A FOREST LAND CAPABILITY CLASSIFICATION FOR THE EAST SLOPES AREA, ALBERTA

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P. J. B. Duffy and Z. Nemeth

FOREST RESEARCH LABORATORY

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ABSTRACT

Guidelines for the application of the National Forest Land Capability Classification to the East Slopes Area were prepared from the analysis of growth data and the aerial photo interpretation of 411 sample plot locations. Mean annual increment values were associated with relief-geology-cover type combinations which were discernible on aerial photographs.

A classification of forest land capability was presented with maximum capability values for the indicator species, lodgepole pine, for given relief-geology combinations. Analysis of permanent sample plot data from 85 locations in spruce cover types showed that lodgepole pine yields are the same or better than those for fully stocked white spruce or Engelmann spruce stands on relief-geology combinations in the East Slopes Area.

Limiting factors to tree growth were also presented together with their effects on the capability class.

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INTRODUCTION

A large portion of Alberta is being surveyed for agriculture, recreation, wildlife and forestry capability under the Canada Land Inventory program. Included is the East Slopes Area which comprises the Clearwater-Rocky, the Bow and the Crowsnest Forests (Figure 1, in back cover pocket). Forest land capability is to be assessed and mapped according to the National Land Capability for Forestry Classification (McCormack, 1967) by the Forest Surveys and Planning Branch of the Alberta Department of Lands and Forests.

The purpose of this paper is to provide a basis for the application of the National Classification in the East Slopes

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[1] Program Co-ordinator, Land Research, Ottawa and Forest Research Technician, Forest Research Laboratory, Alberta-Territories Region, Calgary, Alberta

Area from mean annual increment data from fully stocked stands of lodgepole pine (Pinus contorta var. latifolia), the main indicator species. The basis has been developed from a review of the pertinent literature and from an analysis of available sample plot data and aerial photographs from several hundred forest locations in the East Slopes Area.

THE ENVIRONMENT

Climate

A map of average annual precipitation in the East Slopes Area was recently prepared by Storr[2] (Figure 1). Based on rain gauge data at 95 stations, it provides an adequate picture of rainfall patterns in the area. It is seen that precipitation tends to increase in proximity to the Continental Divide, and to decrease to the east and in the vicinity of major east-west valleys in the foothills. Such east-west valleys are the North Saskatchewan Valley, the Bow Valley, and the Crowsnest Pass.

There is a close relationship between precipitation and average moisture deficit as calculated for the period 1921-1950 (Laycock, 1960). In general the deficit increases with distance from the Continental Divide, although the importance of this trend to forest growth is modified by variations in soil moisture

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[2] Storr, D. 1968. Personal communication, Canada Department of Transport, Meteorological Branch, Calgary, Alberta.

storage capacity and by the capacity of trees to utilize stored soil moisture (op. cit.).

Soils and Surficial Materials

Soils and surficial materials maps and reports are available for portions of the East Slopes Area. The soil survey report for the Rocky Mountain House Sheet (Peters and Bowser, 1960) was employed in the analysis of soil and land conditions on the eastern fringe of the area between the North Saskatchewan and the Red Deer Rivers. Stalker's (1962) surficial geology map of the Fernie Sheet (East Half) was used in the study of landforms in the Crowsnest Forest. In addition, a surficial materials map for the Kananaskis Research Forest served as a guide to the photo-interpretation of landforms in a mountain portion of the East Slopes Area (Duffy and England, 1967).[3]

The Forest

A broad forest classification is given in Rowe's "Forest Regions of Canada" (1959). The Lower Foothills Section (B.19a) of the Boreal Forest lies between 3,000 and 4,000 feet elevation along the eastern side of the East Slopes Area.

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[3] Duffy, P.J.B. and R.E. England, 1967. A forest land classification for the Kananaskis Research Forest, Alberta, Canada. Department of Forestry and Rural Development, Forest Research Laboratory, Calgary, Alberta. Internal Report A-9.

> "The distinctive tree species is the lodgepole pine which, with aspen (Populus tremuloides) and balsam poplar (P. balsamifera), has assumed a dominant position over much of the area in the wake of fire. In older forest stands the white spruce (Picea glauca) is an important constituent and black spruce (Picea mariana) is frequently present too."

The Upper Foothills Section (B.19c) of the Boreal Forest reaches up to 6,000 feet and the foothills are forested to their summits with conifers.

> "A distinctive feature in comparison with the lower-lying forests to the east is the relative scarcity of mixedwood stands, for the poplars (Populus tremuloides, P. balsamifera) and white birch (Betula papyrifera) are only sparsely represented. In addition to lodgepole pine, which is predominant, a major species is the typical white spruce rather than the Engelmann-white spruce complex which occupies the same altitudinal zone in subalpine forests. Black spruce is a frequent constituent of forests north of the Red Deer River, but its occurrence is sporadic to the south. Alpine fir (Abies lasiocarpa) is somewhat less prevalent than in the neighbouring mountains, and tamarack (Larix laricina) has only a scattered distribution."

The East Slope Rockies Section (SA.1) of the Subalpine Forest Region covers the Rocky Mountains and the rugged adjacent foothills between 5,000 and 6,800 feet. The lower limit of the Section (5,000 foot contour) is shown in Figure 1.

> "... a coniferous forest distinguished from that of the Upper Foothills (B.19c) by the presence of Engelmann spruce (Picea engelmanni) and the Engelmann-white spruce hybrid complex. An important associated species is the lodgepole pine whose powers of prolific regeneration following fire have resulted in the replacement of the spruce over wide areas. At higher altitudes within the subalpine zone, alpine fir is abundant, especially in the older spruce forests. Toward treeline, the whitebark pine (Pinus albicaulis) is found on rocky ridges and exposed slopes, and at similar altitudes in the southern half of the Section, the limber pine (P. flexilis) and alpine larch (Larix lyallii) also

> appear. Along the lower altitudinal boundary in extreme South-western Alberta there is some presence of Douglas fir (Pseudotsuga menziesii) where contact is made with a fragment of the Montane Forest, and northward a fringe of aspen groveland occupies the transition to the plains grassland."

Roughly half of the East Slopes Area is in the Subalpine Forest Region. A small portion of the area is in the Douglas Fir and Lodgepole Pine Section (M.5) of the Montane Forest Region; the main elements are located in the Porcupine Hills, and in the Bow and Kananaskis Valleys. Douglas fir - lodgepole pine mixtures occupy the warm dry sites and cool, moist locations are dominated by white spruce.

ANALYSIS OF DATA

Growth Data

The indicator species for this classification is lodgepole pine because it is the dominant coniferous species in the area and it occurs on almost all physiographic sites. For details in the silvics, ecology, and site-growth relationships of pine, the reader is referred to Tackle (1959), Smithers (1962), and Duffy (1964).

Data were examined from several hundred permanent and temporary sample plots from the Alberta Department of Lands and Forests (Forest Surveys and Planning Branch) and from the Canada Department of Forestry and Rural Development (Figure 1). Those plots were retained which represented coniferous stands in age classes from 60 to 130 years and with basal areas which represented

full stocking (i.e. 130 square feet per acre for till and lacustrine sites and 100 square feet for all other sites). Plots with over 1,000 trees per acre were taken to be overstocked and were rejected. For good plots, numbering 411 in all, it was possible to make a reliable estimate of mean annual increment (m.a.i.) at 100 years, the rotation age established for the forest land capability rating in Alberta.

Gross merchantable volume data were used to calculate m.a.i. at stand age and these data were converted to m.a.i. at 100 years using Smithers' m.a.i. curves (1962, Figure 14). The m.a.i. (100) value was then converted to the capability class as described by McCormack (1967):

		m.a.i. at 100 years
Capability Class	3	71-90 cubic feet per acre per annum
	4	51-70 cubic feet per acre per annum
	5	31-50 cubic feet per acre per annum
	6	11-30 cubic feet per acre per annum
	7	Less than 10 feet per acre per annum.

In order to find out whether spruce species would give higher productivity than lodgepole pine, data from 85 permanent sample plots in spruce types were analyzed by similar methods to those outlined above.

Photo Interpretation

In a continuous photo-interpretation exercise each plot location was systematically examined under two Old Delft Scanning Stereoscopes set in tandem. Each plot environment was reviewed

together with sample plot stand data and available soils or surficial material maps. Plots were categorized according to relief - geology - cover type classes, by the following groupings:

1. Relief - U - undulating 0 - 2% slopes
   - GR - gently rolling 3 - 9% slopes
   - R - rolling 10 - 15% slopes
   - H - hilly 16 - 23% slopes
   - M - mountainous 24% and up

2. Surficial material - glacial till
   alluvial - lacustrine
   alluvium - mainly coarse sand and gravel
   aeolian
   colluvium
   residual

3. Cover type - lodgepole pine
   white spruce
   Engelmann spruce
   trembling aspen
   alpine fir

4. Elevation - <4000 feet above sea level
   4000 - 4500 feet above sea level
   4500 - 5000 feet above sea level
   5000 - 5500 feet above sea level

5. Aspects - eight points

6. Miscellaneous notes on stocking level,
position on slope,
drainage anomalies (e.g. springs, seepage areas),
other factors.

The m.a.i. values were then grouped by surficial material, relief class and elevation in order to establish the maximum capability for given physiographic sites (relief - geology - cover type classes) within given elevation limits. No statistical analysis was employed to test significant differences between sites and so the arbitrary nature of the analysis must be recognized.

The highest m.a.i. values were selected from each physiographic site and entered into Table 1. In this regard the relief class was taken as the indicator of drainage class.

Limiting factors were examined to establish estimates of their effects (as subclasses) on capability levels. Examples were aridity (Symbol A), exposure (V), soil moisture deficiency (M), restriction of rooting zone by bedrock (R), and actively eroding soils (E).

RESULTS

Indicator Species

For the Upper Foothills Section of the Boreal Forest (B.19c) it was found that, in general, pine productivity (mean

annual increment) was higher than that of spruce on most sites and in a few cases it was the same.

For the East Slope Rockies Section of the Subalpine Forest Region (SA.1) (over 5,000 feet elevation) pine productivity was higher than that of spruce on all sites except on alluvium where productivity was the same.

Black spruce was associated with poorly and very poorly drained soils and muskeg as far south as the Red Deer River. South of the Red Deer River black spruce was not common.

The main indicator species was taken to be lodgepole pine with spruce species yielding similar productivity on alluvial sites in the Subalpine Forest Region. Black spruce was the recommended indicator species for very poorly drained till, lacustrine, and muskeg sites.

Capability Classes

The capability classes given in Table 1 represent maximum growth rates for fully stocked stands of lodgepole pine on given physiographic sites as recognized on aerial photographs.

The best m.a.i. values (Capability Class 3) in the East Slopes Area were associated with deep, moderately well-drained till sites up to 4,000 feet elevation and occasionally up to 4,500 feet.

TABLE 1. MAXIMUM CAPABILITY CLASSES BY SURFICIAL MATERIALS - DRAINAGE[4] UNDER THE 4,500 FOOT CONTOUR, EAST SLOPES AREA, ALBERTA

DECREASING SOIL AERATION, POROSITY ↓

	INCREASING SOIL MOISTURE →					
	Rapidly[5] drained	Well drained	Moderately, well drained	Imperfectly drained	Poorly drained	Very Poorly drained
Aeolian sand	6	6	5	5	5-6	-
Alluvium	5	5	4	4	5	5-6
Colluvium	5-6	5	4	4	-	-
Residual[6]	5-6	4	-	-	-	-
Till/bedrock	5	4	4	4	5	5-6
Till	5	4	3	4	5	5-6
Alluvial-Lacustrine	5	4	4	4	5	5-6
Muskeg	-	-	6	6	7	-

[4] Based on growth data from 411 sample plots in the East Slopes Area.

[5] For definitions of drainage classes see: National Soil Survey Committee of Canada (1965).

[6] Residual sites are predominantly above the 5,000 foot elevation.

TABLE 2. LIMITING FACTORS (CAPABILITY SUBCLASSES)

Climate	A - drought or aridity as a result of climate - up to 1 class drop C - drought and exposure - up to 2 classes drop H - frost pockets - up to 1 class drop U - exposure - up to one class drop
Soil Moisture	M - deficiency - up to 2 classes drop W - excess - up to 3 classes drop X - M and W mixed
Depth rooting zone	R - restriction of rooting zone by bedrock - up to 1 class drop
Other soil factors	E - active erosion - up to 2 classes drop F - low fertility - up to 1 class drop on some alluvium and aeolian sites P - stoniness - up to 1 class drop on some colluvium sites I - periodic inundation by lakes or streams

Capability Class 4 lands were found on well-drained, moderately well-drained, and imperfectly drained sites on a wide spectrum of surficial materials (alluvium, colluvium, till/bedrock, till, and alluvial-lacustrine) up to approximately the 4,500 foot elevation.

Capability Class 5 lands were found mainly on rapidly drained, poorly drained, and very poorly drained sites on alluvium, colluvium, till/bedrock, till, and alluvial lacustrine surficial materials, on well-drained, alluvium and colluvium, and on moderately well-drained, imperfectly drained, and poorly drained aeolian sand.

Capability Class 6 lands were confined to the dry and the wet ends of the table, namely on rapidly drained and well drained aeolian materials as well as poorly drained aeolian and on very poorly drained alluvium, till/bedrock, till, and alluvial lacustrine sites.

Capability Class 7 was mainly confined to very poorly drained muskegs and rocky alpine sites.

Capability Subclasses (Limiting Factors)

Several factors seemed to limit forest growth in the East Slopes Area. However, it was not possible to give precise estimates of their effects because very little research has been carried out on this subject. What follows is a discussion of what maximum effects might be expected from the several limiting factors. The estimates given here are based mainly on

empirical studies and are meant to serve as guidelines in rating individual relief-geology combinations.

Climate

A - drought or aridity as a result of climate.

Where the annual rainfall is less than 15 inches, the limitation may be a one class drop.

V - exposure (including unfavourable aspects and exposure to drying winds)

South and west aspects and slopes which are exposed to drying winds, may be downgraded as much as one class. A combination of drought or aridity and exposure may be downgraded as much as two classes.

H - frost pockets

Where there is an apparent hazard to unseasonal frosts, there may be a drop of as much as one class.

Soil moisture

M - deficiency

Depending upon the apparent external and internal drainage characteristics on a site, there may be a drop of as much as two classes.

W - excess

As shown in Table 1 this limitation may result in a drop of as much as three classes.

X - M and W mixed

The capability drop will be dependent upon the severity of the moisture deficiency and excess.

Depth rooting zone

R - restriction of the rooting zone by bedrock

Depending upon the surficial material and its depth and other factors there may be a capability drop of as much as one class.

Other soil factors

E - active erosion

Where mass movement, slumping and active erosion is evident, there may be a capability drop of as much as two classes.

F - low fertility

This limitation may be important on some coarse gravelly alluvium and aeolian sites and may result in a capability drop of one class.

P - stoniness

This limitation is apparent in rock slide, talus cone, and colluvial sites in the Subalpine Forest Region. It may result in a drop of as much as one capability class.

I - soil periodically inundated by streams or lakes.

This limitation may be of minor importance in the East Slopes Area. No estimate of capability drop will be made in this paper.

Altitude

Altitude is not a limiting factor in itself, nevertheless altitude is related to forest growth. In this study it was found that, in general, Capability Class 3 occurred on some lands up to 4,000 feet elevation and rarely up to 4,500 feet. Class 4 lands occur up to 5,500 feet elevation, and Class 5 lands can be found up to 6,000 feet elevation.

These represent the best capability classes by elevation class in this review of several hundred permanent sample plot locations.

Application of the Results

Capability classes and subclasses may be assigned for East Slopes Area sites on the basis of aerial photo interpretation of the terrain and forest cover. Given the surficial material and drainage characteristics the photo interpreter may establish the maximum capability class for a relief - surficial material combination. The limiting factors for the given land unit will then be appraised to arrive at the subclass and its effect on the capability class value "on the basis of all known and inferred information about the unit, including subsoil, soil profile, depth, moisture, fertility, landform, climate and vegetation" (McCormack, 1967).

Not all of the East Slopes Area was sampled for growth and yield. Sites over much of the following areas are not represented in this classification (see Figure 1):

a) north of Rocky Mountain House,

b) between the Forestry Trunk Road and the west boundary of the East Slopes Area,

c) between the Kananaskis Research Forest and Dutch Creek, and,

d) the Porcupine Hills.

SUMMARY

In order to facilitate the application of the National Forest Land Capability Classification in the East Slopes Area, available growth and yield data were reviewed together with aerial photographs of the sample plot locations. Mean annual increment values were calculated from data from 411 sample plots and these values were then associated with the common relief-geology combinations. Limiting factors were identified and estimates were made of their downgrading effects on the capability classes.

Lodgepole pine was taken as the main indicator species. The best pine growth (Capability Class 3, M.A.I. 71-90 cubic feet) is associated with deep, moderately well-drained till sites below the elevation of 4,500 feet. Above this elevation this site is associated with Capability Class 4 (M.A.I. 51-70 cubic feet).

Less productive land (Capability Class 4) is found in a wide range of surficial materials (alluvium, colluvium, till/bedrock, till, and alluvial lacustrine) on well-drained to imperfectly drained locations.

As the soil moisture conditions become more extreme (rapidly drained, well drained, poorly drained and very poorly drained) and on porous aeolian soils, capability ratings drop to 5 (M.A.I. 31-50 cubic feet) and 6 (M.A.I. 11-30 cubic feet). Some muskeg and rocky alpine sites are rated Class 7 (M.A.I. less than 10 cubic feet).

The main limiting factors appear to be drought (low rainfall), exposure to sun and drying winds on south and west-facing slopes, soil moisture deficiency and excess, and restriction of the rooting zone by bedrock.

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REFERENCES

Duffy, P. J. B. 1964. Relationships between site factors and growth of lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) in the Foothills Section of Alberta. Canada Department of Forestry Publication No. 1065. 60 pp.

Laycock, A. H. 1960. Drought patterns in the Canadian Prairies. Extract of Publication No. 51 of the International Association of Scientific Hydrology, Commission of Surface Waters, Helsinki, pp. 34-47.

McCormack, R. J. 1967. Land capability for forestry. Canada Land Inventory Report No. 4. Canada Department of Forestry and Rural Development. 26 pp.

National Soil Survey Committee of Canada. 1965. Proceedings of the Sixth Meeting, Laval University, Quebec. Canada Department of Agriculture, Ottawa.

Peters, T. W. and W. E. Bowser. 1960. Soil survey of the Rocky Mountain House Sheet. University of Alberta Bulletin No. SS-1, Department Extension, Edmonton. 51 pp. and 2 maps.

Smithers, L. A. 1962. Lodgepole pine in Alberta. Canada Department of Forestry Bulletin 127, 153 pp.

Stalker, A. M. 1961. Surface geology, Fernie Sheet 829 (East Half). Canada Department of Mines and Technical Surveys, Geological Survey of Canada. Map 31 - 1961.

Tackle, D. 1959. Silvics of lodgepole pine. U.S.D.A. Forest Service, Intermountain Forest and Range Experiment Station, Misc. Publ. No. 19. 24 pp.