudence is required to prevent them from becoming non-productive brushlands. Proper stand improvement is beneficial and economically feasible, to alleviate the stiff competition between various tree species and to direct their growth to a maximum potential.

As shown in tables 24 and 25, sufficient information is available, primarily from the growth and yield survey, to project the softwood increment in released stands.

Table 24. Additional periodic volume increment of released softwoods - m^3/ha (SH stands)

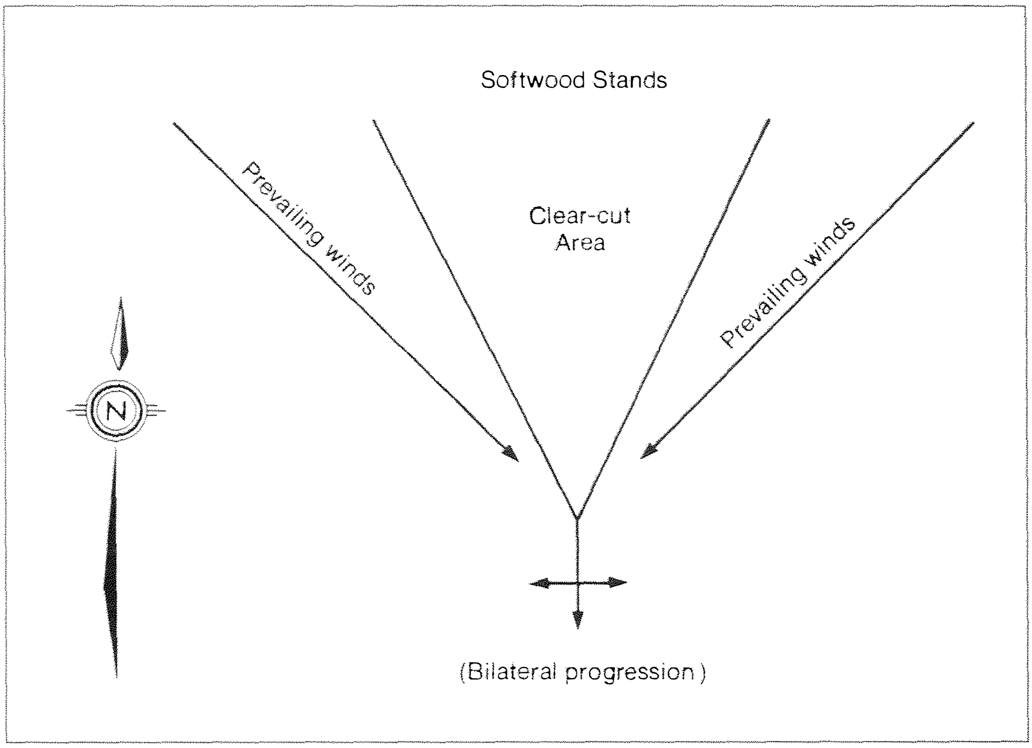
	Approximate Age of Released Stand					
	15			45		70
Cover Type	Harvesting Age 45	70	95	70	95	95
SHA	22	33	40	25	33	15
SHB	45	49	50	28	33	21
SHC	80	90	89	47	46	30
SHD	90	100	94	55	50	23

Table 25. Additional periodic volume increment of released softwoods - m^3/ha (HS stands).

	Approximate Age of Released Stand					
	15			40		65
Cover Type	Harvesting Age 40	65	90	65	90	90
HSA	7	17	25	10	18	12
HSB	24	20	21	18	19	7
HSC	41	47	25	43	21	9
HSD	50	65	44	58	36	21

Photo 40. An early release of softwoods at 10 to 15 years, produces the best results.

Figure 11. Logging diagram for a softwood stand



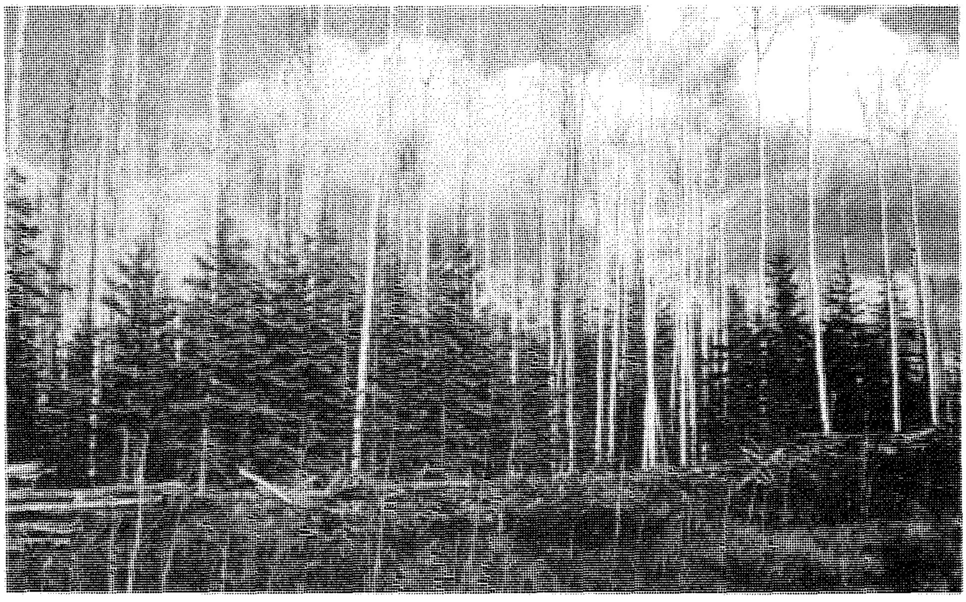


Photo 41. Two-storied stands of aspen and spruce develop at 40 to 50 years of age. It is not too late to release softwoods profitably.

If stand treatments were carried out on the 27,539 ha of presently immature mixedwood (SH) stands within the Mixedwood Section, about 1,178,334 m^3 of additional softwood volume would be obtained during the next 25 years, or 46,933 m^3 annually. Similarly, an additional annual increment of 67,300 m^3 of softwood would be obtained by releasing softwoods within HS stands.

Although 10 to 15 years of age is the best time to release softwoods (Photo 40), it is n●t too late to release softwoods at 40 to 50 years of age (Photo 41).

Various mechanical (brushsaw, brush axe, tree girdler, etc.) and chemical (hypo-hatchet and aerial spraying applications) means are available for softwood release projects.

If feasible, the adoption of a particular cutting method may enhance natural softwood regeneration. Full advantage of seed supply, beneficial shade effect and reduced windthrow are obtained by cutting from north to south. (Figure 11)

5.3.5 PICEA MARIANA-PLEUROZIUM/HYLOCOMIUM ECOSYSTEM (Black Spruce-Feather Moss Type)

Upland black spruce stands are fairly common, varying from small patches to areas of a few hundred hectares in size. The largest blocks of such stands are found at Cub and Little Bear Lakes and on the upper rims of the Pasquia and Porcupine Hills. Fires and the cooler, moister local climate are probably responsible for the origin of these stands (Photo 42).

Photo 42. Black spruce on a well drained site.

Stand development, composition, and management implications are similar in this ecosystem and the well drained counterpart. By extent, the well drained series appears to occupy a lesser land area; therefore, the description within this ecosystem relates to the moderately well drained series with specific mention of drier phases. A very high stand density, absence of shrubs and a complete feather moss ground cover are characteristic features of this ecosystem (Photos 43 and 44).

Ground cover is characterized by a feather moss carpet with no other dominant vegetation. The species include *Pleurozium schreberi*, *Hylocomium splendens* (stair step moss) and *Ptilium crista-castrensis* (knight's plume) as the dominant species with lesser amounts of *Dicranum polysetum* and *Dicranum undulatum*. Only minor amounts of *Cornus canadensis* (bunchberry), *Vaccinium vitis-idaea* (bog cranberry), *Equisetum arvense* (common horsetail), *Mitella nuda* (bishop's-cap), *Geocaulon lividum* (northern comandra), *Ledum groenlandicum* (Labrador tea) and *Equisetum scirpoides* (dwarf scouring rush) are found on these sites.

Photo 43. Black spruce on a moderately well drained site.

The dense tree canopy, varying from 65 to 90 percent in undisturbed stands is the main reason for the feather moss dominant. A more open canopy (resulting naturally or unnaturally) allows more vascular plants in the understory.

Soils commonly supporting these stands consist of moderately coarse to moderately fine textured glacial tills on rolling topography.

On the drier sites, black spruce attains an average height of 12 m at the rotation age of 100 years. The mean annual increment at this rotation age is 1.4 m^3 per hectare, and the total yield is between 135 and 145 m^3 per hectare. Stand maturity is reached between 100 and 120 years with a little gain in merchantable volume past the rotation age. As a result of natural overstocking (over 4,940 stems per hectare) the average tree diameter at breast height outside bark is only between 10.2 and 11.2 cm. Considering only trees greater than 8.9 cm at breast height, the average diameter increases to 12.4 cm and stocking decreases to about 2,470 trees per hectare (Benson, 1973). Therefore, size alone relegates black spruce as a true pulpwood species.

On moister, moderately well drained sites, black spruce reaches an average height of 14 m at the rotation age of 90 to 95 years, with a mean annual increment of 1.7 to 2.1 m^3 per hectare, and yields between 175 and 195 m^3 per hectare. At stand maturity (100-120 years), the total yield increment since rotation age is slight.

Clear-cutting, as determined by topography and merchantability of stands, is the suggested method of harvesting. Although scarification benefits regeneration, it does not always assure a satisfactory stocking. On larger cutovers (Photo 45), without a nearby seed source, adequate natural regeneration cannot be expected. If man's assistance is planned (seeding or planting), consideration should be given to the introduction of white spruce on these sites.

Forest fires assure the continuation of black spruce for another rotation.

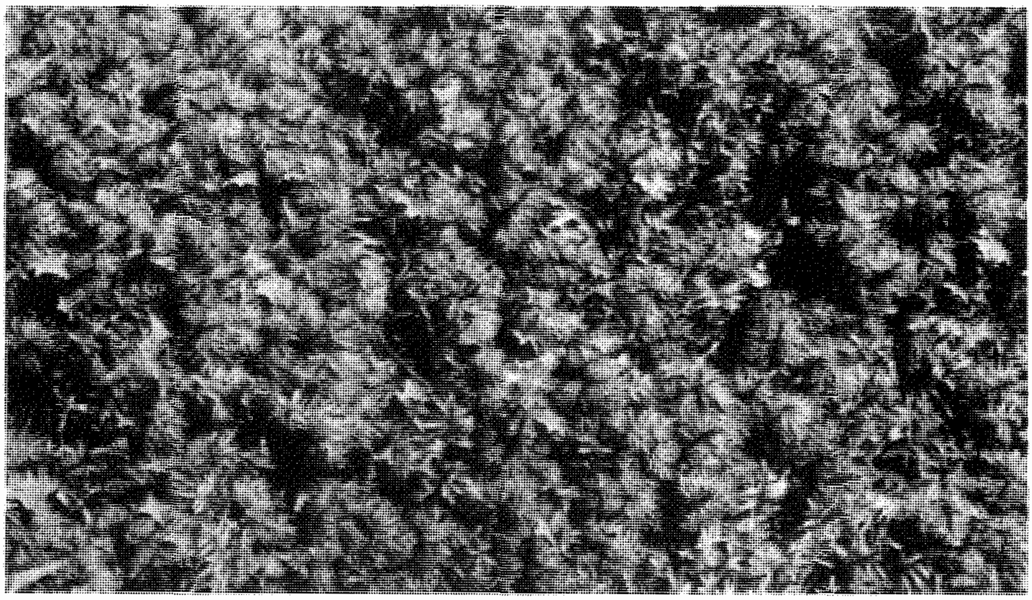


Photo 44. Feather moss is typical ground cover of dense black spruce stands.

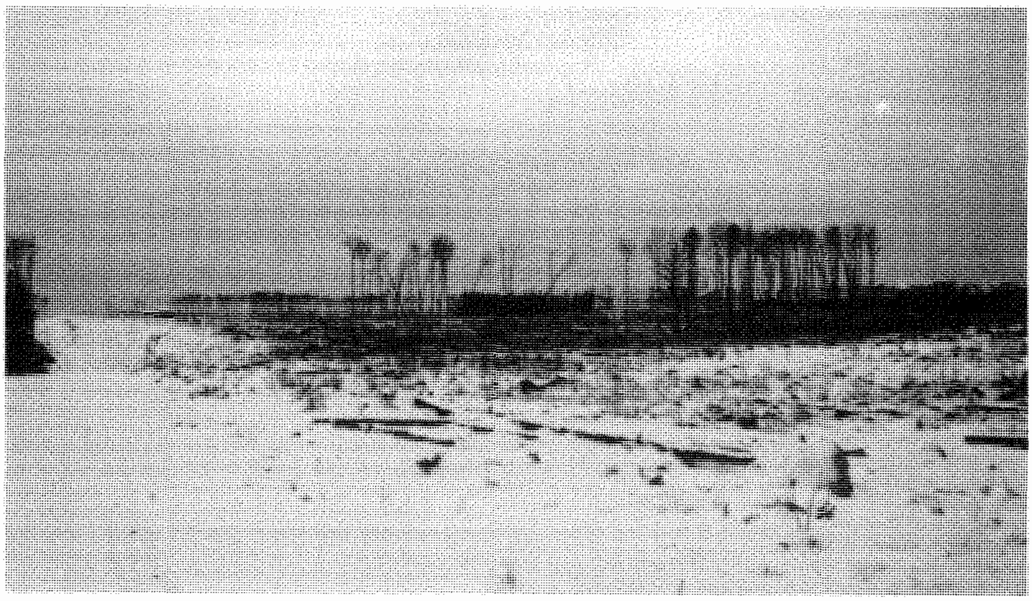


Photo 45. Large cut-over area on a moderately well drained site.

5.4 IMPERFECTLY DRAINED SERIES

Prominent mottling and/or gleying in the soil, and an increased presence of mosses characterize this series. Changes in species occurrence and stand composition from the previous series are also noticeable. Some species, such as jack pine and aspen, decline in vigour and merchantability standards, while balsam poplar increases in frequency, and black spruce attains its highest yields. Although interspersed with black spruce, tamarack also reaches a commercial level in this series.

As in the moderately well drained moisture regime, soils in the imperfectly drained class also occur on a wide spectrum of parent materials, namely: glacial till, glaciofluvial, glaciolacustrine, fluvial-lacustrine and recent deposits. Within a specific textural class, the mode of origin does not appear to significantly influence the productivity of any particular tree species. Imperfectly drained soils occur on level topography or on lower slopes or depressional areas in undulating or hummocky terrrain. They are usually influenced by groundwater and/or run-off water.

Within the Provincial Forest portion of the Mixedwood Section, these soils are usually classified within the Luvisolic order, and to a lesser extent, within the Brunisolic and Chernozemic Orders.

Summer forestry operations within this series are more dependent upon seasonal weather conditions than in the previous series.

5.4.1 PINUS/PICEA MARIANA-PLEUROZIUM ECOSYSTEM
(Jack Pine/Black Spruce-Feather Moss Type)

This is an often unrecognized, widespread (6.64 percent by area) and ecologically confusing ecosystem. This dual cover type also occurs on the well and moderately well drained series; however, its preponderance is on the imperfectly drained sites. The proportion of both dominant species, jack pine and black spruce, varies considerably with the age of stands, but their typical appearance consists of jack pine in the upper, and black spruce in the second story (Photo 46).

Although black spruce often outnumbers jack pine, most of its stems are in the intermediate and suppressed crown classes. Seed production of those trees is reduced, and only a small amount of dominant or co-dominant black spruce produce seed. At stand maturity, 80 to 100 years of age, jack pine thins out because of natural mortality and black spruce becomes the dominant species due to its greater longevity. Stand composition at maturity could be described as 6jP 4bS+wS+bPo+tL.

Because of the stand density, *Pleurozium schreberi* is usually the only dominant understory vegetation, with small amounts of *Hylocomium splendens* (stair step moss) and *Ptilium crista-castrensis* (knight's plume). A scattering of vascular plants is normally present, with *Cornus canadensis* (bunchberry) and *Petasites palmatus* (palmate-leaved coltsfoot) being the most prevalent.

Soils generally supporting these stands are moderately coarse to moderately fine textured glacial tills, and glacial tills which are overlain by coarse to moderately coarse textured glaciofluvial and fluvial-lacustrine deposits.

The mean annual increment of both species together is between 1.4 and 1.7 m^3 per hectare at the jack pine rotation age of 75 years, and the total yield varies between 105 and 130 m^3 per hectare. Rotation age of the black spruce component is between 90 and 100 years. Minor yield increases can be expected at the stand maturity of 100 years. Black spruce volume increases after its rotation age, however, the volume of jack pine decreases. As a result, the net gain at stand maturity is slight.

In view of the fact that no effective management has been developed for this dual cover type, these stands are not yielding a maximum economic return. Diverse biological requirements further complicate its understanding.

As these stands are best suited for pulpwood, clear-cutting appears to be the most practical harvesting method at the present time.

Field observations indicate that following a clear-cut, a fairly good regeneration of both species follows in a proportion similar to the previous stand. The seed source is provided by the slash from harvesting. Scarification usually assures good regeneration. Fire regenerates both species in a similar manner to clear-cutting. In the absence of fire or logging, jack pine will gradually be replaced by black spruce.

Photo 46. Jack pine-Black spruce association.

5.4.2 PICEA GLAUCA/POPULUS-CORNUS/RUBUS ECOSYSTEM
(White Spruce/Aspen-Bunchberry/Dewberry Type)

This ecosystem is not extensive, and is generally located on lower slopes or depressional flats with slow surface drainage. A higher component of softwoods than in the previous Mixedwood ecosystems, and a lower site quality are common features of forest stands in this ecosystem (Photo 47).

The understory vegetation reflects both the density of the canopy and the species composition of the overstory. In general, a dense cover of conifers results in a low species diversity and a preponderance of mosses (*Pleurozium schreberi*). Typical of these sites is the presence of *Cornus canadensis* (bunchberry) and *Mitella nuda* (bishop's-cap).

Herb species commonly found as dominants in combination with the two formerly listed are *Linnaea borealis* (twinflower), *Petasites palmatus* (palmate-leaved coltsfoot) and *Rubus pubescens* (dewberry).

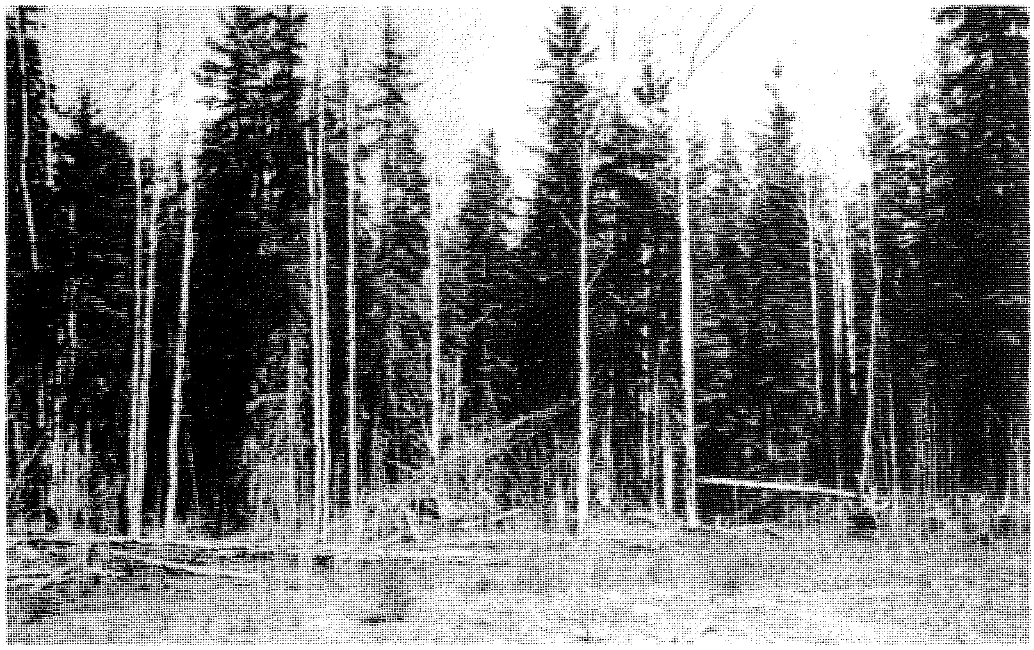


Photo 47. A mixed white spruce-aspen stand growing on an imperfectly drained site.

Stand height varies between 17 and 18 m at the rotation age of 75 years, with a mean annual increment of 2.4 m^3 per hectare. Total yields at rotation age, all species combined, are between 180 and 210 m^3 per hectare. Patch and strip cutting, without artificial reforestation, favours mixed regeneration, with a reasonable number of softwoods. Ground preparation is recommended on these sites prior to planting white spruce.

5.4.3 PICEA MARIANA-PLEUROZIUM/PTILIUM ECOSYSTEM
(Black Spruce-Feather Moss Type)

This ecosystem is transitional, and usually occupies strips of variable width between wet muskegs and uplands. The cover type is pure black spruce, with white spruce (on the drier side) and balsam poplar and some tamarack (on the wetter side) as minor components.

Due to the dense (60-90%) coniferous canopy, ground vegetation is characterized by a feather moss carpet with no other dominant vegetation. Mosses comprising this carpet include

Pleurozium schreberi, *Hylocomium splendens* (stair step moss) and *Ptilium crista-castrensis* (knight's plume) as the dominant species with lesser amounts of *Dicranum polysetum* and *Dicranum undulatum*.

Only minor amounts of vascular plants are found on these sites with *Cornus canadensis* (bunchberry), *Vaccinium vitis-idaea* (bog cranberry), *Equisetum arvense* (common horsetail), *Mitella nuda* (bishop's-cap), *Geocaulon lividum* (northern comandra), *Ledum groenlandicum* (Labrador tea) and *Equisetum scirpoides* (dwarf scouring rush) being the most prevalent.

These sites are similar to the moderately well drained sites with the exception that there is slightly more vascular species diversity.

A typical imperfectly drained profile supporting a good black spruce stand is shown below:

Horizon	Description
LFH	Usually a mor humus form, approximately 10 to 15 cm thick; composed predominantly of feather moss and needles; pH approximately 4.5
Aegj	Generally a platy, ashy horizon. However, in some cases organic matter is washed in from the LFH to give it a dark colour. Approximately 20 cm thick and mottling is generally present. The platiness is usually not as pronounced as the moderately well drained equivalent. Loamy sand to sandy loam textures; pH approximately 4.8.
Btgj	A brown to brownish grey coloured horizon which usually has a subangular blocky structure. This structure is not as well defined as in the moderately well or well drained equivalent. Thickness about 40 cm; mottling and/or gleying is present; pH approximately 6.0; texture ranges from sandy loam to clay loam.
Ckgj	A yellowish grey coloured horizon; lime content varies from very weak to strong; pH greater than 7.0; mottling and/or gleying is present; textures range from sandy loam to clay loam.

Black spruce has the best growth in this ecosystem (Photo 48). An average stand height of 15 to 17 m and higher is attained at the rotation age of 90 years. A single tree with exceptional growth measured 46 cm at breast height and 25 m tall at 140 years of age.

Photo 48. Excellent black spruce growth on an imperfectly drained, heavy textured soil.

The mean annual increment varies between 2.1 and 2.4 m^3 per hectare at the rotation age, and total yields reach 190 to 210 m^3 per hectare. Minor increased yields (approximately 20 m^3) can be expected at stand maturity of 100 to 120 years of age.

Due to the shallow root system, these stands are susceptible to windthrow, expecially when the surrounding areas are clear-cut.

Balsam poplar and white birch (with some willows) regenerate after clear-cutting, but do not hinder the regeneration of black spruce.

When harvesting is restricted to the type itself, the abundant seed and shade from bordering mother stands provide for natural regeneration. Light scalping and exposure of mineral soil hasten regeneration (Photo 49). Forest fires do the same, but the sprouting of white birch, balsam poplar and shrubs is also hastened. Regardless of artificial or natural disturbances, this ecosystem is fairly stable.

Photo 49. Scalping clear-cut strips promotes good black spruce regeneration.

5.5 POORLY DRAINED SERIES

Only black and white spruce and tamarack species generate commercial stands under these growing conditions.

The soils, commonly found in depressional areas, are saturated for a considerable period of the growing season, and are usually characterized by a shallow (0 to 40 cm) layer of peat at the surface. They are classified in the Gleysolic Order.

Logging and site preparation for reforestation can only be carried out when the ground is frozen.

5.5.1 PICEA GLAUCA-EQUISETUM ECOSYSTEM
(White Spruce-Horsetail Type)

Stands in this ecosystem usually occupy fairly flat areas or gradual slopes which encircle less productive lowlands (Photo 50). Its stand composition can be described as (6wS 3bS 1tL+bF+bPo).

Photo 50. White spruce growing on a poorly drained site along a sedge meadow.

The understory vegetation of this ecosystem is an association of *Equisetum* sp., *Carex* sp. (sedges) and *Calamagrostis canadensis* (marsh reed grass). The layer of *Equisetum* is a combination of *Equisetum arvense* (common horsetail) and *E. palustre* (meadow horsetail). Moss ground cover is sparse. Other species commonly found on these sites include *Orchis rotundifolia* (round-leaved orchid), *Circaea alpina* (enchanter's nightshade) and *Alnus tenuifolia* (river alder).

Due to the shorter black spruce and tamarack component, the average height of the tree canopy seldom exceeds 15 m. The mean annual increment is between 1.4 and 1.7 m^3 per hectare at the rotation age between 80 and 85 years. Yield at the same age is between 100 and 140 m^3 per hectare. At stand maturity (about 130 years) the yield increases to 145 m^3 per hectare. As a result of their small diameters, these trees are best suited for pulpwood. Clear-cutting is the suggested harvesting practice. Due to wetness, scarification is limited to frozen ground conditions. Site treatment and planting should be carried out soon after harvest, otherwise shrubs and grasses will take over.

5.5.2 PICEA MARIANA-PLEUROZIUM/HYLOCOMIUM ECOSYSTEM
(Black Spruce-Feather Moss Type)

Although these stands tend to become relatively open, and the trees limby (Photo 51), they still meet present commercial utilization requirements.

A feather moss carpet comprised of *Pleurozium schreberi*, and *Hylocomium splendens* (stair step moss) combined with a *Ledum groenlandicum* (Labrador tea) shrub layer is a typical vegetation strata. Other species found on these sites include *Vaccinium vitis-idaea* (bog cranberry), *Pyrola virens* (greenish-flowered wintergreen). *Pyrola secunda* (one-sided wintergreen), *Moneses uniflora* (one-flowered wintergreen), *Smilacina trifolia* (three-leaved solomon's-seal), *Mitella nuda* (bishop's-cap) and *Equisetum arvense* (common horsetail).

These black spruce stands have only a minor tamarack, white spruce and white birch component. At the rotation age of 120 years they attain an average height of 11 m, with a mean annual increment of 0.9 m^3 per hectare and yields of 95 to 110 m^3. At maturity (120-130 years), the yield increases to 120 m^3 per hectare. Clear-cutting in narrow strips with no further silvicultural treatment, has shown to be of benefit for natural regeneration. Scalping the fibric peat layer has shown favourable results for natural regeneration. Following a fire, the return of black spruce is a normal trend. In general, this ecosystem is considered a permanent type, as no other commercial or pioneer species is capable of invading and maintaining these sites even for the first rotation.

Photo 51. Black spruce on poorly drained mineral soil.

A typical poorly drained soil profile supporting a black spruce stand is shown below.

Horizon	Description
Of,Om,Oh	An accumulation of organic matter, comprised of feather moss and woody material. The degree of decomposition is variable. Thickness about 20 cm; pH approximately 5.2
Cg	Mineral soil has not been affected by the soil forming process. Prominent gleying and/or mottling is evident. Water table usually present in this substratum; pH approximately 7.0; organic matter may be washed into or interspersed in the upper part of the mineral soil.

Table 26. Chemical and physical analysis of a poorly drained profile supporting a black spruce stand near Fishing Lakes (analysis by W.K. Janzen, 1968)

Horizon	Depth (cm)	Particle Size Distribution (Percent): Coarse & Med. Sand	Fine Sand	Very Fine Sand	Total Silt	Total Clay	pH	Organic Matter N (Percent)	$NaHCO_3$-P ppm	Cation Ex. Cap. MEQ/100gm
L (Of)	22.9-17.8	—	—	—	—	—	5.5	0.50	100.0	53.1
F (Om)	17.8- 7.6	—	—	—	—	—	5.4	1.03	107.5	96.4
H (Oh)	7.6- 0	—	—	—	—	—	6.5	0.71	9.0	100.8
Cg1	0 -17.8	56.0	28.9	7.7	3.7	3.4	7.2	—	10.0	9.8
Cg2	17.8-35.6	63.6	26.7	5.0	2.4	2.2	7.3	—	13.5	7.4
Cg3	35.6-50.8	46.0	33.2	11.6	5.5	3.5	7.3	—	15.0	9.9
Cg4	50.8-61.0	50.1	22.1	13.8	8.9	4.9	7.3	—	9.5	18.0
Cg5	61.0-71.1	53.3	21.1	12.0	7.6	5.7	7.2	—	10.0	22.5
Cg6	71.1-83.8	49.7	22.1	14.9	9.3	3.8	7.3	—	7.0	13.8
Cg7	83.8+	65.5	24.4	10.0	25.9	—	7.4	—	8.5	4.9

5.5.3 LARIX/PICEA MARIANA-LEDUM/PLEUROZIUM ECOSYSTEM (Tamarack/Black Spruce-Labrador Tea/Feather Moss Type)

This ecosystem contains about equal proportions of tamarack and black spruce, whereas at the next successional stage (Black Spruce-Feather Moss Type) tamarack is only a minor component. Within this ecosystem, both major species (tL and bS) generally have fair growth (Photo 52). At the rotation age of 90 years, these stands have a mean annual increment of 1.4 m^3 per hectare, and yields reach about 125 m^3 per hectare. At stand maturity, approximately 135 years of age, the yield increases to 140 m^3 per hectare.

Photo 52. Tamarack - Black Spruce type.

It is interesting to note that two species with different light requirements are growing so well together. Generally, they are the same age, or occasionally the larch is older. This is partially due to the fact that, following a fire, larch regenerates more quickly and has a better height increment. Black spruce, apparently does not suffer from this advancement of larch, neither in its reproduction, nor in a later stage of growth. This tolerant growth of two tree species suggests the desirable course for stand management; selective logging of tamarack for posts or rails will favour black spruce growth. A similar response can be expected in patch and narrow strip-cutting. Larger clear-cut areas, and especially fires, will assure the dominance of larch in the next rotation.

Ground vegetation in this ecosystem is characterized by a mixed association of *Ledum groenlandicum* (Labrador tea) and *Pleurozium schreberi*. A variety of other plants including *Cornus canadensis* (bunchberry), *Vaccinium vitis-idaea* (bog cranberry), *Rhamnus alnifolia* (Buckthorn) and *Carex* spp. (sedges) are also present. A scattering of *Betula pumila* (swamp birch) is found on most of these sites. All of the sites examined had an open canopy - a closed canopy would likely result in a greater predominance of *Pleurozium schreberi.*

5.6 VERY POORLY DRAINED SERIES

Declining growth and impoverished growing conditions characterize this series. Black spruce and tamarack are the only species that are able to form marginal commercial stands under these harsh conditions. The soil remains saturated and tree roots rely on the upper organic strata for food and support. Pockets of frozen soil can be found in mid-summer, and early fall frost is a common phenomen of these low-lying areas, leaving a very short growing season for trees and other plants.

Soils in this category are commonly classified in the Gleysolic or Organic Orders. The Gleysolics are similar to those in the poorly drained moisture regime, except that the groundwater table is closer to the surface and usually within the overlying organic matter. The Organic soils are developed from plant remains. The dominant constituents within the Organic profile determine the classification of lowland areas.

The topography on which very poorly drained soils occur is generally level or depressional.

Artificial reforestation within this series is economically unfeasible at the present time.

5.6.1 PICEA MARIANA-LEDUM/CAREX ECOSYSTEM (Black Spruce-Labrador Tea/Sedge Type)

Forest stands are semi-open and marginal for commercial utilization (Photo 53). On better sites they seldom exceed 11 m in height at the rotation age of 130 years. The mean annual increment at rotation age is between 0.7 and 0.8 m^3 per hectare per year and total yields are between 90 and 100 m^3 per hectare. As most of the stems are of insufficient length for two 2.44 m bolts of pulpwood (with the upper diameter of 7.6 cm inside bark), these stands are often by-passed in the present-day wood operations. Lowering of present merchantability standards would include them in commercial pulpwood operations.

Ground vegetation is characterized by a *Ledum groenlandicum (Labrador tea*) (Photo 54), *Carex* spp. (sedges), *Vaccinium vitis-idaea* (bog cranberry), *Pleurozium schreberi* association. *Sphagnum* spp. occurs on these sites in small amounts, but are mainly restricted to the wettest phases.

Other species indicative of the wet environment inlude *Smilacina trifolia* (three-leaved solomon's seal), *Gaultheria hispidula* (creeping snowberry), *Rubus chamaemorus* (cloudberry) and *Potentilla fruiticosa* (shrubby cinquefoil).

A more open tree canopy correlates with a greater diversity of vascular plants. Species which prefer an open canopy include *Drosera rotundifolia* (round-leaved sundew) and *Cinna latifolia* (wood reed).

Photo 53. Black spruce on a very poorly drained site.

Photo 54. Labrador Tea - typical understory vegetation of very poorly drained semi-open black spruce stands.

5.6.2 PICEA MARIANA-LEDUM/SPHAGNUM ECOSYSTEM
(Black Spruce-Labrador Tea/Sphagnum Moss Type)

Forest stands on deep peaty (organic) soils are marginally merchantable, forming a typical "muskeg" type, sometimes associated with tamarack (Photo 55). In the forest land capability survey, this land was rated as non-productive, with a mean annual increment less than 0.7 m^3 per hectare. These stands have an average yield of 80 m^3 per hectare, and a mean annual increment of 0.6m^3 per hectare at a rotation age of 135-145 years.

Photo 55. Black spruce on deep organic soil.

Photo 56. Good regeneration of black spruce on deep organic soil following a fire.

Ground vegetation is dominated by *Sphagnum* moss with some feather moss also present. The feather mosses are primarily *Pleurozium schreberi* and *Hylocomium splendens* (stair step moss) with the species of *Sphagnum* moss being primarily *Sphagnum nemorum* and *S. fuscum* with some *S. angustifolium* and *S. russowii*. Other mosses on these sites include *Tomenthypnum nitens, Aulacomnium palustre* and *Polytrichum commune*. This moss layer combines with a *Ledum groenlandicum* (Labrador tea) shrub layer to form a *Ledum groenlandicum-Sphagnum fuscum/nemorum* association. Other common species include *Smilacina trifolia* (three-leaved solomon's-seal), *Vaccinium vitis-idaea* (bog cranberry), *Geocaulon lividum* (northern comandra), *Rubus chamaemorus* (cloudberry), *Drosera rotundifolia* (round-leaved sundew), *Cladonia rangiferina, Coptis trifolia* (goldthread), *Mitella nuda* (bishop's-cap), and *Gaultheria hispidula* (creeping snowberry).

This and the previous Black Spruce-Labrador Tea/Sedge type occupy approximately 16,000 km^2 in the Mixedwood Section. They are marginally productive sites for wood fibre, but may become well-favoured in the Christmas Tree industry.

Perpetuation of black spruce is achieved partly by seeding and layering. The most effective agent for regeneration has been, and still is, fire (Photo 56). Loose, flaky bark, very low tree crowns and arboreal and ground lichens create a fire hazard in black spruce stands within this and poorly drained sites. From an ecological point of view, this ecosystem and the Black Spruce-Labrador Tea type are both stable ecosystems.

5.6.3 LARIX-CAREX/SPHAGNUM ECOSYSTEM (Tamarack-Sedge/Sphagnum Type)

Tamarack stands in this ecosystem have better growth and higher yields than those of the Tamarack-Sedge type. Forest stands reach adequate densities, often being too dense at an early age. Tamarack grows very rapidly for 40 to 50 years, but beyond that age, the growth rate is reduced considerably. The mean annual increment is 0.8 m^3 per hectare at the rotation age of 100 years, while total yields are from 75 to 85 m^3 per hectare (Photo 57). These yields warrant commercial utilization for fence material and pulpwood; however, primary use is restricted mainly to rails and fence posts, with the slower growing "red" tamarack being preferred because of its durability. Reluctance to use tamarack for pulpwood is a result of its different chipping and delignification properties.

Photo 57. A well stocked stand of tamarack on sedge-'Sphagnum' peat.

Adequate restocking on these sites occurs only after fires or clear-cutting.

Tamarack is very intolerant to shade, not even being able to regenerate effectively under its own canopy. A seedling count on one hundred and ten 4.05 m^2 sample plots in 1967 and 1975 (8 years) illustrates this very well, with the following survival:

Tamarack	9.1 percent
White spruce	25.9 percent
Black spruce	84.5 percent

The most serious enemy of the tamarack is the leaf-eating larch sawfly (*Pristiphora erichosonii* Hartig), a species introduced from Europe. Periodically its populations reach epidemic proportions, resulting in defoliation of tamarack stands. Another natural mortality factor is flooding. Tamarack can withstand high water levels for short periods of time, but prolonged flooding results in mortality. Examples of this were the wet summers of 1974 and 1975, which resulted in the dying of extensive areas of tamarack.

Understory vegetation of this type is characterized by a *Carex-Sphagnum* association. *Carex aquatilis* is the dominant *Carex* and the *Sphagnum* spp. are mainly *S. fuscum* and *S. nemorum*. These sites have lesser amounts of other species typical of wet sites, including *Caltha palustris* (marsh marigold), *Glyceria borealis* (small floating manna grass), *Eriophorum* spp. (cottongrass) and *Scirpus* spp. (bulrush).

A description of a very poorly drained organic profile supporting a tamarack stand is given below:

Horizon	Description
Of	Approximately 12 cm thick; composed predominantly of sphagnum and feather mosses. Labrador Tea, sedge and woody material are also present. Water seepage within 0.1 m of the surface; pH approximately 4.8.
Oh	12+ cm thick; a well decomposed peat; pH approximately 5.3.

Table 27. Chemical and physical analysis of a very poorly drained profile supporting a tamarack stand near Sled Lake (analysis by W.K. Janzen, 1968)

		Particle Size Distribution (Percent)									
Horizon	Depth (cm)	Coarse & Med. Sand	Fine Sand	Very Fine Sand	Total Silt	Total Clay	pH	Organic Matter N (Percent)	NO_3-N ppm	$NaHCO_3$-P ppm	Cation Ex. Cap. MEQ/100gm
Of	0 - 10.2	—	—	—	—	—	5.0	1.41	22.0	66.0	132.8
Oh1	10.2- 15.2	—	—	—	—	—	7.0	2.08	10.0	31.5	236.4
Oh2	15.2- 35.6	—	—	—	—	—	6.6	2.06	6.0	15.0	226.0
Oh3	35.6- 53.3	—	—	—	—	—	6.2	2.12	4.0	6.0	224.0
Oh4	53.3- 71.1	—	—	—	—	—	5.9	—	4.0	2.0	229.0
Oh5	71.1- 88.9	—	—	—	—	—	6.2	—	10.0	3.5	199.0
Oh6	88.9-101.6	—	—	—	—	—	6.0	—	6.0	3.5	196.5
Oh7	101.6-127.0	—	—	—	—	—	5.7	—	4.0	0.5	184.5
Cg	127.0+	7.9	15.2	19.5	38.0	19.4	5.8	—	1.0	6.0	24.3

5.6.4 LARIX-CAREX ECOSYSTEM
(Tamarack-Sedge Type)

Tamarack is the first tree species to inhabit very poorly drained organic soils, being preceded by aquatic plants, sedge/grass, and dwarf birch. It is tolerant of cold and wet soils. These soils are occasionally frozen until mid-July.

Altough of no commercial value to forestry, the wildlife and water conservation aspects of this ecosystem are of importance. This type is the first step in the establishment of forest cover. In the long term, the system is transitional, but in terms of one or two rotations it may be looked upon as a stable unit.

A portion of trees reach merchantable size (10.2 cm D.B.H. and 9 to 10 m in height) at a prolonged rotation of 130 years or more (Photo 58). The mean annual increment is 0.5 m^3 and less per hectare per year, and yields are about 50-60 m^3 per hectare. This type of land presently is considered non-productive.

Photo 58. Tamarack and black spruce on a very poorly drained site.

This site is characterized by the dominance of graminoid vegetation. Both grass and sedge vegetation form the dominant, or either may occasionally be found singly as a dominant. The sedge is primarily *Carex aquatilis* (water sedge), and the grass is *Calamagrostis inexpansa/ neglecta* (northern reed grass). On some sites *Betula pumila* var.*glandulifera* (swamp birch) forms a tall shrub layer in addition to the graminoids.

CHAPTER 6

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 MANAGEMENT NEEDS

1. Forest management should become synonymous with land management.
2. Prior to any harvesting operation, an understanding of the existing ecosystem and its management implications including potential productivity, logging and reforestation alternatives is required.
3. Accelerated reforestaion and supplementary stocking of forest stands are necessary. Presently, there are approximately 511,000 ha of denuded productive forest land, and about 106,000 ha of young and immature forest land without adequate stocking in the Mixedwood Section.
4. Reforestation within an ecological concept enables a fairly accurate prediction of the future stand. The appropriate combination of species and site is a prerequisite for successful artificial regeneration.
5. Prescribed burning, involving standby crews and equipment during periods of low fire hazard, would be especially beneficial on some productive sites which have reverted to brushland.
6. Stand improvement carried out with an understanding of site potential will yield maximum benefits.

6.2 RESEARCH NEEDS

1. A continuous growth and yield survey is essential for furthering knowledge about stand characteristics and growth patterns.
2. Forest soil and land capability surveys should be continued.
3. A lack of meteorological data in forested areas obscures the relevance of climate in growth studies. Additional meteorological stations operated on a yearly basis are required.
4. A study to determine the carrying capacity, as well as the compatibility of grazing with timber production is essential for multiple land-use management.
5. The study concerning leave strips along roads, lakes and streams should be continued, with particular attention paid to forest stands occurring in areas subject to natural hazards.
6. Juvenile stand treatment and stand improvement trials should be continued.
7. Maximum productivity and successful silviculture can be achieved only through a thorough and complete knowledge of forest ecology. Therefore, ecological research should receive adequate consideration along with other forestry exercises.

APPENDIX I

Trees Native to the Mixwood Section in Saskatchewan

Common Names	Botanical Names	Tree Symbol
Softwoods:		
White Spruce	*Picea glauca* (Moench) Voss	wS
Black Spruce	*Picea mariana* (Mill.) B.S.P.	bS
Jack Pine	*Pinus banksiana* Lamb	jP
Balsam Fir	*Abies balsamea* (L.) Mill	bF
Tamarack	*Larix laricina* (Du Roi) Koch	tL
Hardwoods:		
Trembling Aspen	*Populus tremuloides* Michx.	tA
Balsam Poplar	*Populus balsamifera* L.	bPo
White Birch	*Betula papyrifera* Marsh.	wB
Green Ash	*Fraxinus pennsylvanica* Marsh.	gAs
Manitoba Maple	*Acer negundo* L. var *interius* (Britton) Sarg.	mM
White Elm	*Ulmus americana* L.	wE

APPENDIX II

Mean Annual Increment, Rotation and Average Height of Forest Stands in Relation to their Site Quality

Species Association	Mean Annual Increment[1]							Rotation[2]							Average Height[3]						
	Site Quality																				
	I+	I	II+	II	II-	III	III-	I+	I	II+	II	II-	III	III-	I+	I	II+	II	II-	III	III-
White Spruce	5.0+	4.3	3.8	3.1	2.6	2.0	0.7-	65	70	70	75	75	80	95	25+	24	22	20	17	16	13-
Black Spruce	2.4+	2.0	1.7	1.4	1.1	0.8	0.5-	75	90	95	100	110	120	135	17+	15	14	13	14	11	10-
Jack Pine	3.2+	2.7	2.4	2.0	1.6	1.3	0.8-	60	65	65	70	75	80	90	22+	21	19	18	15	13	12-
Tamarack				0.8							100							12			
Mixedwood (Spruce-Aspen)	4.5+	4.1	3.6	3.1	2.5	2.6	1.0-	65	70	70	75	75	80	90	24+	23	22	20	18	17	15-
Mixedwood (Aspen-Spruce)	4.1+	3.7	3.3	2.9	2.4	2.0	1.3-	60	65	65	70	75	80	85	24+	23	21	20	19	18	16-
Mixedwood (Jack Pine-Aspen)	3.5+	2.9	2.5	2.2	1.8	1.5	1.1-	60	65	65	70	75	80	85	23+	21	20	19	17	15	14-
Mixedwood (Aspen-Jack Pine)	3.6+	3.3	2.9	2.6	2.2	1.8	1.3-	60	60	65	70	75	80	85	23+	21	20	20	18	16	18-
Hardwood (Aspen)	3.9+	3.5	3.1	2.8	2.4	2.0	1.5-	60	60	65	70	75	80	85	23+	22	21	21	20	19	17-

1. Mean Annual Increment (M.A.I. in cubic metres per ha) — the total growth until the rotation age, divided by the rotation age.
2. Rotation — the period of years required to establish and grow a timber crop to a specified condition (product); in this case, the maximum wood production of merchantable volume in trees greater than 9.1 cm D.B.H. (o.b.).
3. Average Height — average height (in metres) of dominant and co-dominant trees at the rotation age.

APPENDIX III

Ecosystem Summary

Forest Ecosystem	Drainage	Soil Texture	Understory Vegetation	Site Quality	Rotation Age	M.A.I. (m^3)	Yields (m^3/ha) At Rotation	Yields (m^3/ha) At Maturity	Fire Hazard Rating[1]
Pinus-Cladonia/Arctostaphylos	Very Rapid-Rapid	Coarse	Lichen Low shrub	III	80	0.9	65	90	7/7/8/8
Picea glauca-Agropyron/Arctostaphylos	Very Rapid-Rapid	Coarse	Medium grass Low shrub	III	90	1.4	110	140	2/2/5/4
Populus-Rosa/Elymus	Very Rapid-Rapid	Coarse	Tall shrub	III	80	1.3	100	140	1/1/8/1
Picea glauca/Populus-Corylus	Very Rapid-Rapid	Coarse	Tall Shrub	III	80	1.8	140	175	2/2/4/2
Pinus-Vaccinium vitis-idaea/Pleurozium	Well	Moderately coarse	Low shrub	II	70	2.0	135	180	6/6/6/5
Picea glauca-Pleurozium	Well	Moderately fine	Feather moss	II	75	3.1	225	280	4/4/4/4
Populus-Corylus	Well	Moderately fine	Tall shrub Medium grass	II	70	2.8	185	210	1/1/8/1
Picea glauca/Populus-Cornus	Well	Moderately fine	Low herb	II	75	3.1	210	240	2/2/4/2
Pinus-Pleurozium/Lycopodium	Moderately well	Moderately fine	Feather moss Low herb	I	65	2.9	180	265	6/5/5/3
Picea glauca-Pleurozium	Moderately well	Fine	Feather moss	I	70	4.5	315	455	4/4/4/4
Populus-Aralia/Linnaea	Moderately well	Moderately fine	Medium herb Low shrub	I	60	3.7	225	315	1/1/8/1
Picea glauca/Populus-Cornus/Mitella	Moderately well	Fine	Low herb	I	65	4.3	285	330	2/2/4/2
Picea mariana-Pleurozium/Hylocomium	Moderately well	Moderately fine	Feather moss	I	100	1.4	140	150	9/9/6/6
Pinus/Picea mariana-Pleurozium	Imperfect	Moderately fine	Feather moss	II	75	1.6	120	140	9/9/7/7
Picea glauca/Populus-Cornus/Rubus	Imperfect	Fine	Low herb	II	75	2.4	195	210	2/2/4/2
Picea mariana-Pleurozium/Ptilium	Imperfect	Moderately fine	Feather moss	I	90	2.3	200	220	9/9/6/6
Picea glauca-Equisetum	Poor	Moderately fine	Medium herb	III	85	1.6	120	145	3/3/2/2
Picea mariana-Pleurozium/Hylocomium	Poor	Moderately fine	Feather moss	III	120	0.9	110	120	9/9/7/7
Larix/Picea mariana-Ledum/Pleurozium	Poor	Moderately fine	Tall shrub Feather moss	III	90	1.4	125	140	7/7/8/8
Picea mariana-Ledum/Carex	Very poor	Organic	Medium shrub Tall grass	III	130	0.7	90	—	9/9/7/7
Picea Marina-Ledum/Sphagnum	Very poor	Organic	Medium shrub Sphagnum moss	III	135	0.6	80	—	9/9/7/7
Larix-Carex/Sphagnum	Very poor	Organic	Tall grass Sphagnum moss	III	100	0.8	80	—	2/1/6/1
Larix-Carex	Very poor	Organic	Tall grass	III	130	0.5	65	—	2/1/5/1

1. Fire hazard ratings based on a scale from 1 to 10; one (1) being very low and ten (10) being very high. The numerical description refers to the following: crown fire (cured dormant stage) / crown fire (active growing stage) / surface fire (cured dormant stage)/surface fire (active growing stage).

APPENDIX IV

Site-Specific Reforestation Recommendations

Ecosystem	Stand Composition	Recommended Species[1]	Reforestation
Pinus-Cladonia/Arctostaphylos (jP-Lichen/ Bearberry)	Softwood -jP: 10 jP	jP	Natural regeneration after scarification. Mechanical or hand planting without scarification.
Picea Glauca-Agropyron/ Arctostaphylos (wS-Wheat Grass/Bearberry)	Softwood-wS: 10wS+tA	jP	Scarification in seed years for maintenance of white spruce. Mechanical or hand planting without scarification if jack pine is to be introduced.
Populus-Rosa/Elymus (tA-Rose/Rye Grass)	Hardwood-tA: 10tA+jP+wS+wB	jP	Mechanical planting without scarification. Scarification and hand planting.
Picea Glauca/Populus-Corylus (wS/tA-Hazelnut)	Mixedwood- (wS-tA):	jP	Mechanical planting without scarification. Scarification and hand planting.
Pinus-Vacc.Vitis-Idaea/ Pleur. (jP-Bog Cranberry/Feather Moss)	Softwood-jP: 9jP 1tA+wB+wS+bS	jP	Scarification assures good jack pine regeneration.
Picea Glauca-Pleurozium (wS-Feather Moss)	Softwood-wS: 8wS 1 (tA-bPo) 1 (jP--bS-bF)+wB	wS, (jP)	Scarification in seed years. Scarification and hand planting at other times.
Populus-Corylus (tA-Hazelnut)	Hardwood-tA: 8tA 1wS 1bPo+bS+jP+bF+wB	tA,wS, (jP)	Adequate aspen regeneration after clear-cutting. Scarification and hand planting if softwoods are to be introduced.
Picea Glauca/Populus-Cornus (wS/tA-Bunchberry)	Mixedwood- (wS-tA): 2wS 1 (bS-jP-bF) 6tA 1 (bPo-wB)OR 6wS 4tA+bS+bPo+wB+bF	wS,tA, (jP)	Adequate aspen regeneration after clear-cutting. Scarification and hand planting if softwoods are to be introduced.
Pinus-Pleur./Lycopodium (jP-Feather Moss/Club Moss)	Softwood-jP: 7jP3 (tA-wS-bS)+bPo+wB	jP, (wS)	Scarification assures good jack pine regeneration.

APPENDIX IV. continued

Ecosystem	Stand Composition	Recommended Species[1]	Reforestation
Picea Glauca-Pleur. (wS-Feather Moss)	Softwood-wS: 8wS 2 (bPo-tA-bF-wB-bS)	wS, (jP)	Scarification in seed years. Scarification and hand planting at other times.
Populus-Aralia/Linnaea (tA-Sarsaparilla/Twin-flower)	Hardwood-tA	wS,tA, (jP)	Adequate aspen regeneration after clear-cutting. Scarification and hand planting if softwoods are to be introduced.
Picea Glauca/Populus-Cornus/Mitella (wS/tA-Bunchberry/Bishop's-Cap)	Mixedwood-(tA-wS)	wS,tA, (jP)	Adequate aspen regeneration after clear-cutting. Scarification and hand planting softwoods.
Picea Mariana-Pleur./Hylocomium (bS-Feather Moss)	Softwood-bS: 10bS+tL	wS, bS, (jP)	Scarification assists regeneration. Scarification and hand planting.
Pinus/Picea Mariana-Pleur. (jP/bS-Feather Moss)	Softwood-(jP-bS)	jP, (bS)	Scarification assures good regeneration.
Picea Glauca/Populus-Cornus/Rubus (wS/tA-Bunchberry/Dewberry)	Mixedwood-(wS-tA)	wS, (bS)	Scarification and hand planting.
Picea Mariana-Pleur./Ptilium (bS-Feather Moss)	Softwood-bS: 10bS	bS, (wS)	Scarification. Scarification and hand planting.
Picea Glauca-Equisetum (wS-Horsetail)	Softwood-wS: 6wS 3bS 1tL+bF+bPo	bS, (wS)	Scarification when soil is frozen and hand planting.
Picea Mariana-Pleur./Hylocomium (bS-Feather Moss)	Softwood-bS: 10bS+tL+wS+wB	bS, (tL)	Scarification when soil is frozen.

APPENDIX IV. continued

Ecosystem	Stand Composition	Recommended Species[1]	Reforestation
Larix/Picea Mariana -Ledum/Pleur. (tL/bS-LabradorTea/Feather Moss)	Softwood-(bS-tL): 5tL5bS	bS,tL	Scarification when soil is frozen.
Picea Mariana-Ledum/ Carex (bS-Labrador Tea/ Sedge)	Softwood-bS	bS,tL	Natural regeneration.
Picea Mariana-Ledum/ Sphagnum (bS-Labrador Tea /Sphagnum Moss)	Softwood-bS	bS,tL	Natural regeneration.
Larix/Carex/Sphagnum (tL-Sedge/Sphagnum Moss)	Softwood-tL	tL,bS	Natural regeneration.
Larix-Carex (Tamarack-Sedge)	Softwood-tL	tL,bS	Natural regeneration.

1. Most productive and ecologically site-specific species.

APPENDIX V

Botanical and Common Names of Plant Species Encountered in the Survey

A. Pteridophytes and Spermatophytes (Vascular Plants)

Botrychium virgianum (L.) Sw.	Grape Fern
Cystopteris fragilis (L.) Bernh.	Fragile Fern
Dryopteris cristata (L.) A. Gray	Crested Shield Fern
Dryopteris spinulosa (Muell.) Watt	Narrow Spinulose Shield Fern
Gymnocarpium dryopteris (L.) Newn.	Oak Fern
Matteuccia struthiopteris (L.) Todaro	Ostrich Fern
Equisetum arvense L.	Common or Field Horsetail
Equisetum hyemale L.	Scouring Rush
Equisetum palustre L.	Marsh or Meadow Horsetail
Equisetum scirpoides Michx.	Dwarf Scouring Rush
Equisetum sylvaticum L.	Woodland Horsetail
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
Abies balsamea (L.) Mill.	Balsam Fir
Juniperus communis L.	Ground Juniper
Larix laricina (Du Roi) K. Koch	Tamarack
Picea glauca (Moench) Voss	White Spruce
Picea mariana (Mill.) BSP	Black Spruce
Pinus banksiana Lamb	Jack Pine
Agropyron subsecundum (Link) Hitch.	Bearded Wheatgrass
Agropyron trachycaulum (Link) Malte	Slender Wheatgrass
Agropyron trachycaulum var *glaucum* (Pease & Moore) Malte	
Bromus anomalus Rupr.	Nodding Brome
Bromus ciliatus L.	Fringed Brome
Bromus pumpellianus Scribn.	Northern Awnless Brome
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint; Marsh Reed Grass
Calamagrostis inexpansa A. Gray	Northern Reed Grass
Cinna latifolia (Trev.) Griseb.	Drooping Wood Reed
Elymus canadensis L.	Canada Wild Rye
Elymus innovatus Beal	Hairy Wild Rye
Festuca saximontana Rydb.	Rocky Mountain Fescue
Festuca scabrella Torr.	Rough Fescue
Glyceria borealis (Nash) Batchelder	Small Floating Manna Grass
Koeleria cristata (L.) Pers.	June Grass
Oryzopsis asperifolia Michx.	Rice-grass
Oryzopsis pungens (Torr.) Hitchc.	Rice-grass
Poa glauca Vahl	Meadow-grass
Poa interior Rydb.	Inland Blue Grass
Schizachne purpurascens (Torr.) Swallen	False Melic
Stipa richardsonii Link	Richardson Needle Grass
Carex aquatilis Wahl.	Water Sedge
Carex brunnescens (Pers.) Poir	Brownish Sedge
Carex disperma Dewey	Soft-leaved Sedge
Carex gynocrates Wormsk.	Northern Bog Sedge
Carex leptalea Wahl.	Bristle-stalked Sedge
Carex richardsonii R.Br.	Richardson's Sedge
Carex siccata Dewey	Dry-spike Sedge
Carex vaginata Tausch	Sheated Sedge
Eriophorum sp.	Cottongrass
Scirpus sp.	Bulrush
Disporum trachycarpum (S. Watts.) B & H.	Fairy Bells
Lilium philadephicum L.	Western Wood Lily
Maianthemum canadense Desf.	Wild Lily-of-the-Valley; Two-leaved Solomon's-seal
Smilacina stellata (L.) Desf.	Star-flowered Solomon's-seal
Smilacina trifolia (L.) Desf.	Three-leaved Solomon's-seal
Streptopus amplexifolius (L.) DC.	Twisted-stalk
Calypso bulbosa (L.) Oakes	Venus'-slipper

APPENDIX V. continued

Corallorhiza maculata Raf.	Spotted Coral-root
Corallorhiza striata Lindl.	Striped Coral-root
Corallorhiza trifida Chatelain	Pale Coral-root
Cypripedium acaule Ait.	Stemless Lady's-slipper
Goodyera repens (L.) R.Br.	Rattlesnake Plantain
Habenaria hyperborea (L.) R.Br.	Northern Green Bog Orchid
Habenaria obtusata (Pursh) Richards.	Blunt-leaved Bog Orchid
Habenaria orbiculata (Pursgh) Torr.	Round-leaved Bog Orchid
Listera borealis Morong	Northern Twayblade
Orchis rotundifolia Banks	Round-leaved Orchid
Spiranthes romanzoffiana Cham. & Schl.	Ladies'-tresses
Populus balsamifera L.	Balsam Poplar
Populus tremuloides Michx.	Trembling Aspen
Alnus crispa (Ait.) Pursch	Green Alder
Alnus tenuifolia Nutt.	River Alder
Betula glandulosa Michx.	Dwarf Birch
Betula papyrifera Marsh.	White, Paper or Canoe Birch
Betula pumila L.	Swamp Birch
Corylus cornuta Marsh.	Beaked Hazelnut
Comandra pallida A. DC.	Pale Comandra
Geocaulon lividum (Richards.) Fern.	Northern Comandra
Arceuthobium americanum Nutt.	Dwarf Mistletoe
Actaea rubra (Ait.) Willd.	Red and White Baneberry
Anemone canadensis L.	Canada Anemone
Caltha palustris L.	Marsh Marigold
Coptis trifolia (L.) Salisb.	Goldthread
Ranunculus abortivus L.	Kidney-leaved Buttercup
Thalictrum venulosum Trel.	Veiny Meadow Rue
Drosera rotundifolia L.	Round-leaved Sundew
Mitella nuda L.	Bishop's-cap; Mitrewort
Ribes americanum Mill.	Wild Black Currant
Ribes glandulosum Grauer	Skunk Currant
Ribes hirtellum Michx.	Wild Gooseberry
Ribes hudsonianum Richards.	Wild Black Currant
Ribes lacustre (Pers.) Poir.	Bristly Black Currant
Ribes oxyacanthoides	Wild Gooseberry
Ribes triste Pall.	Wild Red Currant
Amelanchier alnifolia Nutt.	Saskatoon-berry
Fragaria vesca L.	Woodland Strawberry
Fragaria virginianum Duchesne	Wild Strawberry
Geum macrophyllum Willd.	Yellow Avens
Potentilla fruticosa L.	Shrubby Cinquefoil
Prunus pensylvanica L.f.	Pin Cherry
Rosa acicularis Lindl.	Prickly Rose
Rosa woodsii Lindl.	Commond Wild Rose: Wood's Rose
Rubus acaulis Michx.	Dwarf Raspberry
Rubus chamaemorus L.	Cloudberry, Baked-apple Berry
Rubus idaeus L.	Raspberry
Rubus pubescens Raf.	Dewberry, Running Raspberry
Rubus strigosus Michx.	Wild Red Raspberry
Sorbus decora (Sarg.) Schneider	Mountain-ash
Lathyrus ochroleucus Hook.	Cream-coloured Vetchling
Lathyrus palustris L.	Marsh Vetchling
Vicia americana Muhl.	Wild Vetch
Linum lewisii Pursh	Wild Blue Flax
Acer negundo L.	Manitoba Maple; Box Elder
Rhamnus alnifolia L'Her.	Buckthorn
Viola adunca J.E. Smith	Early Blue Violet
Viola nephrophila Greene	Northern Bog Violet
Viola renifolia A. Gray	Kidney-leaved Violet
Viola rugulosa Greene	Western Canada Violet
Viola selkirkii Pursh	Great Spurred Violet
Shepherdia canadensis (L.) Nutt.	Canadian Buffalo-berry
Circaea alpina L.	Enchanter's Nightshade
Epilobium angustifolium L.	Fireweed; Great Willow-herb
Aralia nudicaulis L.	Wild Sarsaparilla

APPENDIX V. continued

Cornus canadensis L.	Bunchberry
Comus stolonifera Michx.	Red Osler Dogwood
Moneses uniflora (L.) A. Gray	One-flowered Wintergreen
Pyrola asarifolia Michx.	Common Pink Wintergreen
Pyrola minor L.	Lesser Wintergreen
Pyrola secunda L.	One-sided Wintergreen
Pyrola virens Schweigg.	Greenish-flowered Wintergreen
Monotropa uniflora L.	Indian-pipe
Arctostaphylos uva-ursi (L.) Spreng.	Common Bearberry
Chamaedaphne calyculata (L.) Moench	Leather-leaf
Gaultheria hispidula (L.) Bigel.	Creeping Snowberry
Kalmia polifolia Wang.	Bog Rosemary
Ledum groenlandicum Oeder	Common Labrador Tea
Oxycoccus microcarpus Turcz.	Small Bog Cranberry
Oxycoccus quadripetalus Gilib.	Bog Cranberry
Vaccinium myrtilloides Michx.	Blueberry
Vaccinium uliginosum L.	Bog Bilberry
Vaccinium vitis-idaea L.	Bog Cranberry
Trientalis borealis Raf.	Star-flower
Gentiana amarella L.	Felwort
Halenia deflexa (Sm.) Griseb.	Spurred Gentian
Apocynum androsaemifolium L.	Spreading Dogbane
Mertensia paniculata (Ait.) G. Don	Tall Mertensia
Mentha arvensis L.	Wild Mint
Melampyrum lineare Desr.	Cow-wheat
Galium boreale L.	Northern Bedstraw
Galium trifidum L.	Small Bedstraw
Galium triflorum Michx.	Sweet-scented Bedstraw
Linnaea borealis L.	Twin-flower
Lonicera dioica L. var *glaucescens* (Rydb.) Butters	Twining Honeysuckle
Lonicera involucrata (Richards.) Banks	Bracted Honeysuckle
Lonicera villosa (Michx.) R. & S.	Fly Honeysuckle
Sambucus pubens Michx.	Red Elder
Symphoricarpos albus (L.) Blake	Snowberry
Viburnum edule (Michx.) Raf.	Low-bush Cranberry
Viburnum trilobum Marsh	High-bush Cranberry
Campanula rotundifolia L.	Bluebell, Harebell
Achillea millefolium L.	Common Yarrow
Antennaria neglecta Greene	Everlasting
Aster ciliolatus Lindl.	Lindley's Aster
Aster conspicuus Lindl.	Showy Aster
Aster laevis L.	Smooth Aster
Hieracium canedense Michx.	Canada Hawkweed
Petasites frigidus (L.) Fries.	Vine-leaved Coltsfoot
Petasites palmatus (Ait.) A. Gray	Palmate-leaved Coltsfoot
Petasites sagittatus (Pursh) A. Gray	Arrow-leaved Coltsfoot
Solidago decumbens Greene	Mountain Goldenrod
Solidago hispida Muhl. var *lanata* (Hook.) Fern.	Hairy Goldenrod
Taraxacum officinale Weber	Common Dandelion

B **Bryophytes (Liverworts and Mosses)**

Mylia anomala (Hook) S.F. Gray
Plagiochila asplenioides (L.) Dum.
Ptilidium ciliare (L.) Hampe
Ptilidium pulcherrimum (Wed.) Hamp.
Calyopgeia sp.
Blassia pusilla L.
Conocephalum conicum (L.) Dum.
Sphagnum angustifolium (Russ.) C. Jens
Sphagnum capillaceum (Weiss) Schrank
Sphagnum fuscum (Schimp). Klinggr.
Sphagnum russowii Warnst.

APPENDIX V. continued

Ceratodon purpureus (Hedw.) Brid.	
Dicranum polysetum Sw.	
Dicranum undulatum Bird.	
Funaria hygrometrica Brid	Cord Moss
Bryum lisae De Not var *cuspidatum* (B.S.G.) Marg.	
Bryum pseudotriquetrum (Heds.) Gaertn. (Meyer & Scherb.)	
Leptobrym pyriforme (Hedw.) Wils.	
Pholia nutans (Hedw.) Lindb.	
Mnium spinulosum B.S.G.	Red-mounted Mnium
Plagiomnium cuspidatum (Hedw.) Kop.	Woodsy Mnium
Plagiomnium drummondii (Bruch & Schimp.) Kop.	
Aulacomnium palustre (Hedw.) Schwaeger.	
Climacium dendroides (Hedw.) Web. & Mohr	Tree Moss
Thuidium recognitum (Hedw.) Lindb.	Fern Moss
Calliergon giganteum (Schimp.) Lindb.	
Campylium stellatum (Hedw.) C. Jens	
Drepanocladus unicnatus (Hedw.) Warnst.	
Drepanocladus vernicosus (Lindb. *ex* C. Hartm.) Warnst.	
Leptodictyum trichopodium (Schultz) Warnst.	
Brachythecium acuminatum (Hedw.) Aust.	
Brachythecium salebrosum (Web & Mohr) B.S.G.	
Eurhynchium pulchellum (Hedw.) Jenn.	
Tomenthypnum nitens (Hedw.) Loeske	
Pleurozium schreberi (Brid.) Mitt.	
Ptilium crista-castrensis (Hedw.) De Not	Knight's Plume
Hylocomium spendens (Hedw.) B.S.G.	Star Step Moss
Tetraphis pellucida Hedw.	
Polytrichum commune Hedw.	Common Hair Cap Moss
Polytrichum juniperinum Hedw.	Juniper Moss

C. **Lichens**

Peltigera aphthosa (L.) Wild.
Peltigera canina (L.) Wild.
Peltigera malacea (Ach.) Funck
Cladonia alpestris (L.) Rabh.
Cladonia amaurocraea (Florke) Schaer.
Cladonia chlorophaea (Florke) Spreng.
Cladonia coccifera (L.) Willd.
Cladonia cornuta (L.) Hoffm.
Cladonia cristatella Tuck.
Cladonia deformis (L.) Hoffm.
Cladonia fimbriata (L.) Fr.
Cladonia gracilis (L.) Willd. var *dilatata* (Hoffm.) Van
Cladonia mitis Sandst.
Cladonia phyllophora Hoffm.
Cladonia rangiferina (L.) Wigg.
Stereocaulon sp.
Icmadophila ericetorum Zahlbr.

APPENDIX VI

(After Bowen, 1974)

Selected Metric (SI and Derived) Units and Ratios, Their Symbols and Uses for Canadian Forestry

Unit or Ratio	Symbol	Measurement Use
centimetre	cm	Diameter of single trees Average diameter of trees in stands Diameter of logs, bolts and poles
cubic metre	m^3	Volume of single trees, stands of trees, logs, wood products and liquids
cubic metre per hectare*	m^3/ha**	Volume of stands of trees per unit area
cubic metre per hectare per year	$m^3/(ha \bullet a)$***	Current, mean, and periodic annual increments (c.a.i., m.a.i., and p.a.i.) of stands of trees per unit area
gram	g	Mass (weight) of trees, branches, fertilizers, etc.
hectare*	ha	Area of land (instead of the acre)
kilogram	kg	Mass (weight) of trees, branches, fertilizers, etc.
kilometre	km	Distance (instead of the mile)
litre****	l or ℓ	Volume of liquids
metre	m	Height of single trees Distance (instead of the foot or chain) Average height of stands of trees Length of logs, bolts, poles and lumber
millimetre	mm	Length of panels Width and thickness of lumber and panels
square centimetre	cm^2	Area (instead of the square inch)
square kilometre	km^2	Area (instead of the square mile)
square metre	m^2	Area (instead of the square foot) Basal area of single trees and stands of trees Quadrats (area of reproduction and other vegetation)
square metre per hectare	m^2/ha	Basal area of stands of trees per unit area of land
stacked cubic metre	m^3 (stacked)	Volume of stacked wood (instead of the cord)
stacked cubic metre per hectare	m^3 (stacked)/ ha	Stacked volume of wood per unit area
tonne*****	t	Mass (weight) of wood, etc.
tonne per hectare	t/ha	Mass (weight) of wood, etc. per unit area

* *Although the hectare (ha) is not an SI unit, it is to be used with the International System of Units for a limited time. One hectare =10 000 square metres (m^2).*

** *Ratios of this type may also be expressed as $m^3 \bullet ha^{-1}$.*

*** *This ratio may also be expressed as $m^3 \bullet ha^{-1}/a$ or $m^3 \bullet ha^{-1} \bullet a^{-1}$ but not as m^3/ha/a.*

**** *Although the litre is not an SI unit and is not recommended for high-precision measurements, it is used with the International System as a special name for the cubic decimetre (dm^3). Its symbol is l or ℓ. The script "ℓ" or the word "litre" written out out in full is also recommended when confusion might result from the use of the lower case l (ell) for the numeral 1 in typewritten documents. One litre = 0.001 cubic metre (m^3) = 1 cubic decimetre (dm^3).*

***** *Although the tonne (t) is not an SI unit, it is used with the International System of Units. It is not to be taken as the French interpretation of the short ton of 2,000 pounds. One tonne = 1 000 kilograms.*

APPENDIX VI. continued

Yard/Pound Units		SI Equivalent
Length		
1 chain (22 yd)	=	20.116 8 m (exactly)
1 foot	=	0.340 8 m (exactly)
1 inch	=	2.54 cm (exactly)
1 mile	=	1.609 34 km
1 yard	=	0.914 4 m (exactly)
Area		
1 acre	=	0.404 686 ha
1 mil-acre	=	4.046 86 m^2
1 square foot	=	0.092 903 0 m^2
1 square inch	=	6.451 6 cm^2 (exactly)
1 square mile	=	2.589 99 km^2
1 square yard	=	0.836 127 m^2
Volume or Capacity		
1 cord (128 stacked ft^3)	=	3.624 56 m^3 (stacked)
1 cubic foot	=	0.028 316 8 m^3
1 cubic yard	=	0.764 555 m^3
1 cunit (100 ft^3 of solid wood)	=	2.831 68 m^3
1 gallon	=	4.546 09 *l* (exactly)
Mass or Weight		
1 ounce (avoirdupois)	=	28.349 5 g
1 pound (avoirdupois)	=	0.453 592 kg
1 ton (2,000 lb)	=	0.907 185 t
Ratios		
1 cord per acre	=	8.956 47 m^3 (stacked)/ha
1 cubic foot per acre	=	0.069 972 5 m^3/ha
1 mile per gallon	=	0.354 006 km/*l*
1 pound per cubic foot	=	16.018 5 kg/m^3
1 square foot per acre	=	0.229 568 m^2/ha
1 ton (2,000 lb) per acre	=	2.241 70 t/ha

APPENDIX VI. continued

SI Units	Yard/Pound Equivalents
Length	
1 cm (centimetre)	= 0.393 701 inch
1 km (kilometre)	= 0.621 371 mile
1 m (metre)	= 0.049 709 7 chain (of 22 yd)
1 m (metre)	= 3.280 84 feet
1 m (metre)	= 1.093 61 yards
Area	
1 cm^2 (square centimetre)	= 0.155 000 square inch
1 ha (hectare)	= 2.471 05 acres
1 km^2 (square kilometre)	= 0.386 102 square mile
1 m^2 (square metre)	= 0.247 105 mil-acre
1 m^2 (square metre)	= 10.763 9 square feet
1 m^2 (square metre)	= 1.195 99 square yards
Volume or Capacity	
1 *l* (litre)	= 0.219 969 gallon
1 m^3 (cubic metre)	= 35.314 7 cubic feet
1 m^3 (cubic metre)	= 1.307 95 cubic yards
1 m^3 (cubic metre)	= 0.353 147 cunit (of 100 ft^3 of solid wood)
1 m^3 (stacked) (stacked cubic metre)	= 0.275 896 cord (of 128 stacked ft^3)
Mass or Weight	
1 g (gram)	= 0.035 274 0 ounce (avoirdupois)
1 kg (kilogram)	= 2.204 62 pounds (avoirdupois)
1 t (tonne)	= 1.102 31 tons (of 2,000 lb)
Ratios	
1kg/m^3 (kilogram per cubic metre)	= 0.062 428 0 pound per cubic foot
1 km/*l* (kilometre per litre)	= 2.824 81 miles per gallon
1 m^2/ha (square metre per hectare)	= 4.356 00 square feet per acre
1 m^3/ha (cubic metre per hectare)	= 14.291 3 cubic feet per acre
1 m^3 (stacked)/ha, (stacked cubic metre per hectare)	= 0.111 651 cord per acre
1 t/ha tonne (per hectare)	= 0.446 090 ton (of 2,000 lb) per acre

GLOSSARY

Arboreal	Attached to or growing on trees.
A.R.D.A.	Agricultural Rehabilitation and Development Act.
Bryophyte	Mosses and Liverworts combined.
Cation Exchange Capacity	Refers to the ability of soils to retain plant nutrients.
Chroma	A colour notation which indicates its strength (or departure from a neutral of the same lightness). Munsell Color Company, Inc., 1954.
D.B.H.	The diameter of a tree at breast height (1.3 m above the highest ground level). Suffixes o.b. and i.b. designate an outside bark or inside bark measurement.
Ecosystem	A general term for ecological systems of any size comprising biota and environment in interaction.
Feather Moss	A common name generally applied to a group of mosses, namely *Pleurozium schreberi, Hylocomium splendens* and *Ptilium crista-castrensis.* It may refer to these species individually or as a group.
Fibric Moss Peat	Slightly decomposed peat which is derived from mosses.
Forest Ecosystem	A landscape ecosystem characterized by cover type, minor vegetation, soil and drainage.
Forest Land	Land area dedicated primarily for timber production. — Productive: land which will produce a forest crop of merchantable size and form within a reasonable period of time. — Non-productive: land incapable of producing a forest crop of merchantable size within a reasonable period of time. This category of land includes treed and open muskegs, treed and bare rocks, marshes and land under roads.
Forest Stand	— Overstocked: a condition of overcrowding in a stand, leading to retarded growth. — Well stocked: a forest sand in which all growing space is effectively occupied without tree growth suppression. — Inadequately stocked: a forest stand of intermediate density between well and understocked stands. — Understocked: a stand in which the growing space is not effectively occupied by trees.
Fruitcose	Referring to the shrublike growth form of lichens.
Glacial Drift	Material transported and redeposited as a result of glaciation.
Gleying	A chemical alteration of soil constituents induced by impeded drainage. Visually, the soil profile exhibits a dull bluish or gray colour. Mottling is generally evident in gleyed soils.
Graminoid	Grasslike vegetation including both Grasses and Sedges.
Herbaceous	Having the characters of a herb as opposed to woody.
Landscape Ecosystem	A geographic (earth space) ecosystem such as a forest, defined by characterstic features of vegetation, soil and landform.
Maturity	The age at which a forest stand no longer increases in volume. That is, stand mortality equals the current annual increment.
Mixed Peat	Peat which may be in various stages of decomposition and/or of variable origin.
Mottling	A chemical alteration of soil constituents induced by impeded drainage. Visually, the soil profile exhibits bright colours in a blotchy or spotty pattern.
Outwash	Gravels and sands deposited by glacial meltwater.
Resorted Glacial Till	Glacial till modified by water.

Rotation	The period of years required to establish and grow timber crops to a specific size for harvesting.
Site	An area considered in an ecological perspective with reference to its capacity for vegetation production. It encompasses the combination of biotic, climatic and physiographic conditions of an area.
Site Index	A single quantitative (numerical) expression of the multitude of environmental factors that make up site quality.
Soil Horizon	A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as colour, texture and chemical composition including organic matter content and degree of alkalinity or acidity (Christiansen et al., 1975).
Soil Profile	A vertical section for soil which displays all its horizons and its parent material. (Christiansen et al., 1975).
Stand and Stock Table	A summary table of number of trees by species and their volume distribution by diameter classes for a given area; in this case, for one hectare.
Succession	The replacement of one plant community by another.
Value	A colour which indicates lightness (Munsell Colour Company, Inc. 1954).

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