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SOIL AND MINOR VEGETATION OF PINE FORESTS IN SOUTHEAST MANITOBA

by
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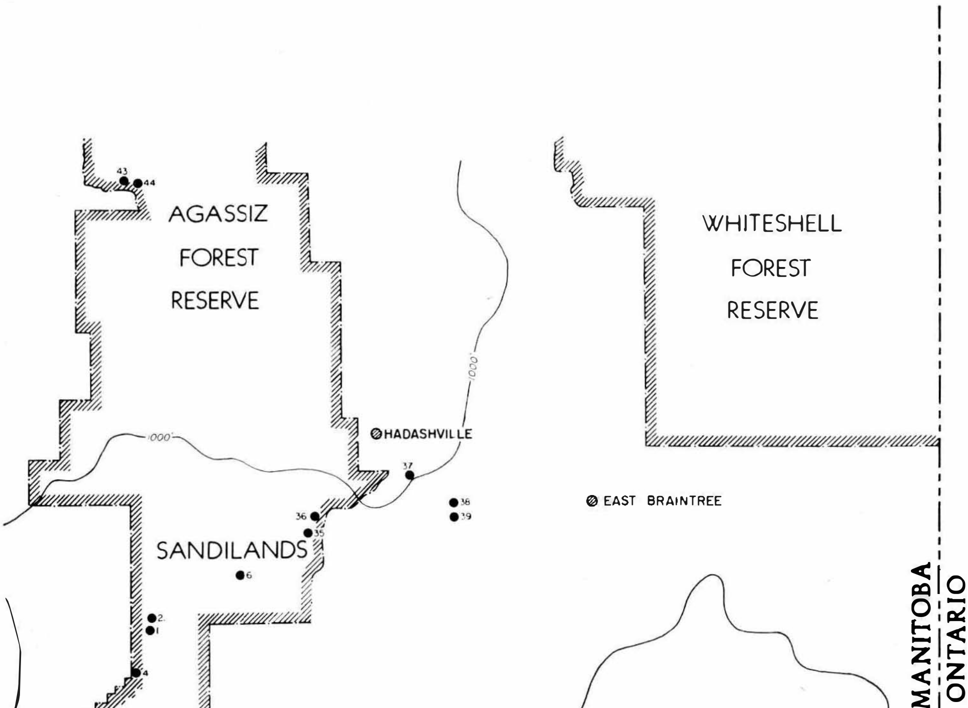

FIGURE 1. Map of the study area, showing location of the pine stands (numbered solid dots), the three main contours (1,000, 1,100 and 1,200 feet), and the approximate boundaries of the Forest Reserves.

Soil and Minor Vegetation of Pine Forests in Southeast Manitoba

by

J. C. Ritchie*

INTRODUCTION

This report deals with part of a broader investigation of forest sites carried out during the summer of 1958 in southeast Manitoba. The intention was to examine relationships between landforms, soil types and forest vegetation, and to attempt to establish at least preliminary categories of forest site. Also it was hoped that some understanding might be gained of forest succession relationships of the region. Thirty of the stands examined in detail were of pine, and of these 26 were pure jack pine (*Pinus banksiana*), and four had mixtures of jack pine and red pine (*P. resinosa*). The approximate locations of the pine stands are shown on Figure 1.

The data on pine sites, presented here in condensed form, is believed to be representative of the region under study. In scope, this paper attempts no more than to describe the range of soils on which pine stands are found in the southeast, to give an account of the minor vegetation, and to provide some preliminary data on the performance of trees in relation to site.

In the Manitoba Forest Resources Inventory Report No. 1, on the South-eastern Forest Section, accounts of the climate, geology and topography of the area can be found. Little need be added, except to refer to the work of Elson (1957) on the surficial geology of southern Manitoba. His findings indicate that the early Mankato ice from the northwest left an extensive upland of calcareous moraine in southeast Manitoba, and that later ice — the late Mankato—from the northeast deposited siliceous material, mainly outwash, on it. Lowland areas, occupied by Lakes Agassiz I and II, show various strandlines, wave-cut terraces and lacustrine deposits. As a result, the soils of the area are highly varied, their exact nature depending upon both physical and chemical attributes of the transported materials.

Almost all the forest vegetation of this southeast section of Manitoba is secondary, the result of extensive disturbance by fire and felling. A few generalizations are offered here to illustrate the relationship between the pine stands and other vegetation. Jack pine predominates on the sandy upland above 1,100 feet altitude, and elsewhere on strandlines and sandy outwash. At lower altitudes the ground water table is found near the surface in summer and there are abrupt transitions to gley soils with a cap of peat bearing black spruce stands. Deeper, wetter peats are occupied by *Larix*, and locally there are extensive string-bogs. This zonation is characteristic on outwash sands, mainly along the northern fringe of the upland area. In the southern parts of the Sandilands Forest Reserve the substratum is often of finer texture, and sandy loams or clay loams bear secondary stands of aspen (*Populus tremuloides*), with white spruce (*Picea glauca*), eastern cedar (*Thuja occidentalis*) and jack pine. The soils are of a grey-wooded type. On areas of poor drainage, black spruce with aspen and stands of black spruce with cedar are common, although here as elsewhere the peats are occupied by black spruce and larch. The upland soils of the Northwest Angle Forest Reserve are largely clay loams of the grey-wooded type, bearing extensive stands of white birch (*Betula papyrifera*) and

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aspen. There is considerable evidence that at the end of last century these substrata bore good forests of white pine (*Pinus strobus*), probably with lesser amounts of white spruce and balsam fir (*Abies balsamea*). Wetter sites are occupied by cedar stands, or by black spruce and larch. In this part of the area, jack pine is not common, being confined to sporadic sandy beaches and outwash.

FIELD PROCEDURE

With the help of local forestry officers, the oldest and least disturbed stands available were chosen. Here it should be made clear that the forests of the entire southeast part of Manitoba have been influenced by frequent fires, and mature stands are fragmentary and rare. This imposes a severe limitation on field procedures and often throws in question the reliability or representativeness of the findings. One-tenth acre square plots were set up, one in each stand, after a cursory examination of the soil and minor vegetation. Care was taken to avoid any obvious changes in soil conditions and/or minor vegetation, although in a few special cases plots were deliberately placed across suspected gradients of soil conditions to explore further any possible trends. Heights and diameters of all trees in each plot were determined, and ages of trees from different diameter classes were recorded from cores taken at breast height. Ground vegetation was recorded as to composition and quantity—the latter from 25 irregularly scattered meter-square quadrats in which cover and abundance were estimated according to the following scales:

Cover	Abundance
1—covering less than 5% of the ground	1—very rare, occurring as single plants
2—from 6 to 25%	2—rare, only a few individuals
3—from 26 to 50%	3—infrequent
4—from 51 to 75%	4—fairly frequent in the sample area
5—from 76 to 100%	5—abundant throughout the sample area

The scales provide some estimate, arbitrarily assigned, of the dispersion of species. For example, a cover-abundance value of 4.1 would indicate that although the species in question occupied a large part of the area of the quadrat, it was represented by only one or two individuals; that is, it had a clumped dispersion. A species with a value of 2.5 would indicate a thinly scattered or widespread dispersion. These are not precise determinations of dispersion, and the term is not used here in the narrower, statistical sense. Relative abundance of the low, medium and tall shrub layers was recorded by visual estimates of the whole plot, using the abundance scale as above.

In each tenth-acre plot at least one soil pit was dug and a formal description made of the profile. Samples were taken from selected pits for textural and certain chemical analyses. Colour was ascertained from dry samples with the Munsell Colour Chart. Reaction of the horizons was determined in the field, using a Beckman "Pocket" pH Meter—an instrument equipped with a combination glass electrode. The accuracy of this instrument was checked periodically by laboratory tests against a "Cambridge" pH Meter, and it was found to be satisfactory. The presence and relative abundance of calcareous material in the soil was estimated by testing with dilute hydrochloric acid.

The soil terminology is essentially that of Wilde (1957). Weakly podzolized sands can be equated approximately with "minimal podzol" as used by the Manitoba Soil Survey in the field in 1959. Likewise, their "orthic podzol" is similar to the sandy podzol and podzolic sand of this report. There is little doubt that the soils described here as grey-wooded will be further subdivided by the Soil Survey, since they have recognized various "double profiles" or bisequa types, with a podzol profile developing in the upper part of a grey-wooded soil.

The results of this work are summarized in the following pages, under the headings of soil, minor vegetation, tree data, and conclusions. The author

wishes to record his thanks to Mr. J. P. Brisbois for excellent assistance in the field, to Mr. J. H. Cayford who gave freely of his time and knowledge of the area in locating stands and discussing problems, and to Mr. A. J. Kotowycz for suggesting suitable stands in the southern part of the area.

SOILS

A complete account of the soils of this area must await the results of current surveys by the Manitoba Soil Survey. The present account is based on the examination of about 30 profiles, all under pine. A complex range of soil conditions was found, and the following appear to be the four main variables:

1. Drainage: varying from excessively drained to poorly drained with a high ground water table.
2. Texture: most of the soils under pine are sandy, but a range from coarse gravelly sands to clay loams and clays was found.
3. Nature of the parent material: the complex glacial geology of this area has resulted in a diversity of parent materials, lacustrine material, sorted outwash sands (usually siliceous), morainic generally unsorted sands (usually calcareous), sand-mantled clays and loams, and deep aeolian sands.
4. The degree of podzolization: a range from melanized sands to sandy gley podzols.

Based primarily on the last criterion, six main types of profiles can be recognized in the region. They are: 1. Melanized sands (MS), 2. Weakly podzolized sands (WPS), 3. Podzolic sands (PS), 4. Sandy podzols (SP), 5. Sandy gley podzols (SGP), and 6. Grey-wooded (GW).

1. **Melanized sands** (3 plots). In general, but not invariably, these are found on level outwash or in regions of dunes. The sand is usually siliceous with only small amounts of calcareous material. In most cases the soils are excessively drained with no evidence of a ground water table at levels as deep as 8 to 10 feet. The characteristics of the profile are a substantial A_1 horizon with incorporated humus and an absence of leached and conspicuous depositional horizons. The following description of a particular profile is representative of this type:

Stand 22		*Location: Bedger, Township 3, Range 12, Section 15*
F	0 – ½″	Black, loose, fibrous humus; pH 4.9
A_1	½″ – 7″	Dark brown, fine sand with humus; pH 5.3
C_1	7″ – 24″	Light brown, fine sand; pH 6.0 at 1.0′
C_2	24″ – 72″	Stratified parent material; bands of fine and coarse sands alternating with calcareous gravel. pH 7.6 in sands, 8.0 in gravels

2. **Weakly podzolized sands** (7 plots). These soils are usually freely drained, coarse to fine sands, often siliceous. There is faint visual evidence of leaching, with weak A_2 and B horizons. The following profile illustrates the type.

Stand 43		*Agassiz Forest Reserve—Township 10, Range 10*
F	0 – 1″	Loose, fibrous dry humus with litter cap; dark brown (10 YR 4/3); pH 5.3
H-A_1	1″ – 2″	Amorphous, slightly spongy when damp, with mineral particles; black (10 YR 2/1); pH 5.4
A_2	2″ – 5″	Dry, coarse sand with a few small stones; yellowish brown (10 YR 5/6); pH 5.6
B_1	5″ – 13″	Coarse sand, locally slightly compacted; yellowish brown (10 YR 5/6); pH 5.3
B_2	13″ – 22″	Coarse gravelly sand; strong brown (7.5 YR 5/6); pH 5.9

C_1	22″ – 35″	Pale grey, coarse to medium sand with small stones; very pale brown (10 YR 7/4); pH 6.4
C_1	35″ +	Coarse sand with calcareous stones, gravel below; mild HCl reaction; light brownish grey (10 YR 6/2); pH 6.9

3. **Podzolic sands** (2 plots). These are characterized by well-developed podzolic horizons, with some evidence of cementing in the illuvial layers. Usually they are well drained with no evidence of ground water table influence. The parent material is mildly calcareous or siliceous, never strongly calcareous. The profile described below is typical.

Stand 27		*Location: Moose Lake, Township 4, Range 17, Section 5*
A_0	0 – 2″	Loose, fibrous, slightly woody humus merging quickly into black amorphous humus and then into the A_1; abundant mycelia; dark yellowish brown (10 YR 3/4); pH 4.6
A_1	2″ – 2½″	Fine sand, texture even; dark brown (7.5 YR 4/2); pH 4.9
A_2	2½″ – 7″	Fine sand, merging into B at 0.5′ level; grey brown (10 YR 5/2); pH 5.6
B_1	7″ – 13″	Fine, even textured sand; yellowish red (5 YR 5/6); pH 5.3
B_2	13″ – 29″	Slightly cemented and brittle, fine to medium sand; yellowish red (5 YR 5/6); pH 5.6
C	from 29″	Fine sand, non-stratified, a few small calcareous pebbles. No HCl reaction; lt. br. grey (10 YR 6/2); pH 7.2

4. **Sandy podzol** (5 plots). These soils are found in varied drainage conditions but they are related closely to the sandy gley podzols. Typically, there is a well-developed A_2 horizon and a compact, brittle, red-brown depositional horizon (B_2). Often the summer ground water table is at the bottom of the solum and evidence of mild gleying is present in a few profiles. The parent material is usually siliceous or a mixture of siliceous and calcareous materials.

Stand 26		*Moose Lake, Township 3, Range 16, Section 25*
FH	0 – 1″	Loose fibrous, somewhat woody humus grading quickly into black, amorphous humus; black (7.5 YR 2/0 above, 10 YR 2/0 below); pH 5.3
A_1	1″ – 2½″	Fine sand with incorporated humus; dark grey (7.5 YR 4/0); pH 5.4
A_2	2½″ – 5″	Fine sand, grey-brown (10 YR 5/2); pH 5.0
B_1	5″ – 20″	Even texture, medium sand, mottled reddish brown, (10 YR 4/4); (dark yellowish brown) pH 5.8
B_2	20″ – 24″	Slightly cemented, medium-coarse sand, mottled slightly, yellowish red (5 YR 5/8); pH 6.1
C	from 24″	Even colour and texture, fine sand, wet at 4.5′ with water table at 5.5′. Black banding at 5′. A narrow layer of calcareous gravel at 3.5′, showing mild reaction with HCl. Light grey brown (10 YR 6/2); pH 7.0

5. **Sandy gley podzols** (2 plots). These soils are developed in sands with a high ground water table (at 3.5′ to 6′ in summer). The profile is characterized by a strongly leached A_2 horizon and a strongly mottled lower section of the solum. (Closely related are several soils described in this study as sandy podzols with high water tables and only moderate mottling of the lower horizons; in all cases these are of the deep gley type, with the gleyed horizon at depths greater than four feet.)

Stand 36		*Location: Dawson Road, Township 7, Range 11, Section 34*
F	0 – 2″	Abundantly mycelial, fibrous humus; dark reddish brown (5 YR 3/2); pH 5.7
H	2″ – 4″	Amorphous, fine humus; black (10 YR 2/1); pH 5.8
A_2	4″ – 8″	Clearly differentiated, fine sandy silt, grading into BG; light grey (10 YR 7/1); pH 6.0
BG	8″ – 43″	Heavily mottled, wet medium sand; yellowish red mottling and light grey (5 YR 5/6 to 10 YR 7/1); pH 7.8. Water table at 3.3′

6. **Grey-wooded** (6 plots). The main characteristics of these soils are highly calcareous parent materials, a well-developed B horizon with heavy, often clay texture, and a distinct leached (A_2) horizon. Most show advanced podzolization with a rapid reversal of soil reaction from very acid in the A horizons to strongly basic in the B and C layers.

Stand 13	*Location: Near Vassar, Township 2, Range 12, Section 2*
F 0 – 1″	Fibrous humus with abundant mycelia; brown (10 YR 4/3); pH 4.30
H (A_1) 1″ – 2″	Fine sand and incorporated humus; dark brown (10 YR 4/2); pH 4.50
A_2 2″ – 5″	Sandy loam; pale grey (10 YR 6/1); pH 4.90
B_1 5″ – 13″	Even, structureless sandy loam; brown (10 YR 5/3); pH 6.20
B_2 13″ – 17″	Clay loam with small weathered calcareous stones and pebbles; mild HCl reaction; reddish brown (5 YR 4/3); pH 7.50
C from 17″	Loamy sand, calcareous (strong reaction with HCl). Light grey (10 YR 7/1), mottled with red and blue (incipient gleying); pH 8.20

MINOR VEGETATION

Field observations indicated, (1) that certain common species predominate on the driest sites and were more or less absent from the wettest sites, (2) that other common species occurred across the whole spectrum of soil conditions with varied changes in relative abundance, (3) that some species were not present in all stands, although they showed no apparent restriction to certain of the soils, and (4) that some uncommon species were too sporadic in occurrence to permit of any clear assessment of their place in any ordination.

The driest soils, especially the melanized sands and weakly podzolized sands, invariably supported large amounts of *Arctostaphylos uva-ursi*, a species which was rare or absent from sites with a high water table or impeded drainage. On the other hand, sandy gley podzols of the swamp border site bore a fairly uniform and characteristic minor vegetation in which *Cornus canadensis*, *Ledum groenlandicum* and *Rubus pubescens* were prominent. *Linnaea borealis* var. *americana* was absent from the driest sites but occurred consistently in the remaining three quarters of the moisture gradient.

In order to examine the relationships between soil and forest vegetation the plots were ordinated in a gradient based primarily on relative degree of apparent podzolization. As field studies indicated that soil moisture has a strong influence both on ground vegetation and the performance of jack pine trees on sandy soil, account was also taken of soil texture, drainage and position of ground water table in making the ordination. For example the soil of Stand 1 was a sandy podzol but it had a freely drained parent material with no detectable ground water table. In all other sandy podzols of this study (profiles 6, 7, 8 and 44) the ground water table was found in late summer at depths between 4 and 8 feet. Therefore, profile 1 was placed between the weakly podzolized sands and the podzolic sands. Profile 12 showed all the characteristics of a melanized sand but its underlying stratum (D horizon) was moist calcareous clay, and it was placed tentatively in the middle of the table. Thus, the order of the profiles, shown in Table 1, is based on an initial sorting into profile types with adjustments made in terms of drainage; note that site indices for jack pine show a general increase along the profile gradient.

TABLE 1.—SAMPLE PLOTS ARRANGED IN ORDER OF INCREASINGLY APPARENT PODZOLIZATION WITH ADJUSTMENTS ACCORDING TO PROFILE DRAINAGE.

Plot	Soil profile	Site index for pine based on the age/height relationship* of dominants
4	MS — Coarse siliceous sand with gravel	45
16	MS — Sandy loam; siliceous	47
22	MS — Sorted siliceous and calcareous gravels and sands	37
15	WPS — Coarse siliceous sand with some calcareous material	45
18	WPS — Coarse gravel—siliceous; shallow solum	39
2	WPS — Coarse gravel over fine calcareous sand	40
43	WPS — Coarse sand with some calcareous gravel	45
39	WPS — Coarse calcareous sand	47
23	WPS — Fine even siliceous silty sand	56
38	WPS — Calcareous sand	46
27	PS — Fine unsorted slightly calcareous sand	56
19	PS — Fine sand, ground water table at 10-11′	53
1	SP — Coarse, slightly calcareous sand	54
44	SP — Coarse morainic material; water table at 8′	50
8	SP — Medium sand, water table at 6′	55
6	SP — Coarse sand, water table at 4′	48
7	SP — Silt loam, water table at 4′	57
26	SGP — Fine sand, water table at 4′ to 5′	58
36	SGP — Medium sand, water table at 3.3′	52
14	GW — Calcareous sandy loam	43
21	GW — Mottled calcareous loamy sand	50
13	GW — Mottled calcareous loamy sand	50
17	GW — Mottled calcareous clay loam	50
35	GW — Wet clay, water table at 6′	53
37	GW — Incipient gleying from A_2 to C horizons	55

* From "Site index curves for jack pine in the Lake States". S.R. Gevorkiantz. Lake States Forest Experiment Station Tech. Note No. 463. 1956.

Table 2 shows cover, abundance and frequency values for the most important species of the ground vegetation arranged in parallel order to the soil ordination. It is clear that some plants are sensitive to changes in soil conditions and others are not. The best indicator species of the gradient from dry siliceous to very moist grey-wooded profiles are the following: *Arctostaphylos uva-ursi, Antennaria canadensis, Lithospermum canescens, Viola adunca, Potentilla tridentata, Linnaea borealis* var. *americana, Pteridium aquilinum* var. *latiusculum, Aralia nudicaulis, Rubus pubescens, Cornus canadensis, Epigaea repens* var. *glabrifolia, Vaccinium myrtilloides, Equisetum sylvaticum, Ledum groenlandicum,* and *Clintonia borealis.* Species which are common in most of the stands but which show no clear continuous variation in relative abundance along the soil gradient are: *Gaultheria procumbens, Vaccinium angustifolium, Oryzopsis asperifolia, Fragaria virginiana, Pleurozium schreberi, Dicranum rugosum, Maianthemum canadense, Chimaphila umbellata* var. *occidentalis,* and *Anemone quinquefolia.*

Certain small areas revealed rapid changes in general vegetation under the same tree cover, with no evidence of differential disturbance as by ground fires. At South Junction under a 50- to 55-year-old stand of jack pine, a rapid transition in ground vegetation was observed from an *Arctostaphylos*-dominated community at the bottom of a slight slope to a *Linnaea/Aralia/Diervilla* community lacking *Arctostaphylos* at the upper part. Over a distance of 100 feet the nature of the ground vegetation changed completely. Exploratory sampling with a soil auger indicated a rapid change in soil across this transition of ground vegetation. Two abutting tenth-acre plots (Stands 16 and 17) were set out so that the long axis of the rectangle they formed was at right angles to the suspected gradient. The composite plot was divided at right angles to the long axis into four sub-plots. In each sub-plot, 15 randomly placed metre-square quadrats

TABLE 2—COVER, ABUNDANCE AND FREQUENCY VALUES FOR THE MORE IMPORTANT SPECIES OF THE GROUND VEGETATION.
(The order of stands is as in Table 1.)

Stands	4	16	22	15	18	2	43	39	23	38	27	19	1	44	8	6	7	26	36	14	21	13	17	35	37
Soil Types	MS	MS	MS	WPS	WPS	WPS	WPS	WPS	WPS	WPS	PS	PS	SP	SP	SP	SP	SP	SGP	SGP	GW	GW	GW	GW	GW	GW
Arctostaphylos uva-ursi	3.6	1.5	1.5	1.0	1.0	1.7	1.1	1.1	1.0	1.0	1.0	1.3	2.0	1.0	1.0	....	....	....	....	1.1	1.0	....	....	1.0	....
	4.8	2.5	4.1	2.7	3.0	3.5	3.0	3.1	1.6	2.3	2.0	2.3	3.5	1.3	1.6	....	....	....	....	2.8	1.0	....	....	1.0	....
	100	100	100	100	80	100	100	96	48	48	4	12	24	32	24	....	....	....	....	76	12	....	....	4	....
Antennaria canadensis	1.0	....	1.0	1.0	1.0	1.0	1.0	....	1.0	1.0	....	....	....	1.0	1.0	....	....	....	....	....	....	....	....	....	....
	1.3	....	1.7	1.5	1.5	1.9	1.1	....	1.5	1.0	....	....	....	2.0	1.5	....	....	....	....	....	....	....	....	....	....
	12	....	44	52	32	24	28	....	8	9	....	....	....	60	8	....	....	....	....	....	....	....	....	....	....
Lithospermum canescens	1.0	1.0	1.0	1.0	1.0	1.0	....	....	....	....	....	1.0	....	....	....	....	....	....	....	1.0	....	....	....	....	....
	1.0	1.0	1.0	1.0	1.0	1.0	....	....	....	....	....	1.0	....	....	....	....	....	....	....	1.3	....	....	....	....	....
	4	17	34	16	4	8	....	....	....	....	....	12	....	....	....	....	....	....	....	32	....	....	....	....	....
Potentilla tridentata	....	....	....	....	....	1.0	1.0	1.0	....	....	....	....	1.0	1.0	....	1.0	....	....	....	....	....	....	....	1.0	....
	....	....	....	....	....	2.2	1.2	1.0	....	....	....	....	1.8	1.0	....	2.5	....	....	....	....	....	....	....	1.0	....
	....	....	....	....	....	88	20	60	....	....	....	....	48	4	....	8	....	....	....	....	....	....	....	4	....
Viola adunca	....	....	1.0	....	1.0	....	1.0	....	1.0	1.0	....	1.0	1.0	....	....	....	....	....	....	1.0	....	....	1.0	....	....
	....	....	1.0	....	1.0	....	1.0	....	1.0	1.0	....	1.0	1.0	....	....	....	....	....	....	1.5	....	....	1.0	....	....
	....	....	8	....	4	....	4	....	4	12	....	4	4	....	....	....	....	....	....	84	....	....	4	....	....
Linnaea borealis var. *americana*	....	....	....	....	....	1.0	1.0	1.0	1.4	1.2	1.0	1.0	2.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	....	....	....	....	....	1.8	2.2	3.0	3.5	2.2	2.2	2.1	2.1	2.5	2.5	2.7	3.2	2.4	3.0	2.1	2.2	2.1	3.3	2.4	2.3
	....	....	....	....	....	24	92	100	100	92	52	92	92	100	100	40	100	96	100	64	84	90	100	100	72
Pteridium aquilinum var. *latiusculum*	....	....	....	1.1	....	....	....	....	....	1.0	....	1.0	....	1.0	1.0	....	1.0	1.0	....	1.0	1.0	1.0	1.0	1.0	1.0
	....	....	....	1.0	....	....	....	....	2.6	1.4	....	1.2	....	2.0	1.5	....	3.0	3.3	....	1.0	1.0	2.0	1.0	3.3	1.0
	....	....	....	32	....	....	....	....	68	36	....	44	....	8	64	....	44	100	....	4	4	90	67	44	12
Aralia nudicaulis	....	....	....	....	....	....	....	1.0	....	....	....	1.0	....	....	....	1.0	....	1.0	....	1.0	....	....	1.0	....	1.0
	....	....	....	....	....	....	....	1.0	....	....	....	1.0	....	....	....	3.0	....	1.0	....	1.0	....	....	1.7	....	1.3
	....	....	....	....	....	....	....	8	....	....	....	4	....	....	....	4	....	4	....	4	....	....	8	....	24
Rubus pubescens	....	....	....	....	....	....	....	....	....	....	1.0	....	....	....	1.0	1.0	....	....	1.0	....	....	1.0	1.0	1.0	1.0
	....	....	....	....	....	....	....	....	....	....	1.0	....	....	....	1.5	2.0	....	....	1.3	....	....	2.1	1.5	1.5	1.6
	....	....	....	....	....	....	....	....	....	....	4	....	....	....	16	4	....	....	42	....	....	100	17	16	88
Cornus canadensis	....	....	....	....	....	....	....	....	....	....	....	1.0	....	1.0	1.0	1.0	2.3	1.3	1.6	....	1.0	1.0	....	1.6	2.0
	....	....	....	....	....	....	....	....	....	....	....	1.7	....	3.0	2.3	2.4	4.5	3.4	4.1	....	1.5	2.0	....	3.6	4.1
	....	....	....	....	....	....	....	....	....	....	....	52	....	96	12	76	100	96	88	....	16	80	....	100	100
Epigaea repens var. *glabrifolia*	....	....	....	....	....	....	....	....	....	....	....	....	1.4	1.0	....	1.5	1.0	....	1.0	....	....	....	1.0	1.0	1.0
	....	....	....	....	....	....	....	....	....	....	....	....	3.0	1.6	....	2.5	2.0	....	4.1	....	....	....	2.6	3.6	4.1
	....	....	....	....	....	....	....	....	....	....	....	....	32	36	....	8	8	....	88	....	....	....	58	100	100
Vaccinium myrtilloides	....	....	....	....	....	....	....	....	....	....	1.0	1.0	....	....	....	1.0	....	1.0	1.0	....	....	....	1.0	....	....
	....	....	....	....	....	....	....	....	....	....	1.3	1.3	....	....	....	2.0	....	1.0	1.0	....	....	....	2.0	....	....
	....	....	....	....	....	....	....	....	....	....	12	12	....	....	....	8	....	36	4	....	....	....	25	....	....

(Continued)

TABLE 2—COVER, ABUNDANCE AND FREQUENCY VALUES FOR THE MORE IMPORTANT SPECIES OF THE GROUND VEGETATION.
(The order of stands is as in Table 1.)

TABLE 2—(*Continued*)

Stands	4	16	22	15	18	2	43	39	23	38	27	19	1	44	8	6	7	26	36	14	21	13	17	35	37
Soil Types	MS	MS	MS	WPS	WPS	WPS	WPS	WPS	WPS	WPS	PS	PS	SP	SP	SP	SP	SP	SGP	SGP	GW	GW	GW	GW	GW	GW
Equisetum sylvaticum	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.0	.....	.....	.....	.....	1.0	1.0	1.0	.....	.....	.....	.....	.....	1.0
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.0	.....	.....	.....	.....	1.7	1.3	1.8	.....	.....	.....	.....	.....	1.0
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	36	48	44	.....	.....	.....	.....	.....	20
Ledum groenlandicum	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	1.3	1.0	1.2	.....	.....	1.0	.....	1.0	1.0
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.6	2.6	1.5	1.2	.....	.....	1.5	.....	2.0	3.0
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	76	44	28	16	.....	.....	20	.....	8	4
Clintonia borealis	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.0	1.0	.....	1.0	.....	.....	.....	.....	.....	1.2	1.0
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.0	1.0	.....	1.6	.....	.....	.....	.....	.....	2.7	1.0
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	4	.....	12	.....	.....	.....	.....	.....	16	4
Gaultheria procumbens	1.3	1.0	1.0	1.0	1.0	.....	1.0	1.0	1.0	1.0	.....	1.0	1.6	1.0	1.0	.....	1.0	.....	.....	1.0	1.0	.....	1.0	1.0	1.0
	3.3	3.7	1.5	2.3	2.0	.....	1.8	3.2	2.1	2.6	.....	2.1	3.5	2.5	2.5	.....	2.0	.....	.....	2.5	1.4	.....	2.0	2.4	1.6
	96	100	88	100	60	.....	84	100	96	96	.....	100	32	96	100	.....	88	.....	.....	96	44	.....	93	92	32
Vaccinium angustifolium	1.0	1.0	1.0	1.0	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.7	1.0	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2.8	2.6	1.1	1.9	1.8	3.0	2.8	1.6	1.6	1.5	1.0	1.1	3.8	2.0	2.9	1.1	2.8	1.2	1.0	1.8	1.0	1.5	1.0	1.7	1.0
	96	100	88	96	72	100	100	100	100	80	12	96	96	100	96	75	100	96	16	96	52	20	75	92	32
Oryzopsis asperifolia	1.1	1.0	1.0	1.0	1.0	1.2	1.0	1.0	1.0	1.4	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	3.2	2.3	2.5	2.8	2.5	3.2	1.8	3.0	1.6	4.1	1.0	3.1	3.2	1.8	2.4	2.0	1.9	2.1	1.5	2.5	2.7	2.8	2.5	1.7	1.3
	100	100	96	100	96	100	100	100	84	100	4	100	96	88	100	72	56	84	32	100	100	100	100	100	84
Fragaria virginiana	1.0	1.0	.....	1.0	1.0	1.0	1.0	1.0	.....	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2.5	1.0	.....	1.6	1.5	2.0	1.4	1.5	.....	2.5	1.0	1.8	3.5	1.0	2.0	2.4	1.7	1.4	3.0	1.7	1.2	2.1	2.3	1.9	3.4
	52	17	.....	24	40	60	60	100	.....	72	4	100	84	12	68	88	52	28	100	44	52	90	50	100	100
Pleurozium schreberi	1.1	1.0	1.6	1.1	1.0	1.7	1.3	1.2	1.2	1.1	2.7	1.0	4.7	1.0	1.7	3.2	1.1	1.3	1.4	1.0	1.0	1.0	1.0	1.0	1.0
	2.1	2.2	3.4	2.5	2.5	3.4	1.1	3.4	2.3	2.8	4.4	1.3	4.9	1.7	3.3	4.8	2.1	3.4	3.9	3.1	1.7	1.5	2.4	1.9	1.8
	28	100	96	92	84	100	92	100	80	100	100	64	100	96	100	100	24	100	100	96	72	20	100	56	96
Dicranum rugosum	1.0	1.0	1.0	1.0	1.0	1.4	1.2	1.0	1.0	1.0	1.1	.....	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	.....	1.0	1.0	1.0
	2.1	1.3	1.4	1.8	1.4	2.9	2.4	1.4	1.6	1.5	2.2	.....	2.7	1.8	2.1	2.6	1.7	1.7	1.1	1.8	1.1	.....	1.7	1.3	1.8
	28	93	88	88	68	88	76	88	44	88	88	.....	68	100	84	84	24	96	44	84	72	.....	33	56	96
Maianthemum canadense	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.8	1.4	1.3	2.0	1.1	2.3	1.1	1.1	2.0	1.3	1.1	2.0	2.0	1.1	2.5	2.0	2.3	2.4	1.0	1.1	2.3	1.5	1.7	1.1	1.1
	24	64	80	64	36	76	80	92	100	72	24	100	48	92	92	100	100	100	36	36	100	60	33	68	68
Chimaphila umbellata var. *occidentalis*	1.1	1.0	.....	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	.....	1.0	.....	1.0	1.0	.....	.....	.....	.....
	3.2	1.0	.....	1.8	1.0	3.0	1.0	1.5	1.0	1.2	2.6	1.2	3.0	1.0	1.6	1.0	.....	1.2	.....	1.0	1.2	.....	.....	.....	.....
	16	24	.....	20	12	4	8	12	20	16	100	32	68	4	12	8	.....	20	.....	4	20	.....	.....	.....	.....
Anemone quinquefolia	.....	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.....	.....	1.0
	.....	1.2	1.8	1.4	1.5	2.5	1.0	1.0	1.4	2.5	2.8	1.5	1.6	1.0	1.7	1.0	2.0	1.0	1.2	1.6	1.3	1.8	.....	.....	1.0
	.....	67	84	84	8	88	20	48	80	88	92	44	12	16	36	4	16	32	16	76	80	90	.....	.....	12

were recorded in the routine manner, and at each quadrat the soil was examined with an auger. Two soil pits were dug, one at the lower end of the transect and the other at the upper. The results of the vegetation analysis are presented in Table 3. Scrutiny of this table will make clear the obvious trends in the ground vegetation. The soil at the lower end of the transect—most of plot No. 16—was a deep, melanized siliceous sand with little profile development. At the upper end a well-developed grey-wooded profile was found with a thick, clayey B_2 and a strongly leached eluvial horizon. A striking correlation between the occurrence of the B_2 horizon, located at depths between 9 inches and 3 feet, and presence of *Linnaea* was revealed.

TABLE 3.—VEGETATIONAL CHANGE IN A TRANSECT OF FOUR CONTIGUOUS SUB-PLOTS, SAMPLING THE GRADIENT FROM A MELANIZED SAND TO A GREY-WOODED SOIL.

Species	Stand 16		Stand 17	
	Sub-plot 1	Sub-plot 2	Sub-plot 3	Sub-plot 4
	Melanized Sand ⟶	Transitional --->		Grey-Wooded
**Arctostaphylos uva-ursi*	100	83	0	0
Vaccinium angustifolium	100	93	83	75
Gaultheria procumbens	100	100	100	93
Maianthemum canadense	67	58	58	33
Pleurozium schreberi	100	92	100	100
Dicranum rugosum	93	58	93	33
Rosa acicularis	17	83	33	33
Oryzopsis asperifolia	93	100	100	100
**Chimaphila umbellata*	25	9	0	0
**Anemone quinquefolia*	67	58	0	0
Polytrichum juniperinum	8	0	0	0
Fragaria virginiana	17	0	0	50
Pyrola secunda	8	8	0	25
Amelanchier alnifolia	17	67	83	25
**Lithospermum canescens*	17	0	0	0
**Panicum depauperatum*	9	8	0	0
**Cladonia rangiferina*	17	33	17	0
Viburnum rafinesquianum	0	8	0	0
Pyrola virens	0	8	0	0
**Pteridium aquilinum*	0	8	33	67
Pyrola elliptica	0	8	0	0
**Linnaea borealis*	0	8	16	100
Antennaria canadensis	0	8	0	0
**Vicia americana*	0	0	33	83
**Aralia nudicaulis*	0	0	0	8
**Epigaea repens* var. *glabrifolia*	0	0	0	58
**Diervilla lonicera*	0	0	0	50
**Vaccinium myrtilloides*	0	0	0	25
**Rubus pubescens*	0	0	0	17

* Species which show a reasonable degree of correlation with the gradient of soil conditions.

Other factors than the soil have certainly had a role in governing the patterns of ground vegetation, particularly fire history and density of stand. For example, a number of stands were examined in which the ground vegetation was in an impoverished condition, with few species. Examination of tree bases and humus layers indicated recent ground fires. In most cases, the ground vegetation provided no obvious clue to the nature of the soil, and the loose scheme of vegetation types tended to break down in these sites. The possibility that recurring ground fires effect an impoverishment of the ground vegetation under pine increases the hazard of assessing site in terms of ground vegetation only.

TREE DATA

In Table 4 a summary of the data from the tree measurements is provided.

TABLE 4.—PROFILE TYPES AND TREE GROWTH.

Soil Profile Type	Number of Plots	Site Index Average	Site Index Range	Plots (51-70 years) Number of Plots	Av. B.A. (sq. ft.)	Av. Vol. (cords)
1. Melanized sands..................	3	43	(37-45)	3	113	25
2. Weakly podzolized sands.........	7	45	(39-56)	5	118	31
3. Podzolic sands...................	2	54	(53-56)	—	—	—
4. Sandy podzols....................	5	53	(48-57)	4	134	36
5. Sandy gley podzols...............	2	55	(52-58)	2	163	51
6. Grey-wooded.....................	6	50	(43-55)	3	160	42

These data are inadequate to permit any more than the most tentative suggestions about the growth and yield of pine species on different soil profile types. However, the values for height at 50 years (site index), basal area, and to a certain extent standard cords, indicate some trend. If stands in the age class 51-70 years are compared, there is noted a fairly consistent increase in basal area and standard cord value as one passes down the table—that is, as one passes along the gradient of soil types. In other words, the best jack pine sites are those of moister soils, a conclusion which was reached by Rowe *et al.* (1957) and Kabzems and Kirby (1956) in their studies of jack pine.

It was on the better sites that marked regeneration by conifers other than pine was observed. Balsam fir and white spruce were found growing well under jack pine on grey-wooded soils, while black spruce seedlings and saplings were locally common on pine sands with a high ground water table.

CONCLUSIONS

In this particular region it seems clear from the point of view of forestry research, and from any point of view in fact, that a classification of site in terms of soil factors is more useful than one using solely the attributes of minor vegetation. To an exceptional extent this area has been influenced by fires which have introduced a serious indeterminable variable in the environment of the ground vegetation. Major types of soil throughout the region are highly varied but easily recognized. A tentative grouping of habitats in terms of soil profile types appears to provide a reasonable degree of correlation with both minor vegetation and tree performance.

It is well enough known that within limits the degree of podzolization usually increases with the soil moisture in any particular region (Wilde 1957). Thus a grouping in terms of the drainage of the whole profile and the degree of podzolization, provides a reasonable system. In the sandy soils of this area the signs of podzolization are fairly easy to detect, and with some knowledge of soils a forester might be expected to be able to recognize the soil types in the field. The nature and depth of organic material, the presence of and degree of leaching of the A_2 horizon, the nature of the depositional horizons, the distance of the ground water table and the evidence of gleying, all can be ascertained by careful augering or excavation. This information, supplemented if possible with an evaluation of the ground vegetation, should permit some assessment of the type of site. With the present limited survey, nothing more elaborate than a division into six basic soil types is attempted, with minor adjustments for local soil peculiarities. Wilde and Leaf (1953) have made a similar contribution for a local area in Wisconsin. The present study differs from theirs only in that it involves somewhat different species in the ground vegetation and a wider range of soil types.

The objective of the present investigation has two aspects—one basic, the other practical. The former is to extend our knowledge of the relationships between forest species and environment; the latter is to provide a framework for the classification of forest site. It is not practicable to take the findings of one geographical region with its particular climate, soils, and history and to apply them in other regions. In other words, systems of site classification must be developed for particular regions, and no claim to more general relevance can be made.

REFERENCES

ELSON, J. A. (1957). Lake Agassiz and the Mankato-Valders problem. Science, Vol. 126, No. 3281: 999-1002.

KABZEMS, A. and C. L. KIRBY (1956). The growth and yield of jack pine in Saskatchewan. Tech. Bull. No. 2, Dept. of Nat. Resources, Saskatchewan.

ROWE, J. S., J. S. JAMESON and J. H. CAYFORD (1957). Forest site classification. Unpublished Report, For. Res. Div., Dept. Northern Affairs and National Resources, Ottawa.

SCOGGAN, H. J. (1957). Flora of Manitoba. Nat. Museum of Canada, Bull. No. 140.

WILDE, S. A. (1957). Forest soils. Ronald Press, New York. 537 pp.

WILDE, S. A. and A. L. LEAF (1955). The relationship between the degree of soil podzolization and the composition of ground cover vegetation. Ecology, Vol. 36, No. 1: 19-22.

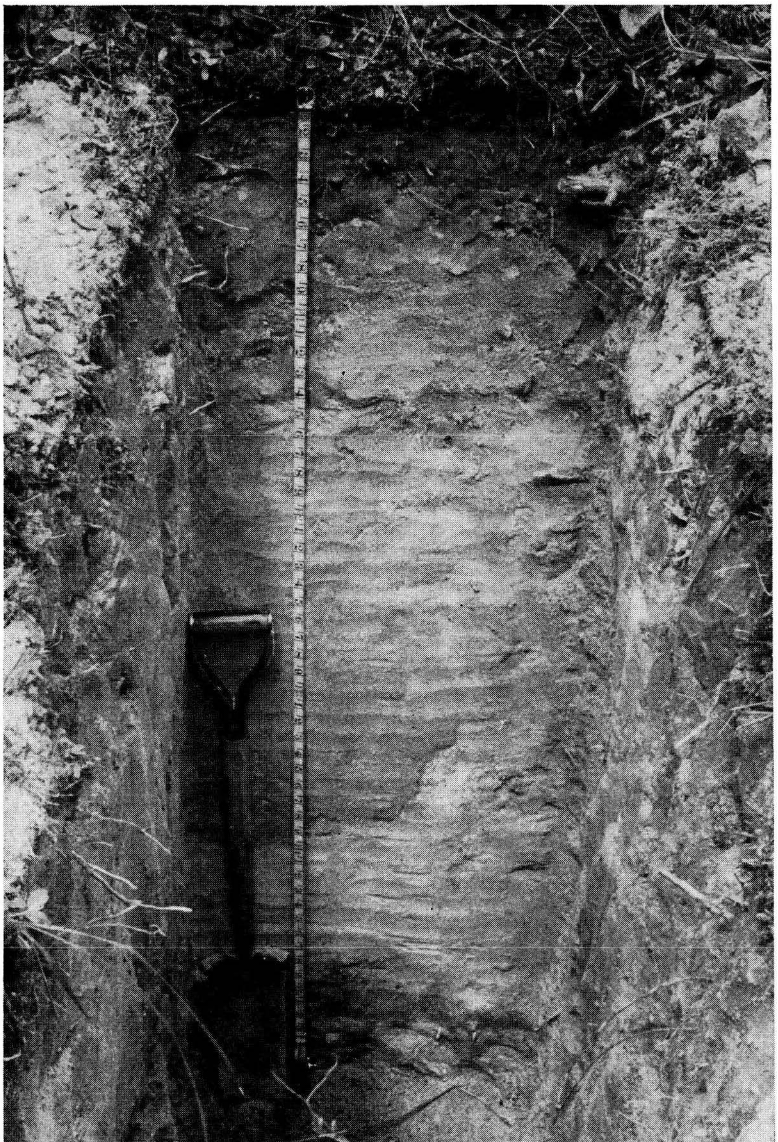

FIGURE 2. Melanized Sand profile (Stand 22), showing feeble profile development and moderately deep humus incorporation in the A.

FIGURE 3. Ground vegetation on a Melanized Sand (Stand 4), with dominance here shared by *Arctostaphylos uva-ursi* and *Gaultheria procumbens.*

FIGURE 4. General view of a 50–55 year old jack pine stand (Stand 22) on Melanized Sand. The ground vegetation has few shrubs and is dominated by *Arctostaphylos.* In the foreground, a small clearing is dominated by *Cladonia,* otherwise a rare plant.

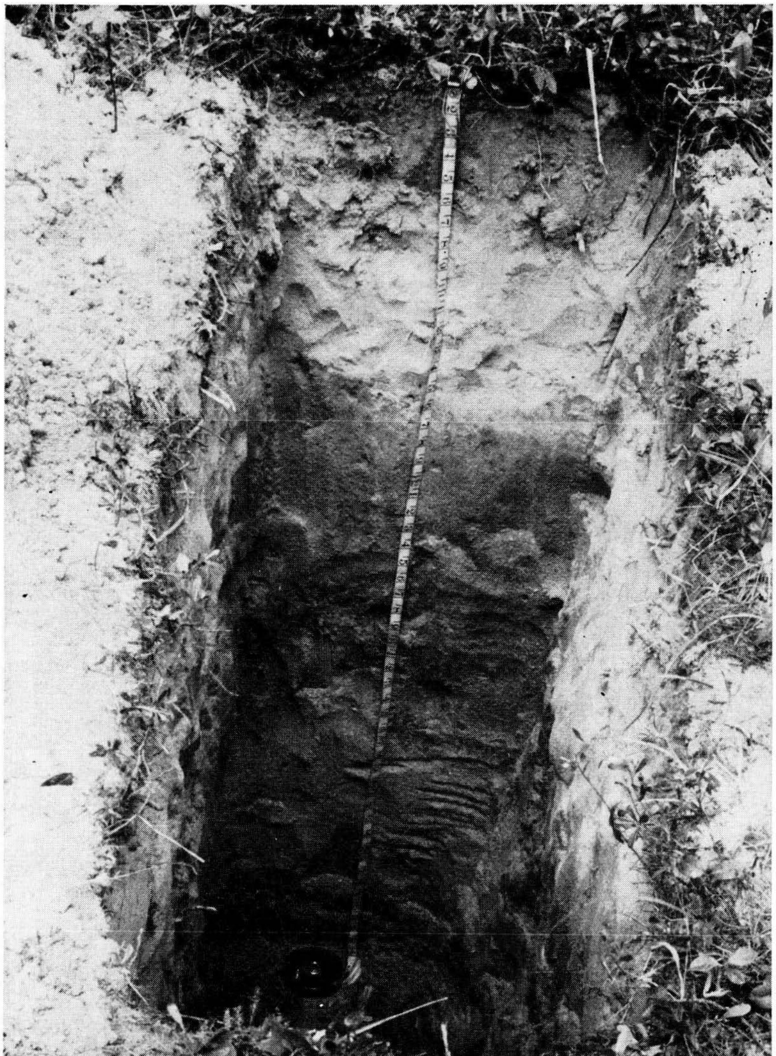

FIGURE 5. A Podzolized Sand, showing a well developed leached horizon and moderately developed illuvial layers.

FIGURE 6. Ground vegetation on a Weakly Podzolized Sand (Stand 39), showing *Arctostaphylos uva-ursi*, *Gaultheria procumbens*, *Oryzopsis asperifolia*, *Linnaea borealis* ssp. *americana*, *Vaccinium angustifolium*, and *Galium septentrionale*.

FIGURE 7. General view of a 70-year-old jack pine stand (Stand 20) on a Podzolized Sand with deep gleying. The ground vegetation has abundant bracken, *Linnaea* and *Pleurozium*.

FIGURE 8. A Grey-wooded profile (Stand 13), showing the well developed A_0, A_2 and B horizons, with calcareous material in the B and C layers.

FIGURE 9. The ground vegetation on a Grey-wooded soil (Stand 37), showing dominance of *Cornus canadensis*, associated with *Epigaea repens* var. *glabrifolia*, *Pyrola elliptica*, *Linnaea borealis*, *Aralia nudicaulis*, *Fragaria virginiana*, and *Maianthemum canadense*.

FIGURE 10. A Sandy Gley Podzol with the summer level of the ground water table at 3.5 feet. Note the strongly developed A_0 and A_2 horizons and the mottled, gleyed B and C layers.

FIGURE 11. Fire-scarred jack pine (60 years old) on a Sandy Podzol with a high water table (Stand 7). The shrubs are alder and the minor vegetation is dominated here by *Cornus canadensis* with local *Ledum groenlandicum.*