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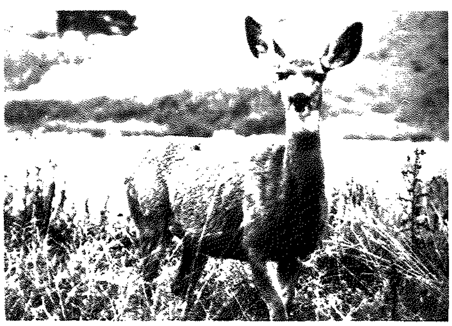
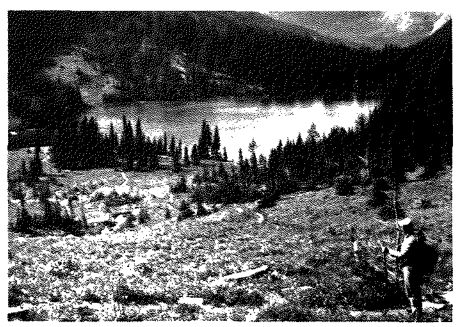
SOILS RESEARCH





SOIL: A BASIC FOREST LAND RESOURCE

This issue of **FORESTRY REPORT** deals with soils – where, what and why we are studying this very important part of our Canadian resources. Soil quality across the country varies from poor to good – from well drained to very poorly drained; from low fertility to highly fertile; from coarse sand or gravel to very fine clays; from prairie climate to mountain and alpine climates in the west to tundra in the north. Soil use and productivity is affected by several hundred variables or changes in environmental conditions.

Part of the job then is to find out where different kinds of soil occur and to locate them on maps. Some mapping techniques are explained in the articles on the Mackenzie River valley.

Because most Canadians live in southern Canada, we usually think of soil and land in agricultural terms. We must remember, however, that except for the true prairie grasslands and the tundra, by far the major portion of Canada is forested land or land that could be forested. Thus, one of the articles included in this issue discusses the approach of a soil scientist to the study of forested soil and compares this to the soil scientist's studies of soil used for agricultural purposes. Further articles discuss the relationships of vegetation to land in the Mackenzie River valley; the relationships of soil to forest nurseries; fire and soil changes; soil and forest growth; and soil and hydrology relationships.

While this issue cannot refer to all aspects of soil and its role as a basic forest land resource, it is hoped that some idea of the scope of soil studies at the Northern Forest Research Centre has been provided and that more information may be brought forth by future issues or by direct request from concerned people.

THE MACKENZIE RIVER VALLEY

Permafrost ** Landscape Patterns ** Vegetation

With the rapid increase of development in Canada's northland and the imminence of oil and gas pipeline construction, the Federal Government has begun a series of research projects to find out what really is there, how the resources can be used and what problems exist. Part of the research team is based at the Northern Forest Research Centre in Edmonton and has the immediate task of describing the land forms, vegetation and soils of the Mackenzie River Valley. This is the site of a proposed pipeline and the information is essential for the most appropriate environmental routing. The team spent last summer in the north and will be there again this year before making a preliminary report. In subsequent years their studies will amplify the report, revising and expanding it to give as accurate an account as possible of the ecological conditions and hazards.

PERMAFROST

The most characteristic feature of the sub-arctic and arctic soils is the presence of permafrost – perennially frozen ground. This condition occurs where the summer heat penetration is insufficient to thaw the frozen ground. Heat is lost from the ground rapidly in the autumn when the surface organic mat is wetted by rains, but, when dry during the summer, the same organic layer acts as an efficient insulator. The organic mat, thus, plays an important role in the development and preservation of permafrost. The kind and thickness of the organic mat depends on the vegetation under which it develops. Vegetation development in turn, is greatly influenced by the soil and drainage conditions. Soil characteristics, such as texture and internal drainage, play a dominant role in determining the ice content of the permafrost layers.

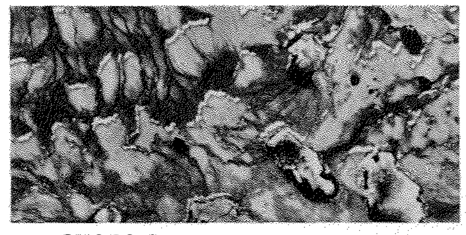
The most southerly occurrence of permafrost is in peatlands, roughly 100 miles northwest of Edmonton, where it may be initiated under the dense shade of black spruce clumps. The moisture content of the frozen peat is generally high, but solid ice accumulations are rare. In some peatlands where moisture is abundant, large hummocks 10 or more feet in height and 300 feet in diameter (called palsas) are formed by ice that accumulates in mineral soil under the peat. Further north, frozen peatlands may cover extensive areas but small, unfrozen ponds are scattered through them forming 'windows' in the permafrost.

In the south, around Fort Simpson, permafrost in mineral soils is initially found in poorly drained situations but further north permafrost becomes universally present except under permanent water bodies. (An effective insulating organic mat is best developed under a sparsely wooded spruce-lichen forest, hence the surface layer that thaws during the summer is thinnest under these conditions.)

The ice content of perennially frozen ground has an extremely important bearing on the consequences of disturbance. It is convenient to distinguish between different types of occurrence of ground ice. The first type, disseminated ground ice, occurs as small ice crystals or layers of thin (generally less than one inch) ice. It may vary from very low amounts (virtually dry permafrost) to high concentrations where over two-thirds of the volume of soil is frozen water (Fig. 1). The amount of disseminated ice depends on both the texture and the topographic position of any particular site. Silts generally contain more disseminated ice than sands or clays on similar slope positions, and silts usually have higher ice content in poorly drained slopes than on drier ridges. This relationship is not always valid, as some ridge positions may accumulate much disseminated ice, since water losses through runoff and transpiration by plants is limited by the short growing season.

The second type of ground ice is segregated ice, consisting of ice bodies of diverse origin. Some forms include wedges of ice, found under the trenches in polygonal ground, as well as irregular bodies of ice that may be tens of feet thick. The presence of ice wedges can generally be determined from surface configurations, but the occurrence of other types of segregated ice is unpredictable. This is possibly due to the fact that many may be fossil features, having been formed under different climatic and terrain conditions than today's. The vegetation pattern offers little help, as ground ice bodies are overlain by frozen soil with disseminated ice and the vegetation reflects this condition. The greatest number of ground ice bodies in the Lower Mackenzie River area occur in silty, glaciolacustrine sediments, generally on the lower portions of long slopes. The ice occurs in thick seams in the bedding planes of the sediments, or as large lenticular bodies (Fig. 2). Their mode of occurrence suggests that the water migrated into the soil and then froze, rather than by burial of blocks of ice.

AIR PHOTO 1



AIR PHOTO 2

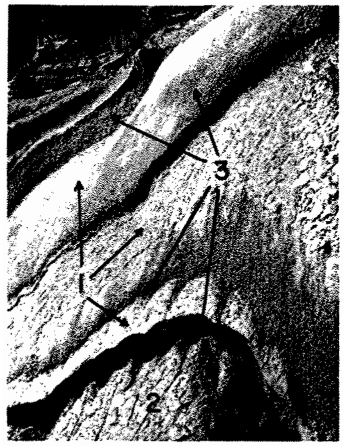
AIR PHOTO 3

LANDSCAPE PATTERNS

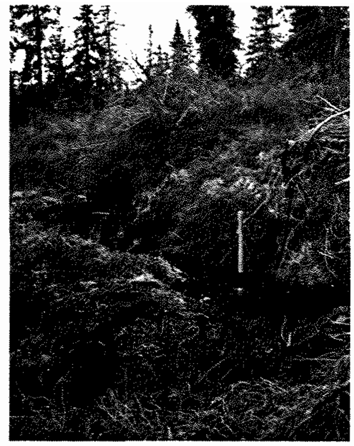
Landscape patterns are formed by the combined effects of relief, country rock, and vegetation. In the discontinuous permafrost zone of the southern Mackenzie River Valley where unfrozen ground adjoins frozen ground, these patterns as seen in air photographs, enable one to differentiate land frozen a few inches below the surface from land not frozen at shallow depth. In the continuous permafrost zone of the northern Mackenzie River Valley, where there is very little unfrozen ground these patterns aid in the differentiation of some of the landscapes having different relationships with the permafrost. Relief or vegetation alone would be less useful.

Country rock below a thin till veneer determines the dips and hollows of the land and the principal drainage pattern. Though it can be very cold, rock does not often contain ice, so this pattern indicates a limit to the amount of ice in the ground. The light shade on slopes is produced by a profuse growth of lichen which, under these conditions, reflects frozen soil to within a few inches of the land surface. The fine, linear drainage pattern is characteristic of slopes, and possibly indicates

Head wall of flow slide. Lower portion contains layers of segregated ice, upper part has disseminated ice. This flow slide was probably activated by forest fire which killed the trees.



Layers of ice (1) and ice core (2) in lacustrine sediments (3).



Early stages of gullying in a seismic line cut on sloping ground.

Theremal erosion in a seismic line on the Peel Plateau.

Large flow slides discharging mud into lake.

past, seasonal slurrying of thawed soil downslope. When slopes become more gentle and the till thicker over the country rock, the fine, linear drainage pattern tends to dominate the landscape (air photo 1).

On valley land, the till thickens and the linear drainage pattern becomes less distinct (air photo 2) and is replaced by a drainage pattern reflecting a tendency towards the polygonal cracking of the frozen landscape so characteristic of subarctic regions. Thick, crisp mats of lichen are more extensive in this landscape than in any other, indicating frozen conditions very close to the surface, even in summer. The greater abundance of lichen contrasts with the fewer spruce trees and their dwarfing compared with the previous landscape units.

On lower land and at more southerly latitudes in the discontinuous permafrost zone, the organic layer locally is thicker, and the landscape is pitted with seasonally thawed hollows associated with mosses (air photo 3). Where mossy hollows are as widespread as frozen, raised peat, labrador tea replaces much lichen in the vegetation, and at mid-summer the substrate is usually frozen below two feet depth. Where the land is unfrozen to greater depths, mosses occur around and between hollows, associated with sedges. Trees tend to be clustered on well drained ridges. This landscape grades into forested land with unfrozen mineral soils.

VEGETATION

Since plant communities are ever changing, different plant communities can be found on identical sites as expressions only of differences in ecologic time. So that we can evaluate abnormal changes, we must piece together the natural successional changes on each land unit to set the standards. Disturbance brings about accelerated change. Figs. 1 and 5 show one consequence of natural disturbance – flow sliding probably triggered by burning. We need to assess the disturbances caused by man to determine their extent and the kind of harm his activities are causing. Only then can we derive a meaningful benefit-cost evaluation of what he is doing.

Disturbance of the vegetative cover has an immediate effect on the thermal regime, increasing the net heat transfer downwards into the upper soil layers and so melting the permafrost. The result is called "thermal erosion" because it is a form of erosion begun by thermal alteration of the physical state of the uppermost soil strata. On flat land this may or may not be environmentally harmful (Fig. 4) but on slopes it can have serious consequences leading to gullying (Fig. 3) or to flow sliding. Interruption of drainage flow and increased siltation of stream are other undesirable possibilities.

Our immediate task is to identify, minimize and remedy the harmful effects of disturbance; because development in the North will, inevitably, cause disturbance. A preliminary step is to relate ground cover to thickness of the active layer – the soil strata above the permafrost table. We have put together a tentative rating of landscape units in order of decreasing depth to permafrost for the area between Norman Wells and Point Separation, the head of the delta.

Greatest depth to permafrost ↑

open water
wet sedge meadows (fens)
forest on recent alluvium
peat bog
recent burn (brule)
unburned spruce forest (closed canopy)
unburned spruce woodland (open canopy)
spruce-lichen woodland
lichen parkland (=taiga); raised peat moor

↓ Least depth to permafrost

The next steps will be to refine and define these classes, understand their successional relationships and extend the classification to the rest of the Mackenzie Valley. Having done this we will know how Nature repairs damage and what her successful remedies are. It will then be our task to learn to simulate or even accelerate natural healing, wherever disturbance cannot be avoided.

FOREST-SOIL RELATIONSHIP

Co-operative studies with the Alberta Soil Survey in the Pembina Oil Field area suggest an essential difference between the site requirements of white spruce and lodgepole pine. Productive sites for lodgepole pine extend from rapidly drained to poorly drained soils. Maximum productivity is reached at moderately well-drained soil conditions, sharply decreasing towards drier or wetter conditions.

Productive sites for white spruce extend from well drained to poorly drained soils. In general, the site quality increases with the increase of water supply, provided that the water is not stagnant.

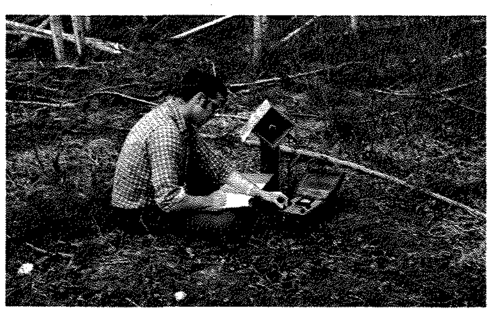
A further difference between the requirements of the two species is the higher productivity of lodgepole pine on moderately well drained lake deposits compared to moderately well drained tills. White spruce has equal productivity on both of these soils.

To facilitate the interpretation of soil survey maps by foresters, soil survey mapping units (soil series) were arranged into groups in which the productivity of white spruce or lodgepole pine is significantly different from that of any other group. The result is shown in the table below.

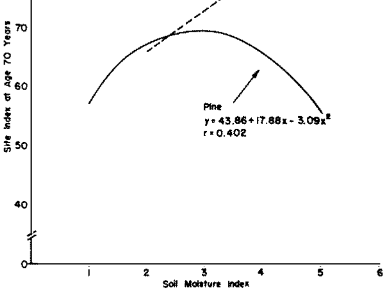
Soil Series Grouped According to White Spruce and Lodgepole Pine Productivity

Species	Group I.	Group II.	Group III.	Group IV.
White spruce	Site Index: 83.1 ± 1.6* Soil Series: Codner, Raven, Wildwood, Newbrook, Wet Alluvial	Site Index: 75.5 ± 0.8 Soil Series: Macola, Hubalta, Maywood, Bremay, Lobley, Evansburg, Codesa, Moist Alluvial	Site Index: 65.4 ± 4.0 Soil Series: Horburg, Caroline, Fresh Alluvial	Site Index: non-productive Soil Series: Kenzie, Eaglesham, Heart, Sundance
Lodgepole pine	Site Index: 75.1 ± 1.5 Soil Series: Maywood, Codesa	Site Index: 68.7 ± 1.1 Soil Series: Hubalta, Bremay, Caroline, Lobley	Site Index: 60.3 ± 0.9 Soil Series: Newbrook, Wildwood, Evansburg, Horburg, Sundance, Heart	Site Index: non-productive Soil Series: Kenzie, Eaglesham, Codner, Raven

* Average site index at 70-year age and standard error.



Measurement of soil moisture and temperature with Colman fiberglass units and thermistors.



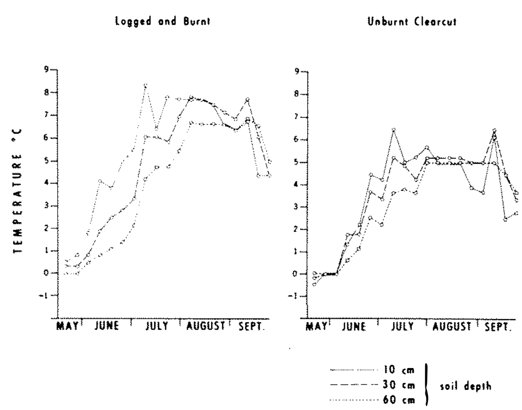
The influence of soil moisture on the site index of white spruce and lodgepole pine in the Pembina Oil Field area.

IMMEDIATE EFFECTS OF A PRESCRIBED FIRE ON SOIL PROPERTIES

An often asked question concerns the effect of fire on the soil. A prescribed burn of spruce-fir logging slash in the Foothills Section of the Boreal Forest Region had no dramatic effect on soil properties. The immediate effects, restricted to the top of the surface organic horizon, were the consumption of some organic material and the deposition of ashes and charcoal derived from burning slash. The alkaline reaction of wood ash reduced soil acidity from pH 5.3 to 6.2 in the forest floor. The organic layer lost about 20% of its nitrogen and organic carbon content, and the addition of ashes increased the available amounts of calcium and potassium. Changes in magnesium and phosphorus were not significant.

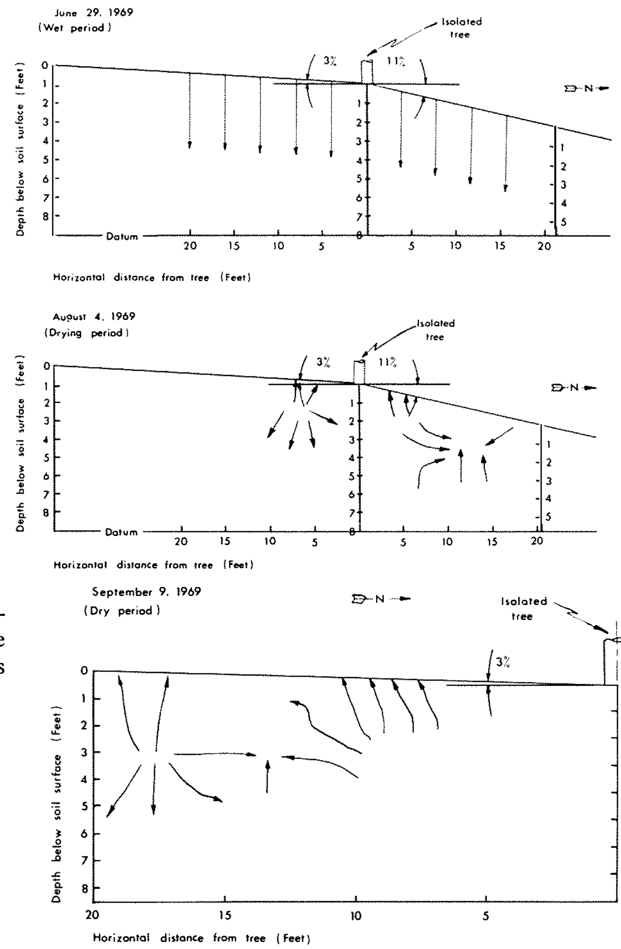
Consumption of the loose moss layer and the darkening of the soil surface increased the soil temperature in the burned area. Soil temperature in the burned area was about 7 degrees C in July and August while it was only about 5 degrees C in the control block.

Higher soil temperatures in the burned block are expected to increase the rate of root growth in seedlings, increasing their chances of survival. The small changes in the nutrient status of the soil probably will not have much effect on seedling growth rate.



The march of soil temperature at 10, 30 and 60 cm. depth in logged and burnt block and in unburnt clearcut.

FOREST HYDROLOGY RESEARCH



Soil water flow through north-south section of soil profile near an isolated tree. (Arrows indicate direction.)

The study of hydraulic properties of forest soils has been undertaken in the three watersheds of Marmot Creek, Streeter Creek and Deer Creek, Alberta, representing spruce-fir, aspen-grassland and lodgepole pine forest cover types respectively.

The study supplements precipitation, surface water, and groundwater investigations, to give a better understanding of the hydrologic cycle. Recommendations can then be made to land managers for maintaining the natural quality of water through erosion and sediment control, and increasing water yields from watersheds if and when required. Such recommendations may eventually form the basis of land management guidelines or environmental quality control legislation.

Soils information is essential to design a test watershed model that predicts how streamflow responds to precipitation or changes in land use.

Water usually enters forest soil through a mat of organic material (the forest floor). Studies on the watersheds of Marmot and Streeter Creeks have shown that the average depth of the forest floor in these areas is 4.47 inches under undisturbed spruce-fir, and 2.62 inches under aspen. The studies also showed that the forest floor under spruce-fir is capable of holding about twice its dry weight of water, and under aspen can hold nearly 2½ times its dry weight. The ability of the forest floor to hold water is less important than its role in protecting the soil from erosion and compaction, facilitating infiltration, and curtailing overland flow. A measure of this water-holding ability is necessary to account for all the water contained by a watershed.

Infiltration is the movement of water through the soil surface into the soil. The minimum infiltration rates of soils on the Marmot and Streeter watersheds were found to be higher than the maximum storm-rainfall intensities. This implies that the soil is capable of handling all the water from such storms under present watershed conditions. Logging on these watersheds will undoubtedly cause local changes in infiltration characteristics.

Liquid water within the soil tends to move from regions of high hydraulic potential to those of lower hydraulic potential. Thus, if hydraulic potential is measured at several points in the soil it will be possible to determine the direction in which the water is moving. This concept was used in a study near the Kananaskis Forest Experiment Station, Seebe, Alberta to observe how water moves from the soil into the tree. Data from this study were used to construct several flow diagrams which indicated that water will move in all directions at once – upwards in response to evaporation, downwards as natural drainage, and towards plant roots. The diagrams show several "sinks" in the root zone of the isolated tree, suggesting that the tree extracts water by local action of its individual major roots rather than through generation by the tree of mass movement of water through the soil.

Instruments for measuring hydraulic gradients and water content of soils.

A soils study, designed specifically to provide information to assist in establishing suitable watershed management practices, has also been completed. It included detailed examination and mapping of soils using computer mapping techniques; field and laboratory determination of soil physical and chemical properties; evaluation of soils in terms of utilization for watershed management; and evaluation of the Canadian Soil Classification System for detailed watershed mapping. Results indicated that soils of Marmot and Streeter watersheds have better infiltration and total storage characteristics than those of Deer Creek watershed. Therefore, following vegetation manipulation, these two watersheds are more likely to experience sustained increases in yield of good quality water than will Deer Creek.

It appears that the Canadian System of Soil Classification cannot readily accommodate a large proportion of the mountain soils encountered in the three watersheds and is therefore unsuited for detailed mapping of such areas*. A modified form of the present system is required – particularly if the system is to be used for hydrologically grouping soils for watershed modelling purposes.

* Beke, G.J. 1969. Soils of three experimental watersheds in Alberta and their hydrologic significance. Unpublished Ph. D. dissertation, University of Alberta, Edmonton, Alberta. 456 p.

THE FORESTER AND SOILS RESEARCH

Historically, the agriculturist has been responsible for the development of the theories, concepts and techniques currently applied in soils research. Generally he is committed to a wider range of soil research studies than is the forester, and is frequently called upon to study problems in nearly every part of soil science, i.e. the micro-biological, physical, chemical, and mineralogical areas.

In contrast, the forester is generally limited to studying a specific type of soil that results from weathering processes that occur under tree cover and often on areas of rough topography. He has some practical control only over the micro-biological aspects of soil. Thus by careful use of certain silvicultural practices, the forester can, to some extent, control the amount and composition of the organic litter layer comprising the forest floor. As a result, to some degree, he also is able to control the important biochemical changes associated within this layer. Changes occurring in the surface organic layer will have an effect on the underlying mineral soil.

Agricultural soils are usually cultivated and cropped annually. The forester works with soils that are seldomly cultivated and are harvested once every 30 to 100 years depending on the tree species. Because of the lengthy time period between tree establishment and harvest, the absence of cultivation, and the normally cooler, wetter, soil surfaces associated with forest areas, decomposition rates of the surface organic layer are slower than the rate of organic matter accumulation from the annual fall of new litter. Changes in tree species cause different kinds of organic matter. As a result of the above activities, organic layers of varying thickness and composition accumulate on the mineral soil surface. As decomposition of the surface organic matter takes place, some by-products, such as organic acids, enter the mineral soil and dissolve some of the primary minerals in the soil. The mineral nutrients that are set free may be absorbed directly by the roots or redistributed in the soil as a result of water movement. These nutrients are transported to all parts of the tree and some are returned to the soil surface in the annual leaf litter fall to go through the nutrient cycle again. There is then, a general upward movement of nutrients with the result that the soil within the rooting volume suffers a gradual reduction of plant nutrients while the organic layer at the surface becomes a reserve of plant nutrients.

The formation of humus is normally considered to be the end product of vegetative decay. Chemically, humus is an organic colloid that is stable and is responsible for many of the nutrient exchange reactions occurring in the soil. Humus imparts its favourable characteristics to the underlying mineral soil with the net result that water retention, aeration, and physical structure is greatly improved. Since the surface organic matter layer varies from completely decomposed humic residues to freshly fallen leaf litter, this layer contains plant nutrients in various degrees of availability; nutrients in freshly fallen litter are unavailable and organically bound while those in completely decomposed fractions are mineralized and readily available. This active organic layer then, provides the major portion of the required nutrient supply to the growing forest stand. In addition, it is an important source of available moisture.

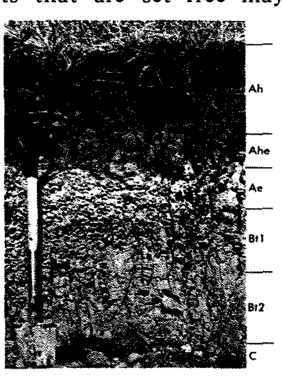
In contrast, the underlying mineral soil serves the forest stand by supplying most of the required mositure as well as providing anchorage for the roots. At the same time, it serves as a secondary source of plant nutrients.

Foresters attach much greater importance to the organic matter of the forest floor layer than to the mineral soil layers (1). Because this L-F-H (L, for newly fallen leaf litter; F, for the fermented and partly decomposed layer; and H, for highly decomposed humus layer) layer is so important in nutrient cycling and is closely associated with stand growth and maintenance, foresters use silvicultural practices to try to preserve a balance between the forest stand and the soil.

By virtue of the micro-biological activity in the L-F-H layer and the transformations which take place, the litter layer supplies the forest stand with both immediate and future nutrient requirements. The following table (2) shows the importance of the surface organic matter layers as a supply of readily available nitrogen, phosphorus and potassium.

Horizon (layer)	Depth (inches)	Organic Matter %	Total Nitrogen %	Available Phosphorus P.P.M.	Available Potassium P.P.M.
L-F-H	4-0	72.5	1.0	78.9	391.0
$Ae_j B_{fh}$	0-3 1/3	6.4	0.2	11.3	36.0
B_f	3½-24	1.1	0.2	4.5	14.0
C	24+	0.7	0.1	2.3	3.5

The photographs (3) compare typical soil profiles from forested and grassland areas. The litter accumulation (L-H horizon), in addition to being a nutrient and moisture source for the stand, fulfills other purposes. It serves as a mulch to preserve moisture (run-off, seepage and evaporation losses) and it also has insulative qualities that help protect plant roots from sudden temperature fluctuations. The forester is well aware of the consequences should this organic layer be totally destroyed either by mismanagement practices or by natural disaster. On the other hand he is also cognizant of the fact that regeneration of a forest stand may be retarded by excessively thick and unmineralized litter layers. There is therefore a great need to exercise extreme care both in forest management and silvicultural practices so that no one interest is emphasized to the exclusion of others. The forester then must act as a referee when conflicts of interest arise, to ensure that the contemplated forest activity does not completely remove the forest floor leaving the site impoverished and unproductive for years.

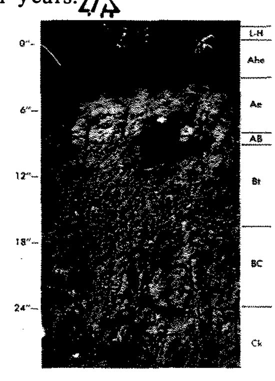


Horizon

Agriculture

SOIL PROFILES

Forested



Horizon

References:

1. Youngberg, C.T. and Davey, C.B. 1968. Tree growth and forest soils, Oregon State University Press, Corvallis, Oreg.
2. Baker, J. 1969. Soil properties and nutritional status of Western hemlock tissue from overstocked stands, (Inf. Rpt. B.C.-X-38) Canadian Forestry Service, Victoria, B.C.
3. Soil Survey Series 1, 1962. Dept. of Extension, University of Alberta, Edmonton, Alta.

NURSERY SOIL RESEARCH

FIG. 1 Drying causes cracking of the heavy clay soil.

The aim of nursery soil research at the Northern Forest Research Centre is to assist the provinces to produce, economically, the highest quality stock and to obtain their maximum survival when planted in the field. Currently, the species of major interest are conifers: jack pine, lodgepole pine, white spruce and black spruce. However, willow, poplar and shelterbelt species such as caragana are also grown.

Provincial nurseries in the region are situated on two main types of soil. In Manitoba and Saskatchewan they are located on deep, medium- to coarse-textured sands whereas that in Alberta is situated on mostly heavy clay.

Although sandy soils are advantageous for early growth of conifer seedlings, those used for nurseries are extremely well drained and possess very little capacity to retain either nutrients or moisture. They are generally neutral or slightly acid on the surface but are alkaline at greater depths. Sulphuric acid and sulphur are used to make them more acid. These soils are also extremely low in nitrogen and phosphorus and moderately low in potassium. Fertilization is therefore a necessity.

The treatment used to improve these sandy soils consists of an application of peat followed by fertilization. Peat increases the capacity of the soil to retain moisture and nutrients and therefore increases the effectiveness of the fertilizers applied.

Fertilization experiments are being conducted to build up the fertility of the soil while increasing growth and survival. At Birds Hill, Manitoba, 200 lbs. N and 80 lbs. P per acre significantly increased the growth of 2-0 jack pine; 200 lbs. N and 160 lbs. P per acre were best for white spruce. By determining the amount of nutrients taken up in each year's growth, a more reliable recommendation can be made for each specie throughout the seedling and transplant stages.

The heavy clay soil at the Alberta provincial nursery has a high percentage of sodium salts and this results in a poor physical condition and makes it very difficult to be worked. It has a blocky structure and, when dry, cracks to give extremely hard clods (Fig. 1). The subsoil is very dense and compact and restricts root penetration and drainage. The high sodium compared to calcium and magnesium results in markedly poor germination and growth (Fig. 2).

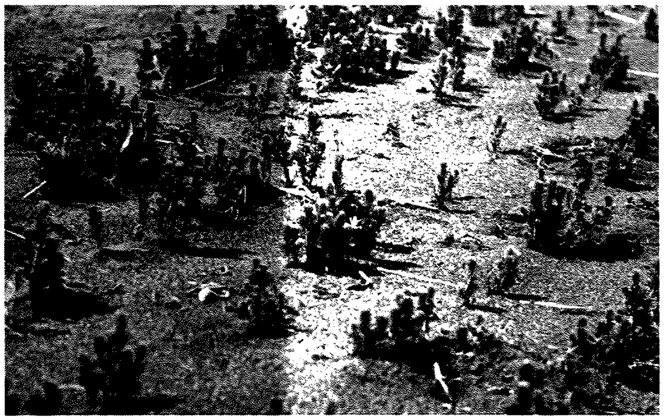


FIG. 2 High clay and sodium contents of the soil lead to poor growth.

FIG. 3 Satisfactory growth in obtained on more sandy and better drained soils.

Much better growth is obtained on a smaller portion of the nursery (Fig. 3) which is coarser in texture, has better drainage and is relatively low in sodium. Table 1 shows the main differences of texture and sodium content between the soil of Area A which produces good growth of conifers and that of Area B where growth is poor.

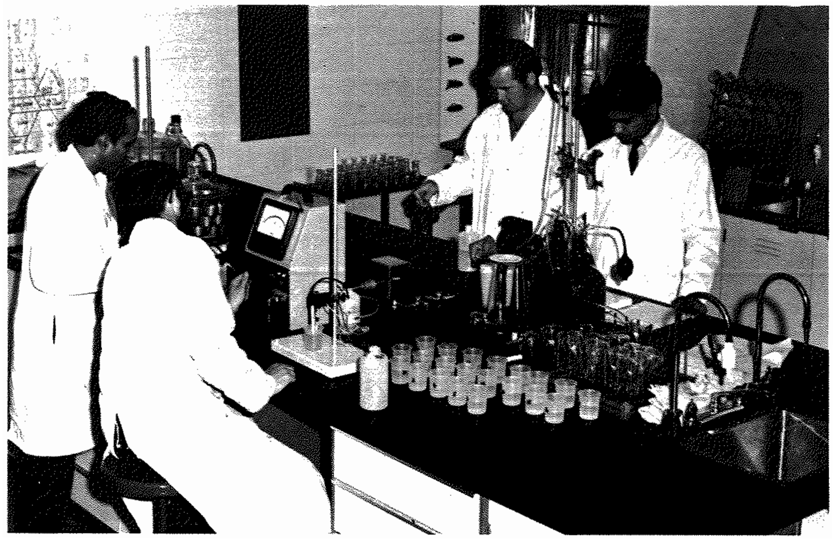
Area	Source of sample	Sand %	Clay %	Sodium lbs. per acre
A (good growth)	top-soil	47	36	190
	sub-soil	72	23	48
B (poor growth)	top-soil	13	71	2,412
	sub-soil	10	80	2,770

What can be done to improve the high-sodium soils of Area B and make them more suitable for growing conifers? This is achieved by replacing the sodium in the soil with calcium and leaching the sodium away from the root zone. Calcium sulphate (gypsum) is commonly used although calcium chloride and aluminum sulphate have been used where there is adequate drainage. In certain agricultural areas, deep plowing (to 24-30") has also proved successful in improving these soils.

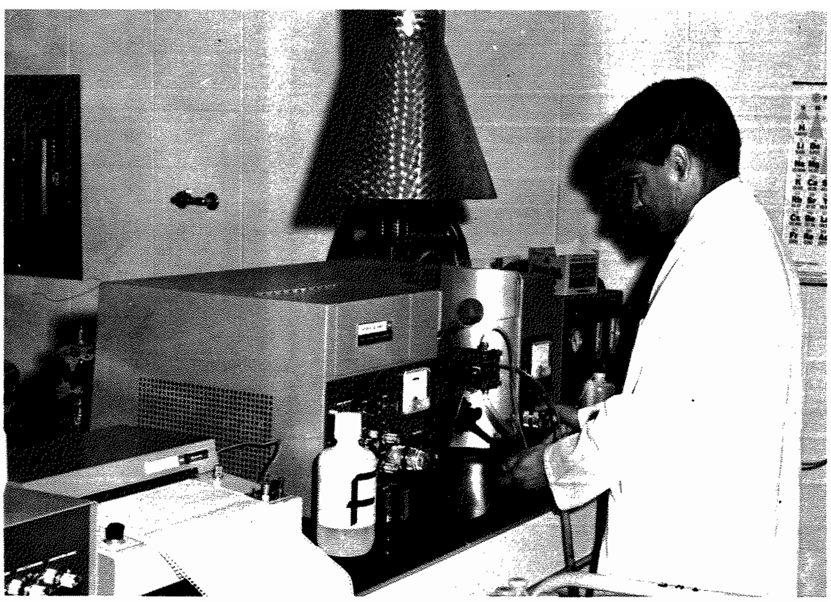
CENTRAL SOILS LABORATORY

The Central Soils Laboratory is an integral part of the Northern Forest Research Centre in Edmonton. The laboratory service provides for quantitative physical and chemical soil characteristics such as acidity, soluble salts, nitrogen, phosphorus, iron, manganese, copper, zinc, etc. Plant samples are analyzed for nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, sodium, iron, manganese, copper, zinc, etc. Similarly, water is analyzed for constituents related to water quality such as alkalinity, hardness and soluble salts.

Additional functions of the soils laboratory are the development and comparison of analytical methods and procedures, and the provision of advice when requested.



Training in analytical methods and use of equipment is provided to the new staff. Two summer students are being shown the procedures for the determination of soil acidity, soluble salts, and organic matter.



This picture shows the determination of plant-available manganese extracted by eight methods from several soils of the Forest Tree Nursery at Oliver. The results will be used for the selection, modification, and development of analytical techniques.

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Aerial photos courtesy of the National Air Photo Library.

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