ECOLOGICAL CLASSIFICATION OF ALBERTA FORESTS AND ITS APPLICATION IN FOREST MANAGEMENT

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Abstract.—*Several available sources of information on vegetation, soil and forest productivity were used in the design of a forest ecosystem classification for a west-central Alberta study area. Management interpretations were made for 12 management concerns.*

Résumé.—*Plusieurs sources d'information sur la végétation, le sol et la productivité forestière ont servi à établir la classification des écosystèmes forestiers aux fins de l'étude sur le centre-ouest de l'Alberta. Des solutions ont été proposées pour 12 problèmes d'aménagement.*

INTRODUCTION

In recent years a greater appreciation of the value of forested land by a variety of potential users has intensified interest in ecosystem classification, evaluation of variation in forest site productivity, and inventories of rapidly changing landscapes. There have been relatively few forest-site studies in the boreal forest of Alberta, Saskatchewan and Manitoba in comparison with other parts of Canada and the United States, mainly because only recently (the last 30 years in Alberta) has any substantial demand for utilization been placed on that forest region. The growing concern that forest resources are being depleted too rapidly or are being managed inefficiently has prompted the search for means of utilizing these resources most effectively while maintaining their productivity.

Some of the earliest site quality work in the western boreal forest was done by Brunkman (1931, 1936) in Alberta with lichens and mosses as site indicators. Smithers (1956) assessed site productivity in dense lodgepole pine (*Pinus contorta* L.) stands in the Kananaskis Forest Experiment Station in Alberta. Duffy (1964) used multiple regression techniques to find relationships between site factors and growth of lodgepole pine in the Alberta foothills. Duffy (1965) developed a forest land classification for the Mixedwood Section of central Alberta on the basis of differences in soil parent material and soil moisture status as they influence white spruce (*Picea glauca* [Moench] Voss) site index. Dumanski et al. (1973), using soil survey maps for the Hinton-Edson area, evaluated the productivity of lodgepole pine forests. Lesko and Lindsay (1973) related lodgepole pine and white spruce site index within 15 forest types to soils in the Chip Lake map area in west-central Alberta. In addition, vegetation distribution in northern and northwestern Alberta has been described by Lewis et al. (1928), Dowding (1929), Raup (1933, 1934, 1946), Moss (1953, 1955), Moss and Pegg (1963), La Roi (1967), Achuff and LaRoi (1977), Corns (1983 and footnote 1) and,

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[1]Corns, I.G.W. 1978. Tree growth prediction and plant community distribution in relation to environmental factors in lodgepole pine, white spruce, black spruce, and aspen forests of western Alberta foothills. Ph.D. thesis, Univ. Alberta, Edmonton. 229 p.

recently, Krumlik et al.[2] during a biogeoclimatic classification of Alberta's forests and also during a biogeoclimatic classification of the British Columbia Forest Products Forest Management Agreement Area[3]. Comprehensive reconnaissance soil surveys and interpretations in the study area have been made by Dumanski et al. (1972), Twardy and Corns (1980), and Knapik and Lindsay (1983).

The objectives of the present study were to classify and describe ecological zones (ecoregions) and their component forest ecosystems within the study area, with respect to their floristic composition, environmental characteristics, successional relationships, and potential for fiber production, and to make interpretations for forest management. All available, relevant sources of vegetation, soils and climate information were consulted and, if possible, incorporated into the present classification and interpretations.

The classification is a hierarchical system that corresponds to the biogeoclimatic system developed in British Columbia by Krajina (1965) and students, and also parallels the scheme used by the Canadian Committee on Ecological Land Classification (CCELC). The system used in western Alberta has three fundamental classification levels: ecoregion, ecosystem association and ecosystem association phase. The ecoregion corresponds to the biogeoclimatic subzone as used in British Columbia (Krajina 1965, Pojar 1983), the ecoregion of Strong and Leggat (1981), and the forest section of Rowe (1972). The ecoregion defines a geographic area that is controlled by the same regional climate (macroclimate) and by characteristic zonal soils and vegetation that have developed in response to climate. Ecosystems at the level of Sukachev and Dylis' (1964) biogeocoenose are grouped into ecosystem associations that resemble the plant association of Braun-Blanquet (1928) and the habitat type of Daubenmire (1952). Ecosystem association phases are not a taxonomic category in the ecosystem classification system but are recognized in order to facilitate more precise resource management interpretations.

[2]Krumlik, G.J., Johnson, J.D. and Lemmen, L.D. 1978. Progress report for 1977-1978 fiscal year. Forest types in northwestern Alberta--first approximation. Dep. Environ., Can. For. Serv., Edmonton, Alta. 104 p. (unpubl.).

[3]Krumlik, G.J., Slaco, R. and Nichols, J.S. 1982. A classification and interpretation of forest ecosystems of the Berland forest management area, Alberta. A first approximation. Vol. 1 and 2. B.C. For. Prod. Ltd. (unpubl.).

Phases of an ecosystem association are distinguished on the basis of differences in physiographic features (percent slope, slope position, aspect, etc.), soils properties (i.e., texture), parent materials and bedrock geology (Mitchell and Green 1981). Ecosystem associations and phases are considered the most practicable operational units and all management considerations are evaluated at this level.

This paper stresses the methodology used in developing a field guide for operational foresters in Alberta.

STUDY AREA

Location and Extent

The study area is in west-central Alberta between latitude 53°-55°N and longitude 116°-120°W. The area includes four National Topographic Series map sheets (Wapiti [83L], Iosegun Lake [83K], Edson [83F] and part of Mount Robson [83E, Fig. 1]) and covers approximately 4.6 x 10^6 ha.

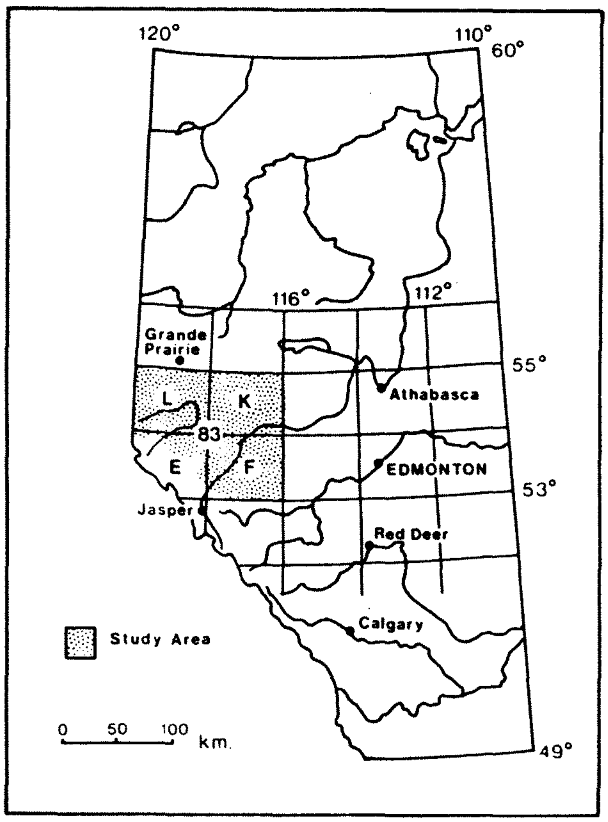

Figure 1. Location of the Alberta study area.

Physiography, Geology and Soils

The predominant physiographic regions in the study area are in the Alberta Plateau (Bostock 1970) and the Rocky Mountains Foothills. The area is underlain primarily by the Paskapoo Formation of Paleocene to Late Cretaceous age and consists of weakly consolidated beds of shale, sandstone, coal, and chert conglomerate.

Both Cordilleran and Keewatin (Continental) glacial ice once covered parts of the study area. Surficial deposits include glacial till of Keewatin and Cordilleran origin occurring as ground moraine, glaciolacustrine silts and clays with bedding, glaciofluvial coarse gravels occurring as river terraces, aeolian sands, recent alluvial deposits and organic peat. A few small areas of shale, sandstone, coal and conglomerate outcrops are present in the more mountainous areas in the southwestern portion of the map area. Elevations range from 600 to 2450 m ASL.

Soils of the Luvisolic, Brunisolic, Gleysolic, Regosolic, Podzolic, and Organic orders of the Canadian soil classification system (Canada Soil Survey Committee 1978) are represented in the study area. The dominant soil subgroups are Orthic Gray Luvisols, Brunisolic Gray Luvisols, Gleyed Gray Luvisols, Podzolic Gray Luvisols and Orthic Eutric Brunisols (Boralfs, Aqualfs, Altalfs, Cryochrepts and Eutrochrepts) (Anon. 1975a).

More detailed descriptions of the nature and extent of the soils in this area are discussed by Knapik and Lindsay (1983), Twardy and Corns (1980), and Dumanski et al. (1972). These reports are accompanied by 1:126 720 scale maps.

Climate

Köppen's classification of climate describes the study area as a cold snow forest (Stringer 1972). This climate is characterized by cool summers and cold winters. The period 1 May to 30 September has a mean air temperature of 10-11°C. Average annual precipitation is 38-46 cm, 25-50% of which falls as snow between November and March; potential evapotranspiration is 38-43 cm, and frost-free period (greater than 0°C) is 60 to 160 days (MacIver et al. 1972). Mean January air temperature (mean of daily max. and min.) at Edson is -14.0°C. Grande Prairie to the north of the study area is colder (-17.3°C), and mean monthly air temperatures are below freezing for all stations from November to March inclusive (Anon. 1975b).

Vegetation

Most forest vegetation of the study area lies within the Mixedwood (B 18a), Lower Foothills (B 19a) and Upper Foothills (B 19c) sections of the Boreal Forest Region and in a small area within the East Slope Rockies Section (SA 1) of the Subalpine Forest Region (Rowe 1972). These units correspond to the Boreal Mixedwood, Boreal Foothills, Boreal Uplands and Subalpine Ecoregions mapped at 1:1 500 000 for Alberta by Strong and Leggat (1981).

METHODS

Plot Sampling and Classification

Data were obtained from approximately 900 sample plots used in the following studies: Krumlik et al.[2,3,4], Nemeth et al.[5], Corns (1978, 1983) and Lesko and Lindsay (1973). Although the work of Lesko and Lindsay (ibid.) is from the Chip Lake Map Area adjacent to the southeastern corner of the study area, it appears to be relevant to many of the lower elevations of the study area farther north. The 0.01- to 0.04-ha sample plots were selected with the aid of forest cover maps and aerial photographs within well developed homogeneous forest stands on a variety of soils and landforms. Plot sampling methodology was similar in all studies, and the sample plots were placed subjectively to obtain the best representation of soil and vegetation conditions. Plot location and general physiography (elevation, slope gradient and aspect, topographic position, relief shape and landform) were recorded on field sheets. Soils were described according to the Canadian System of Soil Classification (Canada Soil Survey Committee 1978). Vegetation was sampled in a fashion compatible with Braun-Blanquet's (1932) methods or those described by Walmsley et al. (1980). Classification was done by tabular comparison (Mueller-Dombois and Ellenberg 1974) with the aid of computer-generated vegetation and environment tables. In addition, all sample plots included forest mensur-

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[4]Krumlik, G.J., Johnson, J.D. and Lemmen, L.D. 1979. Biogeoclimatic system classification of Alberta--progress report for 1978/79 fiscal year. Dep. Fish. Environ., Can. For. Serv., Edmonton, Alta. 220 p. (unpubl.).

[5]Nemeth, Z.J., Kish, S.L. and Hendry, J.R. 1981. Biogeoclimatic classification of Alberta. Alta. Dep. Energy Resour., Resour. Eval. Br., Edmonton, Alta. Prog. Rep. No. 5.47 p. (unpubl.).

ational data. Site index was determined for all plots on the basis of dominant and codominant trees, and for most plots, stand volumes and mean annual increment (MAI) in total volume were also determined.

Ecoregion Mapping

During the 1982 field season, a ground and aerial reconnaissance was carried out by using fixed-wing and helicopter flights and by driving the major roads of the study area. Preliminary ecoregion boundaries were noted on 1:250 000 maps. Additional ground surveys were carried out during 1983 and ecoregion boundaries were placed on 1:250 000 maps from helicopter traverses of the study area. Although the ecoregions grade slowly into each other over a distance of several kilometres, especially in eastern parts of the study area, the different Boreal ecoregions could usually be separated from the air on the basis of canopy cover of tree species on upland sites. However, lodgepole pine is so pervasive (often to the exclusion of other tree species in the canopy) in the Upper Boreal Cordilleran (UBC) and Subalpine (SA) ecoregions that determining the UBC/SA boundary from the air is extremely difficult. The SA boundary is based on the general presence or absence of typical subalpine plant species in forest stands. Boundary points were established on the ground and the boundary was drawn on the map by extrapolating, mainly along elevational lines. LANDSAT images were interpreted and map boundaries were checked and adjusted accordingly.

In some cases, lines from other studies were used (e.g., those of Krumlik et al.[3] for parts of the Berland FMA, and those of Bentz et al. (1984) for REAP studies in the Coal Branch area south of Hinton). The final mapping scale is 1:500 000.

Large-scale mapping (e.g., 1:10 000 to 1:25 000) of ecosystem associations or complexes is recognized as a valuable tool for intensive forest management but was beyond the scope and resources of this study.

Interpretations for Forest Management

Interpretations of the ecosystem in order to address 12 concerns about forest management are made within an ecosystem association framework and are based on a variety of information sources including reconnaissance soil survey reports, available forest ecological information and observations by operational foresters and the authors. Quantitative data were not available for many interpretations nor for some ecosystem associations. In these instances data from similar environmental/ecological situations were extrapolated. Interpretations were made for a variety of attributes significant for forest management: season of harvest, site preparation intensity, soil compaction hazard, soil puddling hazard, soil erosion hazard, reforestation method, limitations, preferred species, seedling frost heave hazard, potential productivity in site index and MAI for dominant species, vegetational competition (type and severity), windthrow hazard, and snowshoe hare damage hazard. Detailed methodology used in making interpretive evaluations is presented in a field guide in preparation by the authors and in Corns and Annas (1984). Abbreviated methodology used in the interpretation follows.

Small-scale (1:250 000 or 1:500 000) computer-generated maps for the various management interpretations were produced with the aid of grid-cell coded reconnaissance soil survey maps, with interpretations affixed to a computer-coded extended legend.

Timber Harvest

The recommended season of harvest is designated "winter" (W) when ground is frozen or "all seasons" (A), depending largely upon the wetness of the site and its ability to support heavy equipment without site degradation through compaction or erosion. Sites suitable for summer harvest are generally suited to winter operations as well. All sites should be avoided during spring snow melt, when soil moisture is above field capacity.

Site Preparation Intensity

Site preparation intensity recommendations were made and designated low, moderate or high depending upon the environment (including soil properties, especially drainage and organic layer thickness), vegetation competition hazard and seed supply. Several equipment options are available to achieve similar results.

Soil Interpretations

Soil interpretations for the various ecosystem associations are based upon the predominant soils found with each association. Reconnaissance soil surveys completed over most of the study area (Dumanski et al. 1972, Twardy and Corns 1980, Knapik and Lindsay 1983) have rated soil mapping units for a variety of relevant interpretations including soil erosion hazard, windthrow hazard and transplant mortality. Work done by others (Boyer 1979) has enabled ratings for soil compaction and puddling to be made for the predominant soils of each ecosystem type.

It must be recognized that the ratings are general and relative, and that variation outside the ratings assigned to the ecosystem association descriptions can be expected as the soils occurring with a given soil subgroup or map unit will have a range of properties. It is not intended that these interpretations should supersede any knowledge gained by the forest manager through systematic observation and experience. It is therefore important to evaluate sites individually where site-specific information is desired. The ratings should be regarded as provisional until more detailed quantitative information is available. The interpretations are provided generally for each ecosystem association for broad management objectives but can be more accurately derived on a site-specific basis with the aid of qualitative and semi-quantitative background criteria provided in the field guide. The background information used in making the ratings comes from detailed sample plot data and relevant soil survey reports (Twardy and Lindsay 1971, Dumanski et al. 1972, Twardy and Corns 1980, Knapik and Lindsay 1983). Interpretations of the soil units/associations of the study area were summarized.

Soil compaction: The degree of soil compaction is influenced by a number of soil physical properties including texture, structure, percentage and type of coarse fragments, percentage organic matter and organic layer thickness (Boyer 1979). Compaction reduces porosity and rate of water infiltration and increases physical impedance to growing roots (Pritchett 1979, Froehlich[6], Greacen and Sands 1980). The horizon that gives the most severe rating in the upper 30 cm of mineral soil will determine the rating for the soil.

Soil puddling: Puddling is the physical condition of soil that results from the dispersal of soil particles, destruction of the soil structure and the formation of a dense crust on the soil surface. This crust has the same effect as a thin compacted layer, and is most common on soil surfaces where litter has been removed by burning or mechanical means. Reduced germination and increased mortality may be expected on soils compacted or puddled by logging equipment (Pritchett 1979). Wet, fine-textured soils with few coarse fragments, shallow organic layers and weak structure are most susceptible to puddling, while soils of any texture with thicker organic layers, abundant coarse fragments and strong structure are least susceptible (Boyer 1979). The ratings are based on the assumption that the organic layer is < 5 cm. If the organic layer is > 5 cm, a rating one class less severe (e.g., from moderate to low) would be applied.

Soil erosion hazard: Soil losses from forest areas are normally very small. Increases in erosion and stream turbidity are due mainly to road construction and other activities that expose large areas of mineral soil (Pritchett 1979). Many factors influence the susceptibility of soil to erosion and its parent materials: texture, type of structure, degree of carbonate cementing (parent materials), stone content, amount and type of vegetation cover, slope angle, length of slope, occurrence of recent fire, rainfall intensity and seasonal distribution, and rapidity of snowmelt. Only water erosion is considered in the present study. Wind erosion is generally not a problem in the study area, with the possible exception of some local soils in the Athabasca River valley. Infiltration capacity and structural stability are regarded as most important in controlling water erosion (Buckman and Brady 1960). The relative water erosion hazard ratings are based primarily on soil texture, estimates of infiltration and permeability rates, soil structure, soil wetness and slope angle, where surface organic layers have been removed.

Interpretations for Reforestation

Species selection: The species selected for reforestation of a site will depend upon both its biological and its economic suitability. The latter is more difficult to judge since it is virtually impossible to know which forest products will be available to and desired by the consumer at the end of the rotation. Clues to tree species biologically well adapted to a site can be determined from soil physical and chemical properties and the species (tree and understory) that naturally occupy the site. Climate, soil moisture regime, and to some extent nutrient regime can be inferred from the composition of the vegetation. Soil properties, particularly drainage and pH, will have a strong bearing upon the species selected for planting a site. The principal factors considered are climate, soil drainage, soil reaction (pH), organic layer properties (principally thickness), soil texture and knowledge of tree growth on various sites. These factors are integrated into the classification of the ecosystem associations. Species selection interpretations are made for each ecosystem association. Most of the soil information can be determined for the area in question from the reconnaissance soil survey reports and accompanying maps (Dumanski et

[6]Froehlich, H.A. 1982. The effects of mechanical operations on soil physical properties and forest productivity. Presentation to IUFRO symposium on site and continuous productivity, Seattle, Wash., 22-28 Aug. 1982 (unpubl.).

al. 1972, Twardy and Corns 1980, Knapik and Lindsay 1983). All factors should be considered together when one is rating a site in order to select the species best suited to that site.

Method of reforestation: Method of reforestation refers to the means by which satisfactory tree stocking is achieved on logged areas. The alternatives are natural seeding from slash or adjacent trees, root suckers (aspen), manual or direct seeding, containerized planting stock, and bare-root planting stock.

Limitations to the success of reforestation: The limitations discussed here are those of the site and do not include management considerations such as planting errors, which can be just as significant as site limitations (Froning 1972). The limitations are self-explanatory and include considerations such as excess moisture, drought, steep slopes and vegetational competition. High soil reaction (pH) is a problem on some soils of ecosystem associations in the Athabasca valley near Hinton. These are not described in this paper.

Frost damage hazard: Frost damage is rated for the predominant soils of the ecosystem associations described on the basis of their likelihood of heaving tree seedlings upon freezing. This rating is based primarily on the texture of the surface soil horizons and on the moisture content of the soil, reflected by its drainage class. The most susceptible soils are those with fine-textured surface horizons, high silt content and imperfect drainage, where surface organic layers have been removed. Topographic situation can be an important determinant of susceptibility to frost heave, with depressional situations being most susceptible.

Productivity of the Ecosystem Associations

Average values of gross mean annual total volume increment (MAI) and site index (70 yr) are given for the dominant species of each ecosystem association. The values are from sample plots in natural, unmanaged stands. Site index is estimated primarily by means of curves prepared by MacLeod and Blyth (1955) although data for 137 plots in the Wapiti map area are from stem analysis (see footnote 1, p. 1).

Certain factors, such as stand history, will contribute to a large range of productivity values, and were not considered in the studies used. A further and major source of error is that MAI was calculated by dividing total volume by average age, which will overestimate the productivity of young stands and underestimate the productivity of older stands. Much further study is required to obtain accurate estimates of the productivity of ecosystem units.

Vegetational Competition

Vegetational competition is rated according to type (predominant species or species groups) and severity, with respect to its influence upon young tree seedlings. Competition occurs for light, nutrients, water and space.

Types of vegetational competition include that by reedgrass (primarily *Calamagrostis canadensis* [Michx.] Beauv.), sedge (*Carex* spp.), ryegrass (*Elymus innovatus* Beal), green alder (*Alnus crispa* [Ait.] Pursh), willow (*Salix* spp.), bracted honeysuckle (*Lonicera involucrata* [Richards.] Banks) and forbs (especially those with large amounts of biomass and dense roots/rhizomes including *Mertensia paniculata* [Ait.] G. Don, *Aralia nudicaulis* L., *Aster conspicuus* Lindl., and *Epilobium angustifolium* L.).

Rodent Damage Hazard

The potential for seedling browsing by snowshoe hares and other rodents is dependent upon the presence of suitable habitat. Preferred habitat for snowshoe hares (the species causing most damage) is low, dense, woody vegetation (Keith 1966, Buehler and Keith 1982) and heavy slash that provides both cover from predators, and food. In the study area, such habitat is most plentiful in the Boreal Mixedwood ecoregion and Lower Boreal Cordilleran ecoregion at elevations below 1100 m, particularly on moist sites. The rodent damage hazard is based on the presence of dense, deciduous, shrubby understories in the ecosystem associations described. The ratings are relative and are given for near peaks in the population cycle in years when hares are very abundant. Other species groups responsible for girdling damage to young conifers include squirrel, mouse, vole and porcupine.

RESULTS AND DISCUSSION

The ecological zonation of the west-central Alberta study area, the forest ecosystem classification, key, descriptions, interpretations and detailed methodology are presented in a field guide being prepared by the authors. Only preliminary drafts of the field guide have been viewed by operational foresters in Alberta, and some of the methodology used in the interpretations, though applied to other geographic areas and based on sound background information, is still untested in Alberta. It will therefore be necessary to monitor user response to the guide with the aim of improving the classification and interpretive methodology.

It is anticipated that extension efforts in the form of office and field workshops will be conducted for potential users of the guide.

The Canadian Forestry Service is not involved with the inventory and ecological classifications of forest lands in Alberta. These activities are undertaken by the Resource Evaluation and Planning Branch of the Alberta Department of Energy and Natural Resources. Future research efforts in support of ecological classification will likely be aimed at quantifying growth and environmental responses to forest management activities, with the goal of developing predictive capability and optimizing forest land use and management decisions.

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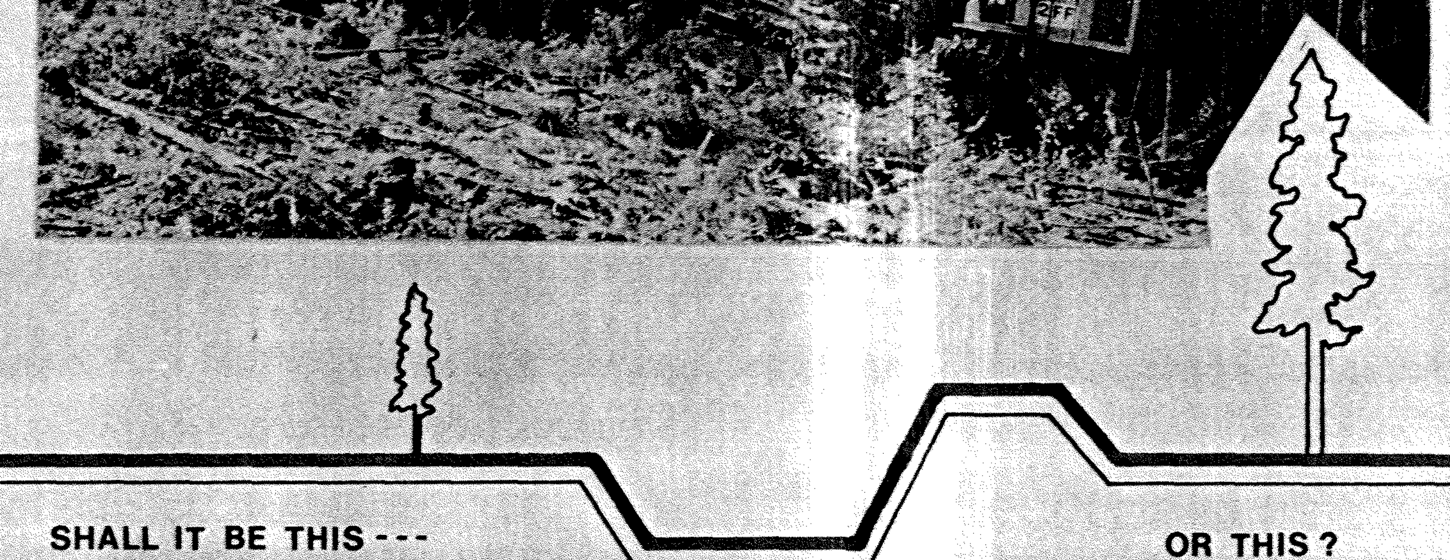
Site Classification in Relation to Forest Management



Proceedings of a Symposium sponsored by the Ontario Ministry of Natural Resources and the Great Lakes Forestry Centre under the auspices of the Canada-Ontario Joint Forestry Research Committee

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Ontario Ministry of Natural Resources
and the
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Canada-Ontario Joint Forestry Research Committee
Sault Ste. Marie, Ontario
27-29 August, 1985

G.M. WICKWARE and W.C. STEVENS, COCHAIRMEN

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