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ECOLOGY OF THE FORESTS
IN THE ROCKY MOUNTAINS OF ALBERTA

by

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(Manuscript based on Projects A-59 and A-71)

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ABSTRACT

The Rocky Mountains of Alberta are described in terms of the climate, geology, soils, and vegetation. The spruce and pine forests are classified into a number of associations and communities, each of which is typified by specific habitat and floristic characteristics. A brief description and classification is given for the black spruce, Douglas fir, and aspen stands of the mountains.

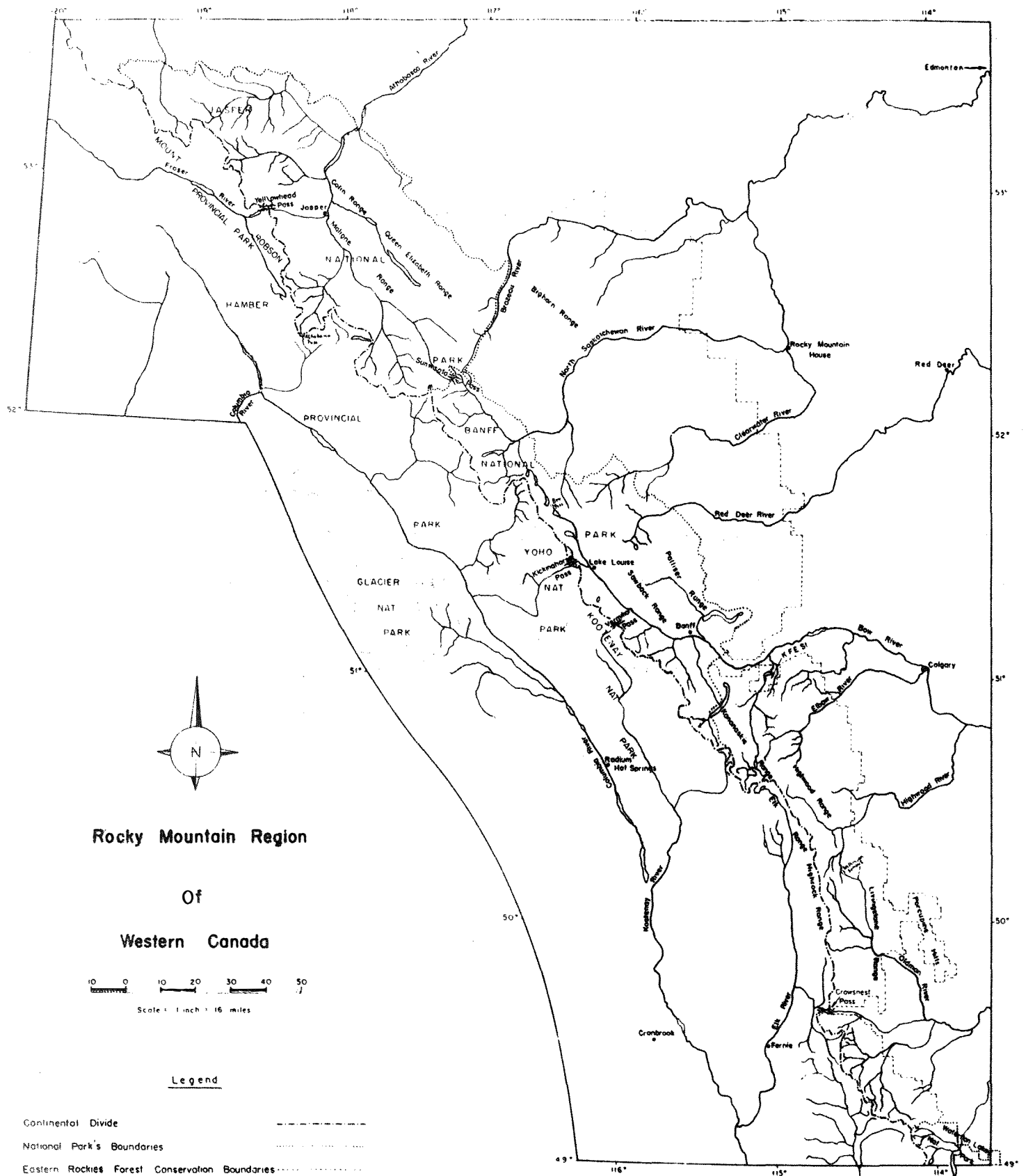


FIGURE 1.

ECOLOGY OF THE FORESTS IN THE ROCKY MOUNTAINS OF ALBERTA^{1/}

by

R. T. Ogilvie^{2/}

INTRODUCTION

This investigation was begun as an ecological study of the spruce-fir forest of the Rocky Mountains of Alberta. Following two years of work, by which time an ecological classification for the spruce-fir forest had been obtained, it was apparent that to obtain a complete classification for the forested mountain region, the investigation should be extended to include the extensive lodgepole pine stands. The following two years were devoted to investigating the lodgepole pine stands, with some additional analyses of spruce-fir stands.

The purpose of the investigation was to obtain descriptive information of the forests of the mountains, to obtain detailed information on the range in environmental features and the associated vegetation, and to provide a vegetation-environmental classification of this forest region.

The following is a preliminary account of the results of this work. Only the essential data are included in this report; the detailed data of the association tables, soil analyses and tree measurements are omitted and will be presented in a subsequent, more detailed report.

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GENERAL DESCRIPTION OF STUDY AREA

The study area extends from the British Columbia-Alberta border, the Continental Divide, eastward to the outermost range of the mountains where it is bordered by the foothills region (Figure 1). From north to south it comprises the area from Jasper National Park to Waterton Lakes National Park at the International Border.

Vegetation

The mountain slopes are covered with lodgepole pine and spruce forest. The lodgepole pine stands (Pinus contorta var. latifolia)^{1/} are of fire origin, and in the absence of fire will be replaced by spruce stands. Fire has recurred repeatedly through this region and probably 65% of the forested area is composed of seral lodgepole pine stands. The spruce forest is composed of Picea glauca near the valley bottoms, and Picea engelmannii in the upper slopes near timberline, and in the broad zone between, hybrids predominate: Picea glauca X Picea engelmannii. Abies lasiocarpa is co-dominant with Engelmann spruce and the hybrid spruce. Near timberline Pinus albicaulis and Larix lyallii occur. The latter species only occurs south of the headwaters of the Bow River. Timberline occurs at ca. 7000 feet elevation; above this is alpine heath and meadow vegetation. Along the bottoms of the broad valleys there is a complex of vegetation. There are westward extensions into the mountains of the prairie grassland, and of the boreal-foothills forest. In the warmer and drier parts of the valleys Douglas fir, Pseudotsuga menziesii var. glauca, vegetation occurs. In the northern part of the region there is restricted occurrence of Picea mariana.

^{1/} Nomenclature for vascular plants follows Moss (1959) and Hitchcock et. al. (1955-1961); for bryophytes, Bird (1962).

Climate

These broad vegetation types have their own characteristic climatic conditions. The higher elevations and the parts closer into the crest of the mountains have a higher annual precipitation (ca. 30 - 45 inches per annum), and the seasonal distribution pattern is winter-high, summer-low, similar to a maritime pattern. In the broad valley bottoms and further out from the main crest of the mountains the total precipitation decreases and the distribution pattern is summer-high, winter-low. This is similar to a continental distribution pattern as in the prairie-grassland and boreal-foothills vegetation. Stations which are of the latter group, are: Banff Town - 18 inches per annum, Jasper Town - 14 inches p.a., and Coleman - 20 inches p.a., (see Tables 1 & 2, Figures 2 - 5).

Table 1.

Selected Climatic Data for Stations In The Rocky Mountains,
(Dominion Meteorological Division).

| | <u>Alt.</u> | (1) | (2) | (3) | (4) | (5) | (6) |
|-------------|-------------|-----|--------|--------|-------|-------|------|
| Coleman | 4300' | 37° | -2, - | -, 76 | 19.7" | 10.4" | 9.3" |
| Kananaskis | 4400' | 36° | 3, 26 | 43, 72 | 26.7 | 10.9 | 15.7 |
| Banff | 4500' | 36° | 4, 22 | 43, 73 | 17.95 | 8.7 | 9.3 |
| Lake Louise | 5050' | 31° | -8, 17 | 36, 71 | 26.9 | 16.6 | 10.3 |
| Jasper | 3500' | 37° | 4, 20 | 45, 74 | 14.3 | 6.4 | 7.9 |

Data included: (1) mean annual temperature, (2) range of winter temperature: lowest mean minimum and highest mean maximum in winter; (3) range of summer temperature: lowest mean minimum and highest mean maximum in summer; (4) mean annual precipitation in inches; (5) winter precipitation (October 15 to May 15); (6) summer precipitation (May 15 to October 15).

Mean Monthly Precipitation - Inches

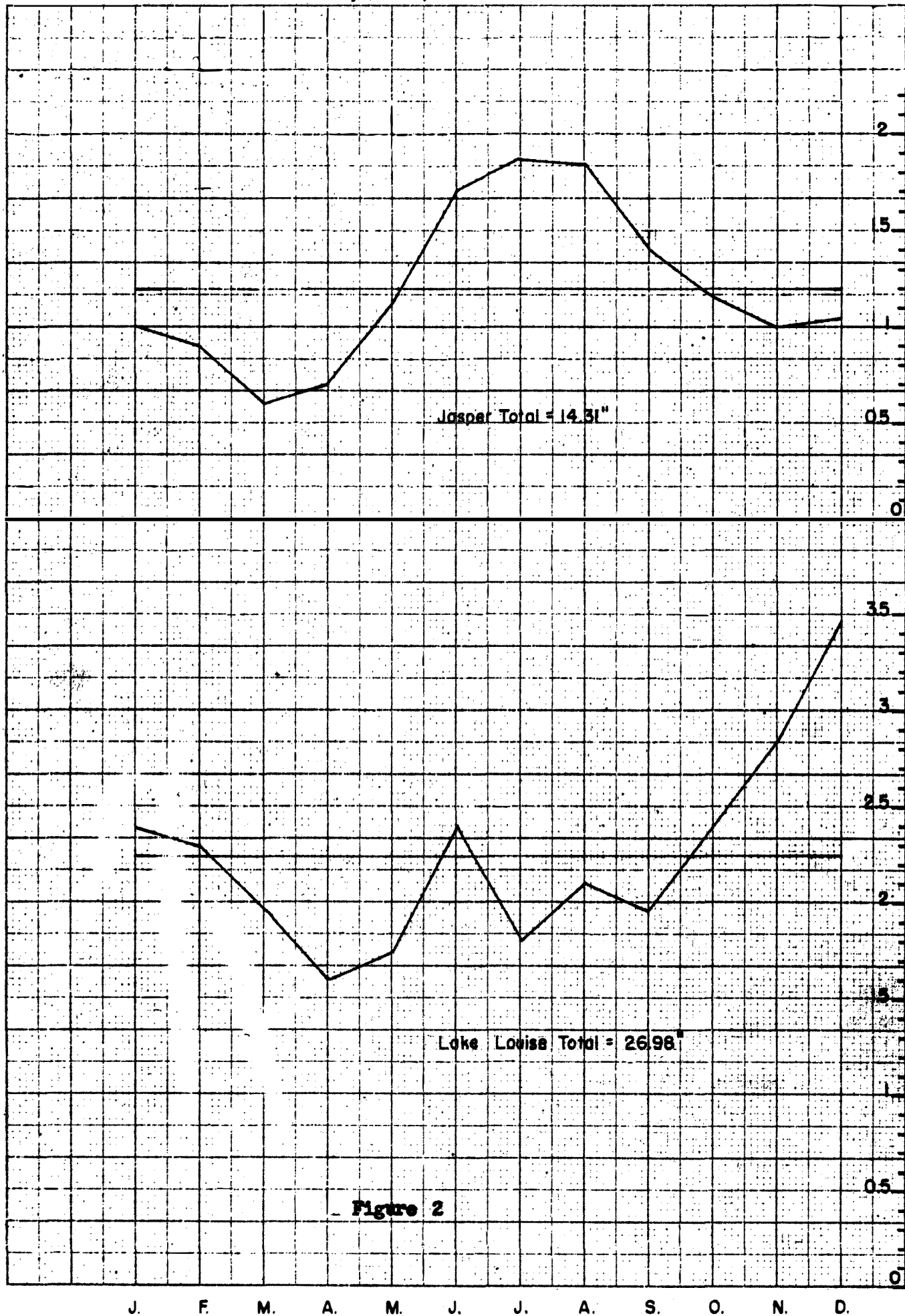
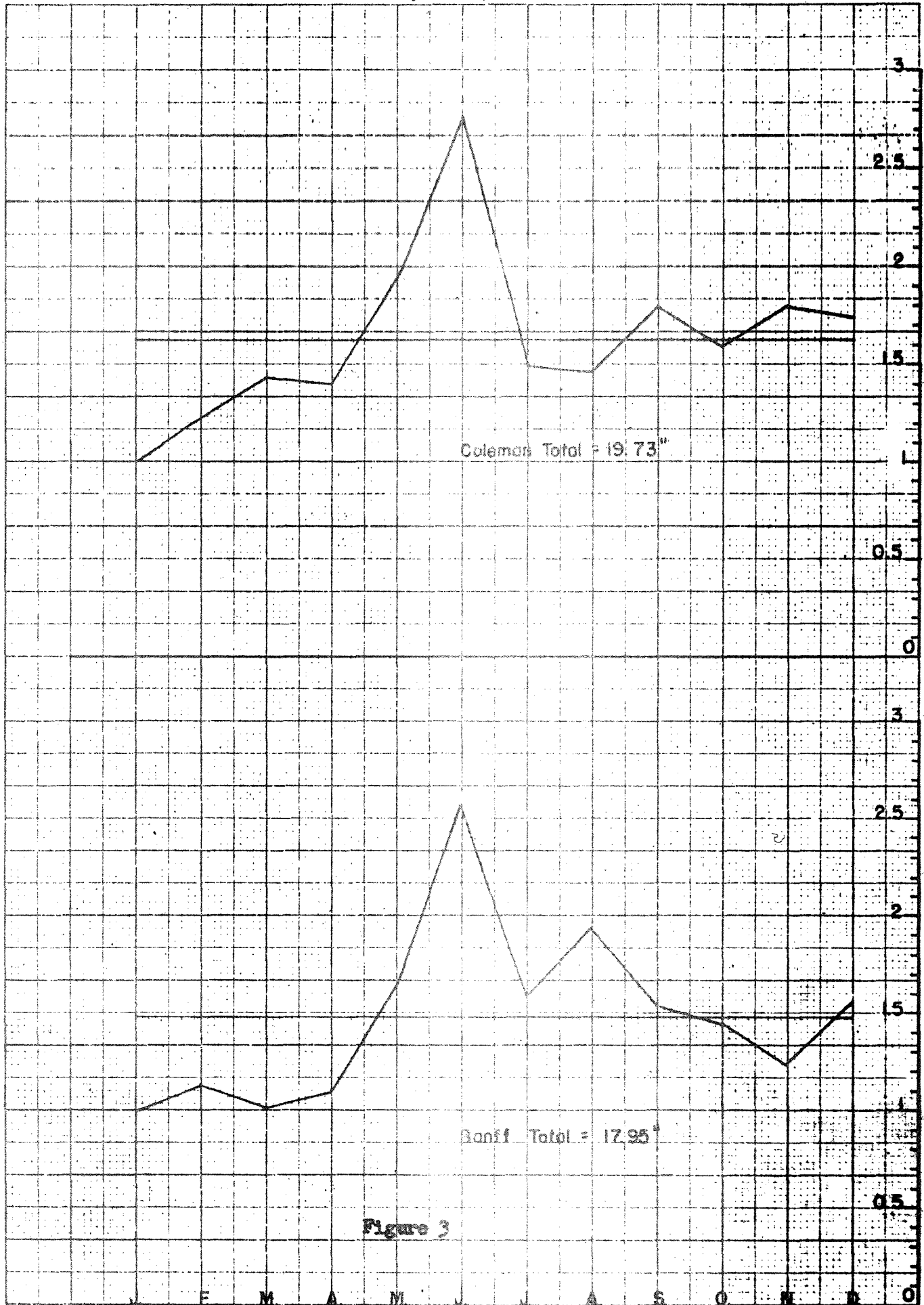
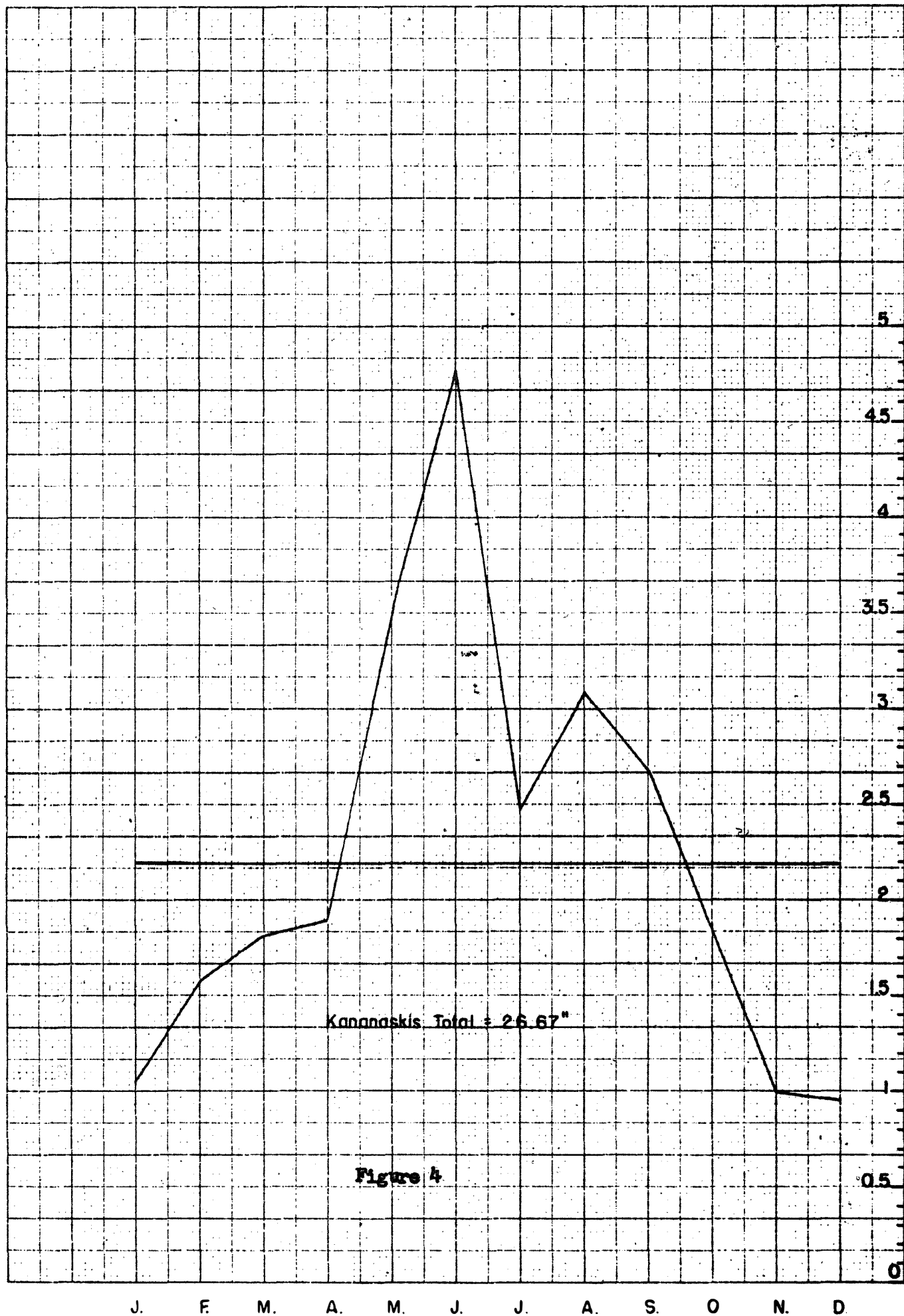


Figure 2

- 5 -
Mean Monthly Precipitation - Inches



Mean Monthly Precipitation—Inches



- 7 -
Mean Monthly Precipitation—Inches

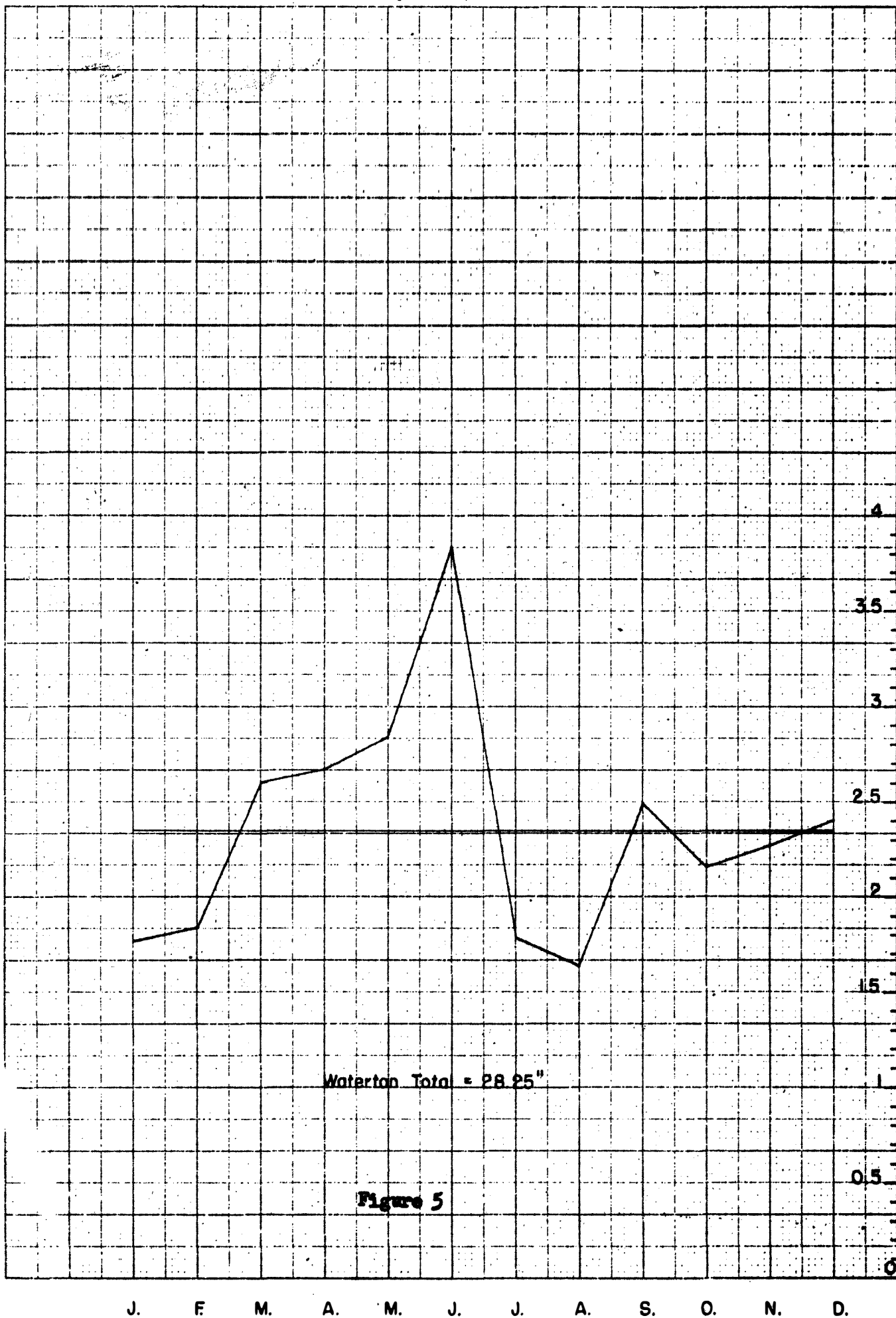


Figure 5

Table 2.

Winter (October 15 - May 15), Summer (May 15 - October 15), And
Annual Precipitation Data, From Stations Of The Eastern Rockies Forest
Conservation Board.

| | <u>South of Crowsnest</u> | | | <u>Oldman Drainage</u> | | | <u>Southern Bow Drainage</u> | | |
|-----------------|---------------------------|----------|----------|------------------------|----------|----------|------------------------------|----------|----------|
| <u>Altitude</u> | <u>W</u> | <u>S</u> | <u>A</u> | <u>W</u> | <u>S</u> | <u>A</u> | <u>W</u> | <u>S</u> | <u>A</u> |
| 4000-5000' | 15.2 | 11.1 | 26.7 | 11.3 | 9.8 | 21.1 | 9.1 | 11.7 | 20.7 |
| 5000-6000 | 22.6 | 12.0 | 35.7 | 11.9 | 11.4 | 23.3 | 12.3 | 10.7 | 22.6 |
| 6000-7000 | 24.8 | 13.5 | 37.0 | 13.3 | 11.9 | 25.6 | 15.1 | 11.0 | 26.7 |
| 7000+ | | | | 11.7 | 10.4 | 22.0 | 15.9 | 9.6 | 25.4 |

Summer drought and deficient soil moisture during the growing season is common in well-drained valley bottom sites and the lower southerly-facing mountain slopes. In these sites this is one of the prime factors influencing plant growth in general, including forest regeneration (Day, 1963).

The growing season is extremely short, approximately three to four months duration. Snowfall and freezing temperatures occur in every month of the year. This severe climate limits growing conditions as well as the floristic composition of the region.

The major air masses controlling the climate of the mountain region are the cold polar air masses from the north and warm maritime air masses from the west. During the winter, warm, dry, adiabatically-heated air masses from the west produce the "Chinook" phenomenon which is characteristic of western Alberta. The rapid and extreme fluctuations in temperature and the exposure of vegetation by snow-melt during the winter, are important factors affecting the vegetation.

The typical pattern of decreasing temperature with increased altitude is frequently reversed by nocturnal inversions and downslope cold air

drainage. Stark (1959) and Henson, et. al. (1954) describe winter temperature inversions along the Bow Valley in Banff National Park. When cold, arctic, continental air masses are not displaced by new air masses they stagnate over the valley, and by radiational cooling the lowest air layers become increasingly cooler than the air above. On three days, January 29-31, the minimum daily temperatures at valley bottom were four to six degrees (F.) lower than at 700 feet up the valley slope, (Stark, 1959). Forest vegetation along the mid-slopes of the valleys is undoubtedly influenced in a number of ways by the "thermal belt" which occurs below the extreme temperatures at higher elevations, and above the extreme temperatures produced by the inversions in the valley bottoms. For example, foliage damage to lodgepole pine by desiccation (red belt injury) occurs along the east face of the Bow Valley opposite the major mountain passes in an altitudinal zone coinciding with the bottom of the thermal belt where temperatures fluctuate most (Henson, 1952).

Geology and Soils

The Rocky Mountains occur along a major trough - the Cordilleran Geosyncline - which has undergone repeated submergence and uplifting. Extensive sedimentary strata of limestones, sandstones, and shales were deposited during the periods of submergence. The most recent uplift which gave rise to the present mountain chain occurred during the Pleiocene and Pleistocene epochs.

The mountains have been described on the basis of four stratigraphic groups (Mackay, 1952). Precambrian and Lower Paleozoic strata form the broad backbone of the mountains. They occur in the western parts of Banff and Jasper Parks, and compose most of the mountains in

Waterton Park. The rocks are hard, compact quartzites, shales, slates, and limestones. Most of the eastern part of Banff and Jasper Parks are composed of strata of the Devonian, Carboniferous, Permian, Triassic, and Jurassic group. These rocks are hard siliceous shales and limestones which are resistant to weathering. They form the prominent fault-block ridges and ranges such as in the Goat Range, Sulphur Mountain, Mount Rundle, Spray Valley, and along the crest of Crowsnest Pass. The Lower Cretaceous group is composed of compact shales, hard sandstones, and finely-cemented conglomerates, which are more resistant to weathering than the Upper Cretaceous group. These strata are found mainly in the foothills, but occur in Banff National Park in the Palliser Range and Three Sisters Mountain, and extend southward parallel to the Continental Divide to the Crowsnest area. The youngest group of strata, of Upper Cretaceous and Tertiary, are soft rocks consisting of soft shales, slightly compacted sandstones, and loosely cemented conglomerates. Their occurrence is mostly in the foothills region but they extend westward into the mountains in a few localities. There is a small occurrence of this group in Jasper Park, in the Kananaskis Valley, and along the Continental Divide to the Crowsnest, and in the eastern part of Waterton Park.

During the Pleistocene epoch extensive glacial erosion of the mountains and valleys occurred, and deposition of glacial materials took place. The Laurentide Ice Sheet extended westward to about the 4000-foot level along the foothills. The Cordilleran Glacier Complex, consisting of a coalescence of the valley and mountain glaciers, extended down and out from the east flank of the Rocky Mountains for about fifty miles (Flint, 1957). Thus, there was a coalescence of the Cordilleran and Laurentide glacier systems, and an intermingling of their deposits.

Apparently, however, there are a few areas along the mountains and foothills in which the two ice sheets did not meet; these areas are of phytogeographical significance.

The glacial deposits, as well as the alluvial materials washed and deposited by the streams, are mostly calcareous. Thus most of the soil-forming parent materials are calcareous. Most of the upland soils are Podzolic, in addition to some Brunisolic profiles. Regosolic and Gleysolic Soils occur along streams where there is a high water table. Organic Bog Soils occur in areas where impervious substrata cause impeded drainage and peat accumulation.

METHODS

Stands were selected for study which were essentially healthy and of uniform density, and free from recent disturbance by fire, logging, and animals.

A one-tenth acre plot was used for analysis. Trees were measured for diameter at breast height, height, and age. Height and ages were recorded by height class. A minimum of ten trees were selected from each of the dominant and co-dominant classes, and a minimum of five trees were selected from each of the intermediate and suppressed classes. Age samples were made of the different sizes of regeneration.

All the plant species were listed by six strata, and the percentage cover was determined for each of the strata:

- dominant and co-dominant trees
- intermediate trees
- suppressed trees and tall shrubs greater than 2 m.
- suppressed trees and low shrubs less than 2 m.
- herbs
- bryophytes and lichens

Each plant species was rated for cover-abundance and for sociability, according to ten-degree scales. Notes were made of: elevation, degree and direction of slope, topographic position, as well as the effects on the stand of animals, insects, pathogens, wind, and snow.

The soil profile was described by horizon, for texture, structure, stoniness, moisture, colour, and presence of carbonates from reaction with dilute hydrochloric acid. Samples were collected from each soil horizon; these were air-dried, passed through a 2 mm. sieve, and the percentage gravel determined. The pH was determined using a Beckman pH meter. Mechanical analysis was done by the hydrometer method (Bouyoucos, 1951).

Voucher specimens were collected for each plant species encountered, and collections were made of any plants which were taxonomically complex or in poor condition for field identification. One hundred and seventy-five plots were analysed in this manner; and in addition field notes were made of the vegetation and habitat features of many other stands which were not analysed in detail.

RESULTS

The data from the soils, habitat notes, and floristic analyses were used to typify the forest communities which were delimited in the classification. Main weight was given to species of high cover-abundance and high constancy. The stands have been classified into categories called plant associations. This category has been used only for stands of climax status. Seral stands such as lodgepole pine have been grouped as a sub-category of the appropriate plant association, and are called community. In the usual usage, the term community is a general one applied to a grouping of plants, regardless of size of group. Here,

it is used in this general sense, and not as a specific taxonomic unit of synecology. The land area occupied by the plant association, regardless of the present successional status of the stands, is called habitat type (Daubenmire, 1952). It is a term used to include all the successional stages of the land area of a plant association. Thus, there is an Arctostaphylos uva-ursi habitat type which exists as mature, climax spruce forest, as lodgepole pine stands, or as recently burnt-over or logged-over areas. Minor differences of habitat and vegetation within a plant association are treated as variants of the plant association.

Most of the spruce stands examined were around 200 years old, the younger ones about 100 years, and the oldest stand 480 years. The lodgepole pine stands were mainly around 75 to 100 years; a number of 50 year old stands were studied, and the oldest stand was 300 years. Fire has been extremely common in the forest. All of the lodgepole pine stands are of fire origin; and for the most part are even-aged, with an understorey of spruce and fir regeneration. There are a few pine stands which are so large and remote from spruce and fir seed source that seedlings and regeneration of these species are rare. Many of the spruce stands have been burnt at some time in the past; charcoal is frequently encountered in the upper soil horizons. The stands near timberline have had the most protection from fire, and probably only these stands have not been burnt at some period in the past. Regeneration of spruce and fir in lodgepole pine stands occurs over an extended period, resulting in broadly-aged spruce-fir stands. Subsequent regeneration in spruce stands produces an uneven-aged composition. The spruce stands studied were essentially either uneven-aged or broadly-aged.

Forest productivity is relatively low and tree growth is comparatively

slow in this region as compared, for example, to adjacent British Columbia. The maximum height of spruce is around 120 or 130 feet, at 250 or 300 years. The maximum diameters at breast height for these ages are ca. 24 to 30 inches. Lodgepole pine grows rapidly in its early years, until about 90 years, after which time growth is extremely slow. One hundred year old pine at maximum height are about 85 feet tall, with 14 inches diameter at breast height. Maximum height is ca. 110 feet, and maximum diameter breast height is 18 inches, at around 250 years.

The habitat types have been rated qualitatively for tree growth. This five-part scale: very poor, poor, fair, medium, and good, is based largely on maximum dominant height. Stands rated as very poor are unmerchantable, stands rated as poor are marginal in merchantability. Such stands are at high elevation; their low timber volume, sparse stocking, and small trees, as well as the inaccessibility of the stands and the erodability of the terrain suggest that they should be left as watershed protection forest.

When the investigation was begun it was found that the study area was not similar throughout; there are marked differences between the southern portion (the Crowsnest-Waterton area) and the portion to the north, (Ogilvie, 1962). There are over one hundred species of vascular plants, and also a number of mammals, which occur in the southern area but not in the area to the north. There are also many plant species which are very abundant in the southern area but which occur only occasionally in the rest of the mountain region. There are several significant climatic differences between the southern part and the rest of the mountain region. All these features combine to make the southern

Crowsnest-Waterton area significantly different biologically and climatically from the rest of the mountain region. For this reason the two areas are treated separately, and separate ecological classifications are made for each.

Resume of Classification

To provide a broad view of the classification, a list of the types is given below along with an abbreviated generalised statement of the habitat conditions of each of the types.

11. Picea - Abies / Vaccinium scoparium - 6400 feet to timberline; well podzolised soils; glacial parent material; deep snow; soil frozen late.
6. Picea - Abies / Menziesia - Lycopodium - 5500 to 6300 feet; strongly podzolised soils; glacial parent materials.
Picea - Abies / Ledum - Empetrum - mid-valley slopes; seepage; gleyed podzolic soils.
4. Picea - Abies / Hylocomium - Cornus - 4500 to 5500 feet; northerly aspects; podzolised soils; glacial and glacial-fluvial parent materials.
Hylocomium - Alnus - less pronounced bleached A₂ horizon.
Hylocomium - Vaccinium - medium-textured parent materials.
Hylocomium - Cladonia - coarse parent material, stony from surface throughout profile.
7. Picea - Abies / Equisetum - bordering tributary streams at mid-elevations; stratified medium-textured alluvial parent material; gleyed profile, high water table.
2. Picea - Abies / Calamagrostis - 4600 to 5000; lower south-facing slopes and valley bottom; medium-textured alluvial and glacial-fluvial parent materials; weakly podzolised soils, bleached A₂ less pronounced; susceptible to fires.

Calamagrostis - Vaccinium - more acid humus; A₂ more pronounced and bleached.

Calamagrostis - Cladonia - coarser parent material, stony from surface throughout profile.

9. Picea / Arctostaphylos - 4200 to 4700 feet, valley bottom and lower terraces; well drained, coarse alluvial parent material; weakly podzolised soils; susceptible to fires.

Arctostaphylos - Vaccinium - hard, compact parent materials.

Arctostaphylos - Cladonia - stony soils.

Picea / Equisetum - bottom of broad major valleys, along rivers; medium-fine textured, recent alluvial parent material; high water table; gleyed profile.

9. Picea / Sphagnum - Ledum - bottom of broad major valleys; ponded, lacustrine, clay materials; impeded drainage, excessive stagnant water, peat accumulation.

Southern Area

Picea - Abies / Menziesia - infrequent; high elevations; shallow podzolised soils with bedrock close to surface.

Picea - Abies / Xerophyllum - high elevations; south aspects; shallow podzolised soils from thin glacial material on bedrock.

Picea - Abies / Xerophyllum - Pachistima - intermediate elevations; well podzolised soils on glacial parent material.

Picea - Abies / Menziesia - Tiarella - middle and upper slopes, 5000 to 6000 feet; highly developed podzolic soils on glacial parent material.

Picea - Abies / Pachistima - mid-valley slopes, 4500 to 5500 feet; podzolised soils on coarse glacial and glacial-fluvial parent materials; susceptible to fires.

Picea - Abies / Calamagrostis - Lupinus - valley bottom and lower valley slopes; southerly aspects, well drained, medium-coarse, alluvial and glacial-fluvial parent materials; weakly podzolised profiles; susceptible to fires.

Picea - Abies / Heracleum - Equisetum - valley bottom, bordering streams; medium textured alluvium; high water table, gleyed profile.

Pseudotsuga menziesii Associations

Pseudotsuga menziesii / Arctostaphylos - calcareous, coarse, stony alluvium; profile unpodzolised.

Pseudotsuga menziesii / Calamagrostis - podzolised soil on coarse, glacial-fluvial parent material.

Pseudotsuga menziesii / Calamagrostis - Lupinus - shallow, unpodzolised soils on glacial or glacial-fluvial parent materials.

Pseudotsuga menziesii / Symphoricarpos - more mesic conditions: deeper soils and more northerly aspects.

Picea mariana Associations

Picea mariana / Carex - valley bottom; calcareous, heavy clay, alluvial-lacustrine material; impeded drainage.

Picea mariana - Larix laricina / Ledum - Sphagnum - Carex - level terrain; impeded drainage; deep peat.

Picea mariana - Abies lasiocarpa / Ledum - Carex - higher elevations, glacial parent material; high water table; gleyed profile.

Picea mariana - Picea glauca / Arctostaphylos - valley bottom; intermixed fine and coarse alluvial parent material, calcareous, unpodzolised.

Spruce-Fir Habitat Types

Main Area

Picea / Equisetum Association

Along the major rivers there is flat terrain formed from material which has been deposited by the river. Much of the material is medium-fine textured: silts and fine sands. Near the river where the water table is relatively high, the soils are immature, gleyed, fine alluvial soils, with an A - C horizon sequence. Mottling from gleisation occurs high in the profile, at around 9 inches, and lime occurs throughout the C horizon.

A₀₀ + A₀ 0-2" litter from needles, horsetails and mosses; very sparse mycelium. pH 7.4 (7.05-7.65)

A₀ (+ C) 2-6" intermixed, decomposed organic matter and mineral material; granular; loam; lime. pH 7.75 (7.7-7.95)

C 6-9" brown-gray, slight red mottling; massive to granular; loamy sand to loam; lime. pH 8.0 (7.95-8.1)

9" - gray, mottled with red; strong seepage; massive; loamy sand to loam; lime; fine, river-deposited parent material. pH 8.0 (7.85-8.2)

The tree layer is composed of Picea glauca, and a small amount of Populus balsamifera.

The sparse shrub layer consists of mainly: Lonicera involucrata, Salix spp. (S. barclayi, S. pseudomonticola), Rubus pubescens, Viburnum edule, and Cornus stolonifera.

A dense growth of Equisetum arvense and E. pratense covers the ground in the herb layer. Other typical herbs are: Carex vaginata, C. concinna,

Petasites frigidus var. palmatus, Equisetum scirpoides, Osmorhiza chilensis, and Mitella nuda.

The bryophyte and lichen layer consists typically of: Mnium affine, Mnium spp., Brachythecium sp., and Timmia austriaca.

Spruce growth is good in this type. The trees tend to be shallowly rooted, and exposed parts of the stands are susceptible to windthrow. The moistness of this habitat protects the stands of this type from fires, and lodgepole pine rarely occurs in this type.

Picea / Sphagnum - Ledum Association

Elsewhere along the broad river flats there are areas where fine clay material has been deposited. Drainage is impeded, and excessive stagnant water gives rise to bog vegetation. Peat from Sphagnum and Carex material accumulates to a depth of at least 4 feet to form Bog Soils. The peat material is highly basic at the surface, becomes more acid with depth, and is underlain by calcareous clay.

Deeper Bog Profile

0-7" living Sphagnum. pH 7.65

8-11" peat. 7.7

15" free water.

20-22" peat. pH 5.8

30-32" peat. 5.55

43-45" peat. 6.0

Shallower Peat Profile

0-4" peat. pH 6.6

17-20" peat. 6.35

22" free water.

22-24" clay loam with organic matter. pH 7.2

32-35" clay; blue with red mottling, lime. 8.2.

The tree layer is composed of small, narrow-crowned Picea glauca, suggesting the physiognomy of black spruce muskeg. Pinus contorta is sometimes present.

There is a well-developed shrub layer consisting typically of: Ledum groenlandicum, Betula glandulosa, Salix candida, and S. myrtillofolia. Beneath this, are the low, procumbent shrub species: Empetrum nigrum, Vaccinium vitis-idaea, V. oxycoccus, and Rubus pubescens.

The herb layer is dominated by Carex aquatilis, C. leptalea, C. vaginata, as well as Equisetum scirpoides, E. variegatum and E. arvense. Other typical species are: Juncus balticus, Eriophorum viridi-carinatum, Glyceria striata, and Pedicularis groenlandica.

The abundant moss layer consists of: Sphagnum spp., Aulacomnium palustre, Camptothecium nitens, and Polytrichum juniperinum on the summits of the dry peat tussocks.

This type is not abundant in the mountain region as a whole; however, locally along the Bow River it is common. Peat habitats also occur in Jasper National Park, but those are occupied by Picea mariana communities.

Less developed variants of this type occur, having a shallower peat layer and sometimes indications of occasional flooding: the peat is overlain by a band of silt and further peat is formed above. Correlated with these profile differences are a reduction in Sphagnum spp., and an increase in Equisetum arvense and Carex spp.

Spruce growth is very poor in this type. Rooting is shallow, windthrow is common, and stocking is sparse. The ground beneath the peat

frequently remains frozen late in the year.

Picea / Arctostaphylos uva-ursi Association

Well away from the river on older, coarse gravel and sand deposits, the soils are more mature. There is some development of an acid, leached A₂ horizon and of a B horizon.

| | | |
|----------------------------------|------------|--|
| A ₀₀ + A ₀ | 0-3/4" | sparse, dry litter from needles and <u>Arctostaphylos</u> leaves; mycelium absent or very sparse. pH 7.1 (6.75-7.55) |
| (A ₁) | 3/4-1 1/2" | patchy occurrence, or absent; dark brown-black, melanised; granular; lime. pH 7.8 (7.5-8.0) |
| A ₂ | | patchy occurrence, ca. 1/4" thick; light gray, single grain. pH 6.4 (5.85-6.75) |
| B _{Ca} | 2-10" | red brown to yellow brown; weak blocky gravel and stones, loamy sand to loam; lime. pH 7.8 (7.15-8.35) |
| C _{Ca} | 12" | gray brown; massive, coarse alluvial material with abundant stones, gravel and sand; lime. pH 8.1 (7.7-8.6) |

This type occurs at elevations between 4200 and 4700 feet.

Picea glauca makes up the tree layer.

There is a well-developed shrub layer composed typically of:

Shepherdia canadensis, Juniperus communis, Potentilla fruticosa, Rosa acicularis, and occasionally Symphoricarpos albus. Beneath this is the low, prostrate shrub layer dominated by Arctostaphylos uva-ursi, with some Juniperus horizontalis.

The herb layer consists typically of: Elymus innovatus, Carex concinna, C. eburnea, Anemone multifida, Viola adunca, Campanula rotundifolia, Gentianella amarella, Pyrola virens, and Fragaria virginiana var. glauca.

The bryophyte and lichen layer is rather impoverished, with some occurrence of: Drepanocladus uncinatus, Dendroalsia abietina, Brachythecium

sp., Tortula ruralis, Polytrichum piliferum, Peltigera canina, and Cladonia spp.

Spruce growth is fair; the stocking is generally sparse.

Because of the coarseness of the soil material the soil is excessively drained and droughty. The dryness of this habitat renders the forest stands susceptible to fires, and much of this type is now occupied by Pinus contorta.

The Arctostaphylos type is common under Pinus contorta stands.

A generalised soil profile is as follows:

| | | |
|---|---|--------------------|
| $A_{00} + A_0$ ($0-\frac{1}{2}$ or 1") | thin organic matter from pine needles, <u>Arctostaphylos</u> and grass foliage; charcoal; mycelium absent or very sparse. | pH 5.97 (5.2-7.35) |
| A_1 ($\frac{1}{2}$ -1") | variable: thin or sometimes absent; melanised material; loamy sand to sandy loam. | pH 7.0 (6.7-7.5) |
| A_2 ($1-1\frac{1}{2}$ ") | variable: thin or sometimes absent; yellow gray, single grain; sandy loam. | pH 6.2 (5.7-6.65) |
| A_3 ($1\frac{1}{2}$ -3") | variable: thin or absent; yellow gray; granular; loose; sandy loam. | pH 6.7 (6.2-6.85) |
| B_1 (3-6") | variable: thin or absent; yellow brown; granular; gravelly sandy loam. | pH 6.7 (6.2-7.05) |
| B_2 (6-18") | yellow brown; lime; blocky; stony; gravelly to very gravelly sandy loam to sand. | pH 7.2 (6.6-8.1) |
| B_3 (18-21") | thin or absent; lime; weak blocky; gravelly sand. | pH 7.4 (7.2-7.6) |
| C (21" -) | yellow gray; lime; massive; stony very gravelly sand to sandy clay loam. | pH 8.1 (7.9-8.5) |

The shrub layer is well developed, composed typically of:

Arctostaphylos uva-ursi, Shepherdia canadensis, Rosa acicularis, Juniperus communis, and Amelanchier alnifolia.

The herb layer is abundant, with: Elymus innovatus, Linnaea borealis var. americana, Achillea millefolium var. lanulosa, Campanula rotundifolia, Fragaria virginiana var. glauca, Gentianella amarella ssp. acuta, Pyrola virens, Solidago multiradiata, Carex concinna, and Aster conspicuus.

The bryophyte and lichen layer is well developed, composed typically of: Brachythecium salebrosum, Brachythecium spp., Drepanocladus uncinatus, Polytrichum juniperinum, P. piliferum, Tortula ruralis, Dicranum rugosum, Cladonia spp., and Peltigera canina.

Pine growth is fair in this type.

There are two variations of the Arctostaphylos type. One of these has an abundance of Vaccinium caepitosum associated with Arctostaphylos uva-ursi. This type occurs commonly on hard and compact, water-washed glacial tills. Other floristic differences are an increase in: Antennaria nitida, Aster ciliolatus, Hedysarum sulphurescens, and Pyrola secunda.

The other variation of the Arctostaphylos type occurs on coarse stoney alluvial and glacial materials, with abundant stones at the surface.

This community has high dominance of Cladonia spp. Other species occurring in greater abundance in this type are: Juniperus communis, Antennaria neglecta, Koeleria cristata, Senecio cymbalarioides, and Solidago multiradiata.

Picea - Abies / Calamagrostis rubescens Association

This association occurs on the medium-textured materials along the valley bottom, and extending up the south-facing valley slopes.

Although moisture conditions are favourable for growth, the ground vegetation is highly inflammable and this type is very susceptible to fires. Most of the stands of this type are lodgepole pine.

The soils are podzolic, with a leached A₂ horizon above a brown B horizon.

| | | | |
|----------------------------------|---------|--|--------------------|
| A ₀₀ + A ₀ | 0-1" | litter from pine needles and grass foliage; sparse mycelium; charcoal. | pH 5.3 (4.75-6.2) |
| A ₂ | 1-3" | yellow gray, single grain, sandy loam, loose and soft. | pH 6.0 (4.95-6.9) |
| A ₃ | 3-6", | or absent. Yellow gray; sandy loam to sandy clay loam; granular. | pH 6.8 (6.3-7.25) |
| B ₁ | 6-9", | or absent. Yellow brown; sandy loam to sandy clay loam; weak blocky to granular. | pH 6.9 (6.05-7.7) |
| B _{2Ca} | 9-20" | brown; gravelly, sandy clay loam to loam; blocky; compact. | pH 7.5 (7.0-7.9) |
| B _{3Ca} | 20-24", | or absent. Gray brown; gravelly, sandy clay loam; weak blocky to massive. | pH 8.0 (7.7-8.3) |
| C _{Ca} | 24" | yellow gray; gravelly, sandy loam to loam; massive. | pH 8.15 (7.9-8.6). |

The tree layer consists of Pinus contorta, Picea glauca, Abies lasiocarpa, and occasionally some Populus tremuloides.

The shrub layer is well developed, consisting typically of: Shepherdia canadensis, Arctostaphylos uva-ursi, Rosa acicularis, Juniperus communis, and Spiraea lucida, and often Vaccinium caespitosum and V. scoparium.

The herb layer is very abundant, consisting mainly of: Calamagrostis rubescens, Elymus innovatus, Aster conspicuus, Linnaea

borealis var. americana, Fragaria virginiana var. glauca, Pyrola virens, Hedysarum sulphurescens, Arnica cordifolia, Carex concinna, Castilleja hispida, Aster ciliolatus, Achillea millefolium var. lanulosa, and Gentianella amarella ssp. acuta.

The bryophyte and lichen layer is only moderately developed, with mainly: Brachythecium spp., Drepanocladus uncinatus, Dicranum rugosum, Pleurozium schreberi, Hylocomium splendens, Polytrichum juniperinum, Cladonia spp., and Peltigera apthosa.

Growth of lodgepole pine is fair in this type.

There are two variations of the Calamagrostis type. The Calamagrostis - Cladonia community has very abundant Cladonia spp.; the soil is coarser and stonier, and there are abundant stones at the surface.

The Calamagrostis - Vaccinium community has abundant Vaccinium caespitosum and often V. scoparium; the soil profile has a more acid humus horizon, and there is a more pronounced ashy A₂.

Picea - Abies / Hylocomium splendens - Cornus canadensis Association

Moving up out of the valley bottoms on to the lower valley slopes, from 4500 to 5500 feet elevation, on north to east aspects, the precipitation begins to increase, and the soils are more podzolised. There is an acid mat of moss and needle material, an ashy, leached A₂ horizon, and a well-developed B horizon.

A₀₀ + A₀ 0-3" decomposing moss and needles; abundant mycelium.

pH 4.9 (3.9-6.7)

A₂ 3-4" bleached, ashy gray; single grain; sandy loam.

pH 4.5 (3.7-4.9)

B₁ 4-5" variable; yellow brown to gray brown; granular to weak blocky; sandy loam to sandy clay loam.

pH 6.5 (5.1-7.7)

| | | | |
|----------------|-------|--|--------------------|
| B ₂ | 5-20" | yellow red to red brown; blocky; gravelly, sandy loam to clay loam. | pH 6.7 (5.0-7.9) |
| C | 20" | coarse, stony glacial and glacial-fluvial material; gravelly to extremely gravelly, loamy sand to clay loam; lime. | pH 7.3 (5.6-8.15). |

The tree layer is composed of Picea glauca, the hybrid P. glauca X P. engelmannii, and Abies lasiocarpa.

A sparse shrub layer consists mainly of: Rosa acicularis, Lonicera involucrata, and occasionally Ribes lacustre, Juniperus communis, and Alnus crispa var. sinuata.

The herb layer is moderately developed, composed typically of: Cornus canadensis, Linnaea borealis var. americana, Pyrola secunda, Elymus innovatus; as well as: Arnica cordifolia, Stenanthium occidentale, Pyrola asarifolia var. purpurea, and P. uniflora.

The striking feature of this association is the continuous carpet formed by the predominant bryophyte and lichen layer. The typical species consist of: Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis, Peltigera aphthosa, and Cladonia spp.; as well as: Mnium spp., Dicranum fuscescens, and Timmia austriaca.

Spruce growth is good in this type; spruce regeneration may tend to be excessive and cause overstocking and suppression.

Lodgepole pine stands are abundant in this type. The main features of difference between the spruce-fir stands and the pine stands are: in the pine stands there is a great increase in the shrub and herb layers, a rather thinner humus horizon, and a less bleached and less acid A₂ horizon.

A generalised soil profile is as follows:

A₀₀ + A₀ 0-2" organic matter from decomposing moss and pine needles;

| | | | |
|----------------|--------|---|--------------------|
| | | abundant mycelium. | pH 4.7 (3.6-6.05) |
| A ₂ | 2-3" | variable; bleached ashy gray to yellow gray; single grain; sandy loam. | pH 5.3 (5.0-6.2) |
| B ₁ | 3-6" | variable; red brown; granular to weak blocky; sandy loam to sandy clay loam. | pH 6.8 (5.9-7.7) |
| B ₂ | 6-20" | yellow brown; blocky; gravelly to very gravelly, loamy sand to sandy clay loam. | pH 7.05 (5.8-8.1) |
| B ₃ | 20-24" | variable; yellow brown; weak blocky to massive; very gravelly, sandy loam to clay loam; lime. | pH 7.3 (6.35-7.8) |
| C | 24" | yellow gray; massive; stony, gravelly to extremely gravelly, sandy loam to sandy clay loam; lime. | pH 7.9 (6.75-8.15) |

The shrub layer is well developed, consisting of: Shepherdia canadensis, Rosa acicularis, Juniperus communis, and Salix spp.

The herb layer is well developed, composed typically of: Elymus innovatus, Cornus canadensis, Linnaea borealis var. americana, Pyrola secunda, Fragaria virginiana var. glauca, Epilobium angustifolium, Arnica cordifolia; as well as Pyrola virens and Calypso bulbosa.

The bryophyte and lichen layer is most abundant, consisting of: Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis, and Dicranum fuscescens.

Pine growth is good in this type.

Hylocomium - Alnus community

This community is striking in its dense, tall shrub layer, composed of Alnus crispa var. sinuata, with some Rosa acicularis, Shepherdia canadensis, Viburnum edule, and Juniperus communis.

The herb layer is similar to the main Hylocomium - Cornus association, with a few minor species showing greater abundance, such as:

Pyrola asarifolia var. purpurea and Habenaria obtusata.

The bryophyte and lichen layer consists typically of: Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis, Peltigera aphthosa, and Rhytidiadelphus triquetrus.

Lodgepole pine growth is best in this type.

This community occurs typically on northerly slopes, on coarse alluvial and glacial-alluvial materials. Compared to the typical Hylocomium - Cornus association the soils of this type are less acid in the surface horizons: $A_{00} + A_0$ pH 5.4 (4.9-6.1), A_2 pH 6.0 (5.05-6.6). The A_2 also lacks the bleached, ashy colour, and tends towards yellow gray to reddish gray.

Hylocomium - Cladonia community

This community occurs on level terrain, on coarse alluvial and glacial-alluvial materials. The soil profile consists of coarse, stony material extending from the ground surface throughout the profile. The humus layer is thinner, less developed, and has sparse mycelium, compared to the main Hylocomium - Cornus association. The shrub layer consists of greater abundance of Arctostaphylos uva-ursi, Vaccinium scoparium and V. caespitosum. The herb layer is essentially the same as in the typical Hylocomium - Cornus association. The distinct difference in this type is the great abundance of Cladonia spp. In addition to the moss species of the typical Hylocomium - Cornus type, the bryophyte and lichen layer has more abundant Dicranum rugosum, Polytrichum juniperinum, and P. piliferum. This type has fair lodgepole pine growth.

A frequent variant of this type has very abundant Vaccinium scoparium and V. caespitosum in the shrub layer. This variant is probably worthy of recognition as a separate community, but because of scarcity of plot data, it is included with the Hylocomium - Cladonia type with which

it has the most similarity. Pine growth is medium in this type.

Picea - Abies / Menziesia ferruginea - Lycopodium annotinum Association

On the middle and upper valley slopes, from 5500 to 6300 feet elevation, the mountain spruce-fir forest reaches its maximum development. Moisture conditions are favourable throughout the growing season, there is deep snow accumulation, and the soils are strongly podzolised. There is a deep acid layer of organic matter, a broad, ashy A₂ horizon, and a well developed, reddish, acid B horizon.

| | | | |
|----------------------------------|--------------|---|--------------------|
| A ₀₀ + A ₀ | 0-4" | decomposing litter from needles and mosses; mycelium very abundant. | pH 4.3 (3.7-5.15) |
| A ₂ | 4-6½" | bleached, ashy gray; platy to single grain; sandy loam. | pH 3.9 (3.5-4.3) |
| B ₁ | 7-10" | brown red; granular to weak blocky; soft, loose consistency; gravelly, sandy loam to sandy clay loam. | pH 4.9 (4.25-5.45) |
| B ₂ | 10-20" | yellow brown; blocky to weak blocky; gravelly to very gravelly, sandy loam. | pH 5.4 (4.8-6.8) |
| C | upper 20-24" | gray brown; massive; no lime; frequent cementation; very gravelly to extremely gravelly, sandy loam. | pH 6.5 (5.4-7.7) |
| | lower 24" | yellow gray; massive; lime; frequent cementation; stony, very gravelly to extremely gravelly, sandy loam. | pH 7.5 (5.5-8.1) |

The tree layer consists of the hybrid Picea engelmannii X P. glauca, Picea engelmannii, and Abies lasiocarpa.

The tall shrub layer is dense, composed of Menziesia ferruginea, with a small amount of Rhododendron albiflorum, Lonicera involucrata, and

Ledum groenlandicum. Below this, the low shrub layer is composed of: Vaccinium scoparium, Vaccinium myrtillus, and some V. membranaceum.

The herb layer is very sparse, consisting mainly of: Lycopodium annotinum, Linnaea borealis var. americana, Arnica cordifolia and A. latifolia, Cornus canadensis, Pyrola secunda, and Elymus innovatus.

The very abundant bryophyte and lichen layer consists of: Pleurozium schreberi, Hylocomium splendens, Ptilium crista-castrensis, Peltigera aphthosa, Dicranum fuscescens, and liverworts.

Spruce growth is good in this type.

Stands of the Menziesia - Lycopodium type are less susceptible to fires and are infrequently burned. Lodgepole pine stands of this type are rare. Their soils have a shallower and less acid humus horizon: pH 4.4 (3.7-5.0), the A₂ is less acid: pH 4.75 (4.3-5.7) and is frequently a yellowish or reddish gray, rather than the typical bleached ashy gray. The shrub layer is similar to the spruce-fir stands of this type, except for an increased abundance of Juniperus communis. The herb layer is more abundant than under spruce-fir stands of this type, with a greater amount of Epilobium angustifolium and Pyrola virens. Growth of lodgepole pine is very poor.

Picea - Abies / Ledum groenlandicum - Empetrum nigrum Association

Along the valley slopes there are localised places where groundwater comes closer to the soil surface and seepage occurs. The soil is gleyed-podzolic, with a bleached A₂ horizon, but with mottling in the lower B and C horizons.

The vegetation of this association shows relationships to the communities which adjoin it. This association might be considered as "seepage variants" of the Vaccinium, Menziesia - Lycopodium, and Hylocomium - Cornus associations, but it has a degree of distinction in the greater abundance of Ledum groenlandicum, Empetrum nigrum, Equisetum scirpoides,

E. variegatum, Pedicularis bracteosa, and Senecio triangularis.

Picea - Abies / Vaccinium scoparium Association

This type occurs at the highest elevations, from 6400 feet to near timberline. There is very deep snow accumulation, an extremely short growing season with suboptimal temperatures, and frozen soil late in the year. The stands have a distinctive physiognomy: low, ericaceous shrubs and gray Cladonia tufts cover the floor beneath the narrow-crowned trees. Towards timberline the forest becomes discontinuous, with meadows and heaths interspersed between the stands of trees.

The soils are podzolic, but because of the lower temperatures the degree of podzolisation is less than at lower elevations such as in the Menziesia - Lycopodium type. The soil profile has a narrow humus horizon, an ashy A₂, and an acid B.

| | | | |
|----------------------------------|---------------------|---|-------------------|
| A ₀₀ + A ₀ | 0-2" | decomposing needle and moss litter; very sparse to sparse mycelium. | pH 4.7 (3.8-5.65) |
| A ₂ | 2-3 $\frac{1}{2}$ " | ashy gray, single grain to platy; sandy loam to loam. | pH 4.5 (3.9-5.25) |
| B ₁ | 4-6" | variable. yellow red to red brown; weak blocky; gravelly, sandy loam to loam. | pH 4.8 (4.2-5.5) |
| B ₂ | 6-16" | yellow brown to red brown; weak blocky; gravelly, sandy loam to sandy clay loam. | pH 5.4 (4.5-6.45) |
| C | 16" | variable; yellow gray; massive; frequently cemented; gravelly to extremely gravelly, sand to sandy clay loam; the upper part of this horizon tends to be acid, and varies to basic and calcareous in the lower parts. | pH 6.8 (4.85-8.2) |

The tree layer consists of Picea engelmannii, Abies lasiocarpa, and occasional Larix lyallii and Pinus albicaulis.

The low shrub layer is well developed, composed mainly of: Vaccinium scoparium, Phyllodoce glanduliflora, P. empetriformis, Empetrum nigrum, Cassiope mertensiana, C. tetragona, and Salix vestita.

The herb layer is very sparse: Arnica latifolia, Pedicularis bracteosa, Valeriana sitchensis, Sibbaldia procumbens, Potentilla diversifolia, Antennaria neglecta, and Pyrola secunda.

The bryophyte and lichen layer is very abundant, with: Cladonia spp., Peltigera aphthosa, liverworts, Dicranum fuscescens, Pleurozium schreberi, and Hylocomium splendens.

Spruce growth in this type is poor. Lodgepole pine may occur as scattered individuals in the stands.

Picea - Abies / Equisetum Association

Along tributary streams at higher elevations there are conditions resembling the river flat Equisetum type of the valley bottom. The stream-laid materials are relatively fine: stratified sand, silt, and some gravel. The water table is high and the soil profile is an immature gleysolic with an A - C horizon sequence.

| | | | |
|----------------------------------|-------|--|-------------------|
| A ₀₀ + A ₀ | 0-1" | decomposing needle and moss litter; mycelium very sparse. | pH 6.5 (5.7-7.65) |
| A ₁ | 2-6" | variable. organic matter + mineral material; granular structure. | pH 6.0 (5.4-6.4) |
| C | 6-12" | moist; gray brown; stratified, sand to loam. | pH 7.2 (5.9-7.85) |
| C _G | 12" | brown gray; mottling; seepage, wet; stratified, sandy loam to clay loam. | pH 6.9 (5.25-7.9) |

The tree layer consists of the hybrid Picea glauca X P. engelmannii, and Abies lasiocarpa.

The shrub layer is moderately developed, consisting mainly of: Lonicera involucrata, Rosa acicularis, Ribes lacustre, Salix spp., and Rubus pubescens.

The abundant herb layer is dominated by Equisetum arvense and E. pratense. Other typical species are: Equisetum scirpoides, Mitella nuda, Cornus canadensis, Linnaea borealis var. americana, Epilobium angustifolium, Carex spp., Pyrola secunda, Fragaria virginiana var. glauca, Petasites frigidus var. palmatus, and Osmorhiza chilensis.

The bryophyte and lichen layer is abundant, composed typically of: Timmia austriaca, Mnium affine, Hylocomium splendens, Peltigera canina, Ptilium crista-castrensis, and Pleurozium schreberi.

This association is a spruce-fir type; lodgepole pine occurs only rarely. Spruce growth is excellent in this type.

Southern (Crowsnest-Waterton) Area

Picea - Abies / Heracleum lanatum - Equisetum Association

This type occurs in valley bottoms, on the level terrain bordering streams. The soils are formed from medium-textured alluvial materials, and are youthful gleysolic with an A - C horizon sequence, and have a high water table.

| | | | |
|----------------------------------|------|---|--------------------|
| A ₀₀ + A ₀ | 0-2" | decomposing material from needles, moss, and herbs. Mycelium very sparse or absent. A ₀ is granular and well mullified. | pH 5.95 (4.8-6.45) |
| A + C | 2-8" | intermixed organic matter and mineral material; black to gray brown; sandy loam. | pH 6.6 (6.0-7.25) |

C upper 8-12" uppermost mineral material with some darkening from humus; gray brown; weak mottling, very moist; sandy loam to clay loam. pH 6.7 (5.15-7.75)

C_G 12" gleyed, mineral material; gray with strong red mottling; sandy loam to clay loam; becoming gravelly and stony at depth; wet. pH 7.25 (6.3-8.1)

The tree layer is composed of Picea engelmannii and Abies lasiocarpa with some occurrence of Populus trichocarpa and P. tremuloides.

The shrub layer is moderately developed, composed mainly of: Lonicera involucrata, Ribes lacustre, and Lonicera utahensis, as well as some Rubus strigosus and R. parviflorus.

The herb layer is lush and rich in species. The main species are: Heracleum lanatum, Equisetum arvense, E. pratense, E. scirpoides, Actaea arguta, Angelica dawsonii, A. arguta, Osmorhiza occidentalis, O. chilensis, and O. depauperata, as well as: Thalictrum occidentale, Smilacina racemosa, Streptopus amplexifolius, and Galium triflorum.

The bryophyte and lichen layer is moderately developed, with mainly: Timmia austriaca, Mnium affine, and Brachythecium spp.

Spruce growth is excellent on this site. This type is predominantly spruce-fir; lodgepole pine rarely occurs and then only as an admixture.

There are some minor variations within this association. On fine sands and loams with a very deep water table, Equisetum scirpoides becomes more dominant, and there is a decrease in the herb layer and especially of Equisetum arvense and E. pratense.

In another variant there is a greater abundance of fern species: Gymnocarpium dryopteris, Dryopteris dilatata, and occasionally Athyrium filix-femina var. cyclosorum.

Picea - Abies / Calamagrostis rubescens - Lupinus sericeus Association

Away from the streams, beyond the ground with high water table on the lowest valley slopes, there are well-drained soils on medium-coarse parent materials. The soil profile is weakly podzolised, with a narrow A₂ and a thin humus horizon.

A₀₀ + A₀ 0-1" decomposing organic matter from needles and grass;
charcoal; mycelium very sparse to sparse.

pH 5.1 (4.5-5.6)

A₂ 1-1½" yellow gray to gray; sandy loam; single grain.

pH 5.2 (4.4-5.75)

A₃ - B₁ 2-6" yellow brown to yellow gray; granular to weak
blocky; sandy loam to loam, some gravel.

pH 5.2 (4.35-5.85)

B 6-18" brown to yellow brown; blocky; gravelly, sandy
clay loam.

pH 5.45 (4.9-5.8)

C 18" variable; gray to brown gray; massive, very compact;
stony, very gravelly, sandy loam to clay loam.

pH 6.9 (5.6-8.2)

Moisture conditions tend to be suboptimal during the growing season. The establishment of regeneration is difficult on the warm, dry, south-facing slopes. Stands of this type are susceptible to fires and most of them are occupied by lodgepole pine.

The tree layer is composed of Pinus contorta, with regenerating Picea engelmannii and Abies lasiocarpa. Populus tremuloides may occur mixed with pine, or form pure stands.

The shrub layer is abundantly developed, composed typically of: Spiraea lucida, Amelanchier alnifolia, Rosa acicularis, Vaccinium caespitosum, V. myrtillus, and Symphoricarpos albus.

The herb layer is well developed, dominated by a dense growth of Calamagrostis rubescens. There is a fairly rich herb component: Lupinus sericeus, Pyrola secunda, Arnica cordifolia, Aster conspicuus, Galium boreale, Hieracium albiflorum, Aster ciliolatus, Lathyrus ochroleucus, Fragaria virginiana var. glaucula, Chimaphila umbellata var. occidentalis, Smilacina racemosa, and Senecio pseud aureus.

The bryophyte and lichen layer is very sparse; it consists mainly of: Brachythecium salebrosum, Drepanocladus uncinatus, Pohlia spp., Polytrichum juniperinum, and Cladonia spp.

Pine and spruce growth is fair in this type.

In moister phases of this type, and on more acid parent materials, there is an increase in shrub species: Rubus parviflorus, and Symphoricarpos albus; there is also an increase in some herb species such as Thalictrum occidentale.

Picea - Abies / Pachistima myrsinites Association

This association is typical of the middle valley slopes, from 4500 to 5500 feet elevation, on south and west aspects. The soils are podzolic, having a distinct A₂, and a brown acid B horizon, formed from glacial and coarse water-washed glacial parent materials.

A₀₀ + A₀ 0-1½" decomposing organic matter from needles; charcoal;
abundant mycelium. pH 4.8 (3.95-5.6)

A₂ 1½-2½" gray to yellow gray; single grain; gravelly, sandy
loam. pH 4.75 (4.25-5.85)

B₁ 2½-6" yellow red to yellow brown; weak blocky; gravelly,
sandy loam to sandy clay loam.

pH 5.1 (4.8-5.3)

B₂ 6-18" red brown to yellow brown; blocky; gravelly to very gravelly, sandy loam to sandy clay loam.

pH 6.2 (5.0-7.2)

C 18" yellow gray; massive; very gravelly, sandy clay loam.

pH 7.2 (6.0-7.85)

This type also has been severely affected by fires and is mainly in lodgepole pine stands.

The tree layer is composed of Pinus contorta, with regenerating Picea engelmannii and Abies lasiocarpa.

The shrub layer is well developed, composed typically of: Pachistima myrsinites, Spiraea lucida, Mahonia repens, Rubus parviflorus, Vaccinium membranaceum, and Amelanchier alnifolia.

The rich herb layer consists mainly of: Arnica latifolia, Goodyera oblongifolia, Chimaphila umbellata var. occidentalis, Aster conspicuus, Clintonia uniflora, Thalictrum occidentale, Pyrola secunda, P. virens, and Hieracium albiflorum.

The bryophyte and lichen layer is rather sparsely developed, composed mainly of: Brachythecium spp., Drepanocladus uncinatus, Mnium spinulosum, Dicranum spp., Rhytidiopsis robusta, and Cladonia spp.

Stands tend to be overstocked in this type; if density is not too adverse, both lodgepole pine and spruce have good growth.

Moist phases of this association show greater abundance of such species as: Rubus parviflorus, Heracleum lanatum, Osmorhiza chilensis, O. occidentalis, Angelica dawsonii, A. arguta, and Veratrum eschscholtzii.
Picea - Abies /Menziesia ferruginea - Tiarella unifoliata Association

This type is very extensive and shows the best development of the spruce-fir forest. It extends over the middle and upper slopes from

5000 to 6000 feet elevation, where the soils are highly developed podzolic, with a strong, ashy A₂ horizon, a rich, red acid B horizon, and often cementation in the coarse, stony, glacial parent material.

| | | | |
|----------------------------------|-------|--|---------------------|
| A ₀₀ + A ₀ | 0-3" | decomposing organic matter from needles and moss; abundant mycelium; mor. | pH 4.9 (4.3-5.5) |
| A ₂ | 3-5" | ashy gray; single grain; sandy loam, occasionally gravelly. | pH 4.5 (3.75-5.7) |
| B ₁ | 5-8" | red to yellow red; granular, soft and loose; gravelly, sandy loam. | pH 4.85 (4.35-5.65) |
| B ₂ | 8-24" | yellow red to red brown; blocky; gravelly to very gravelly, sandy loam to sandy clay loam; cementation common below. | pH 5.5 (4.9-6.7) |
| C | 24" | yellow gray to brown gray; massive, frequent cementing; stony, very gravelly, sandy loam to clay loam. | pH 6.0 (4.9-8.05) |

The tree layer is composed of Picea engelmannii, Abies lasiocarpa, and occasionally scattered Pinus albicaulis.

The dense shrub layer is dominated by Menziesia ferruginea, as well as containing Vaccinium scoparium, V. membranaceum, Sorbus sitchensis (and S. scopulina), Lonicera utahensis, and Rhododendron albiflorum.

The herb layer is fairly well developed, consisting typically of: Tiarella unifoliata, Arnica latifolia, Listera cordata, Goodyera oblongifolia, Pyrola secunda, P. uniflora, Streptopus amplexifolius, Clintonia uniflora, Viola orbiculata, and Veratrum eschscholtzii.

The bryophyte and lichen layer is moderately developed with: Dicranum fuscescens, liverworts, Fleurozium schreberi, Mnium spp. (M. drummondii, M. spinulosum), and Rhytidiopsis robusta.

Spruce growth is good in this type. Lodgepole pine stands of this type are rare; in such stands there is generally an increase in some herb species, and shrub species such as: Vaccinium myrtillus, Alnus crispa var. sinuata, and Spiraea lucida.

Moist variants of this association occur locally along the valley slopes, having a greater abundance of: Heracleum lanatum, Osmorhiza occidentalis, O. chilensis, Angelica spp., and Veratrum eschscholtzii.

Picea - Abies / Xerophyllum tenax Association

This association is the distinctive one of high elevations on southerly slopes where the soils are shallow and bedrock is close to the surface.

The soils are podzolic, with a narrow A₂, and a shallow, acid, stony B, on thin glacial material overlying bedrock.

A₀₀ + A₀ 0-1" fibrous organic matter from Xerophyllum and needles;
mycelium very sparse to absent. pH 4.5 (4.2-4.8)

A₂ 1-1½" ashy gray; single grain; gravelly, sandy loam.
pH 4.0 (3.7-4.75)

B 2-16" yellow brown to red brown; weak blocky; stony, very
gravelly, sandy loam to clay loam. pH 4.6 (4.2-5.55)

C 16" bedrock with scattered fine material: yellow brown;
sandy loam to clay loam. pH 4.8 (4.5-5.2)

The tree layer is open, and composed predominantly of Abies lasiocarpa, as well as containing Picea engelmannii, and some Pinus albicaulis.

The moderately developed shrub layer is dominated by: Vaccinium myrtillus, V. scoparium, and V. membranaceum, with sparse occurrence of Sorbus sitchensis.

Rank tussocks of Xerophyllum tenax dominate the abundant herb layer. Other typical species are: Arnica latifolia, Pyrola secunda, Viola orbiculata, Luzula wahlenbergii, and Pedicularis bracteosa.

The bryophyte and lichen layer is rather sparsely developed, consisting typically of: Mnium spinulosum, Brachythecium spp., Dicranum fuscescens, D. strictum, Polytrichum juniperinum, Cladonia spp., and liverworts.

Growth of spruce and pine is poor in this type. Lodgepole pine stands of this type are rare.

Picea - Abies / Xerophyllum tenax - Pachistima myrsinites Community

There are a number of stands on the middle valley slopes which are floristically related to the Xerophyllum and the Pachistima associations. Because of the relative abundance of such stands they are treated here as comprising a separate community.

The soil profile is well podzolised with a well developed A₂, and a deep reddish B horizon on coarse glacial parent material.

| | | | |
|----------------------------------|--------|--|--------------------|
| A ₀₀ + A ₀ | 0-1½" | decomposing organic matter from needles and <u>Xerophyllum</u> ; abundant mycelium. | pH 4.8 (4.4-5.45) |
| A ₂ | 1½-2½" | bleached ashy to yellow gray; single grain; gravelly, sandy loam. | pH 4.7 (4.45-4.9) |
| B ₁ | 3-6" | yellow gray to yellow brown; weak blocky; stony , gravelly, sandy loam. | pH 5.3 (4.85-5.65) |
| B ₂ | 6-24" | yellow brown to red brown; blocky; stony , gravelly, sandy loam to clay loam. | pH 5.7 (5.3-6.7) |
| C | 24" | yellow gray to brown gray; massive, hard and compact; gravelly to very gravelly, sandy loam to clay loam. | pH 6.6 (5.3-7.8) |

The tree layer is composed of Picea engelmannii, Abies lasiocarpa, and Pinus contorta.

The shrub layer is well developed, consisting typically of: Spiraea lucida, Lonicera utahensis, Sorbus sitchensis, Amelanchier alnifolia, Alnus crispa var. sinuata, Vaccinium myrtillus, Mahonia repens, and Rubus parviflorus.

The herb layer is very abundant, and is dominated by Xerophyllum tenax. Other typical species are: Arnica latifolia, Viola orbiculata, Goodyera oblongifolia, Clintonia uniflora, Aster conspicuus, Chimaphila umbellata var. occidentalis, Thalictrum occidentale, Pyrola secunda, Osmorhiza chilensis, and Aster engelmannii.

The bryophyte and lichen layer is moderately developed, composed of: Rhytidiopsis robusta, Mnium spinulosum, Dicranum scoparium, Drepanocladus uncinatus, Brachythecium salebrosum, and Gladonia spp.

Lodgepole pine stands are relatively abundant in this type; both pine and spruce growth is good.

Picea - Abies / Menziesia ferruginea Association

At high elevations, near timberline, there are a few ancient fir-spruce stands occurring on shallow, lithosol-like soils. A typical soil profile is as follows:

| | | | |
|----------------------------------|-------|---|---------|
| A ₀₀ + A ₀ | 0-1" | decomposing organic matter from needles; very sparse mycelium. | pH 4.75 |
| A ₃ (?) | 1-2½" | brown-red; coarse granular-nutty; clay. | pH 4.35 |
| B | 3-18" | brown-red; blocky; stony, gravelly, clay loam. | pH 4.65 |
| C | 18" | bedrock with pockets of fine sandy clay loam material, brown-red. | pH 4.7 |

The tree layer is dominated by old, mature Abies lasiocarpa, with scattered Pinus albicaulis and Picea engelmannii.

Menziesia ferruginea forms an extremely dense cover in the shrub layer, with lesser amounts of Sorbus sitchensis and Vaccinium membranaceum, V. myrtillus, and V. scoparium.

The sparsely developed herb layer consists of: Arnica latifolia, Luzula glabrata, Viola orbiculata, Erigeron peregrinus ssp. callianthemus, and Castilleja miniata.

The sparse bryophyte and lichen layer consists of: Dicranum fuscescens, liverwort spp., Mnium sp., and Brachythecium sp. Tree growth is very poor.

Douglas Fir Habitat Types

Pseudotsuga menziesii occurs sporadically along the lowest valley slopes, in the drier exposed positions: on southerly aspects and shallow soils. Much of the Douglas fir is of seral status in spruce habitat types. Often this species occurs as one or two widely scattered individuals in a savannah-like vegetation. There are a few open stands of Douglas fir of climax status.

Pseudotsuga menziesii / Arctostaphylos uva-ursi Association

A stand of this type was studied in Jasper National Park, on gently sloping terrain, at 3390 feet elevation. The soil profile is unpodzolised, on coarse, stony alluvium which is highly calcareous.

A₀₀ + A₀ 0- $\frac{1}{2}$ " sparse litter from needles and Arctostaphylos leaves;
mycelium. pH 6.95

A₁ $\frac{1}{2}$ -2 $\frac{1}{2}$ " gray brown, melanised; granular; loamy sand; lime.
pH 7.0

B 3-5" red-brown; loamy sand; granular, very loose; lime.
pH 8.1

- | | | | |
|---|-------|---|--------|
| B | 5-15" | yellow brown; massive; loose; loamy sand with abundant stones and gravel; lime. | pH 8.0 |
| C | 15" | brown gray; massive, loose; sand, gravel and stones; lime. | pH 8.4 |

The tree layer is composed of widely-spaced Pseudotsuga menziesii, with abundant regeneration of this species, but with sparse Pinus contorta and Picea glauca regeneration in the understorey.

The shrub layer is dominated by Arctostaphylos uva-ursi, with lesser amounts of Symphoricarpos albus, Amelanchier alnifolia, Shepherdia canadensis, and Rosa acicularis.

The herb layer is rather sparse, composed mainly of: Elymus
innovatus, Koeleria cristata, Senecio cymbalarioides, Solidago multiradiata,
Gentianella amarella ssp. acuta, and Viola adunca.

The sparse bryophyte and lichen layer consists of: Peltigera
canina, Cladonia spp., Drepanocladus uncinatus, and Brachythecium spp.

Douglas fir growth is medium in this type; stocking is sparse.

Pseudotsuga menziesii / Calamagrostis rubescens Association

A stand of this type was studied in Banff National Park, at ca. 5000 feet elevation, on a moderate south-facing slope. The soil profile is podzolised, formed from coarse, water-washed glacial material.

- | | | | |
|----------------|-----------------------------|--|--------|
| $A_{00} + A_0$ | $0-\frac{1}{2}"$ | thin, decomposed organic matter from needles and grass, intermixed with some thin melanised material; mycelium absent. | pH 6.0 |
| A_2 | $\frac{1}{2}-1\frac{1}{2}"$ | gray to yellow gray; single grain, loose; sand. | pH 5.7 |
| A_3 | 2-7" | gray to yellow gray; single grain, loose; loamy sand, stones. | pH 6.9 |

| | | | |
|----------------|--------|---|---------|
| B | 7-18" | red brown; blocky; compact; loam; stony. | pH 7.0 |
| B ₃ | 18-22" | brown yellow; stony, loamy sand; blocky-massive, compact; lime at 18" | pH 8.05 |
| C | 22" | yellow gray; loamy sand, abundant gravel and stones; massive, cemented and hard; lime. | pH 8.4 |

The tree layer is composed of Pseudotsuga menziesii, with some Pinus contorta in the understory.

The rather poorly developed shrub layer consists of: Arctostaphylos uva-ursi, Rosa acicularis, Vaccinium caespitosum, Spiraea lucida, Shepherdia canadensis, and Juniperus communis.

The herb layer is very abundant and is dominated by Calamagrostis rubescens, as well as containing: Elymus imovatus, Astragalus decumbens var. serotinus, Aster conspicuus, Castilleja hispida, Hedysarum sulphurescens, Fragaria virginiana var. glauca, and Antennaria neglecta.

The sparse bryophyte and lichen layer consists mainly of: Cladonia spp., Peltigera canina, Pleurozium schreberi, Dicranum strictum, Brachythecium spp., Drepanocladus uncinatus, and Polytrichum juniperinum.

Douglas fir growth is fair; stocking is sparse.

Pseudotsuga menziesii / Calamagrostis rubescens - Lupinus sericeus Association

This type occurs in the Crowsnest Area, on south-facing slopes, usually on shallow soils formed from glacial or glacial-fluvial parent materials.

| | | | |
|----------------------------------|--------|---|---------|
| A ₀₀ + A ₀ | 0-1½" | sparse organic matter from decomposing needles and grass; sparse mycelium. | pH 6.2 |
| A ₁ | 1½-2½" | black to gray brown, melanised; granular | pH 6.65 |

- | | | | |
|---|--------|---|---------|
| B | 13-17" | yellow brown; blocky to columnar; compact; loamy sand, stony . | pH 6.6 |
| C | 17-24" | glacial material intermixed with shaley rock fragments; yellow brown; massive, loose. | pH 6.25 |

The tree layer is composed of widely spaced Pseudotsuga menziesii, with occasional Populus tremuloides.

The shrub layer consists of: Spiraea lucida, Amelanchier alnifolia, Prunus virginiana, Mahonia repens, Rosa woodsii, R. acicularis, Arctostaphylos uva-ursi, and Juniperus communis.

The herb layer is well-developed and rich in species: Calamagrostis rubescens, Poa sp., Stipa columbiana, Koeleria cristata, Festuca idahoensis, Bromus sp., Lupinus sericeus, Aster conspicuus, Heuchera cylindrica, Balsamorhiza sagittata, Calochortus apiculatus, Allium cernuum, Collinsia parviflora, Sedum stenopetalum, and Selaginella densa.

The bryophyte and lichen layer is very sparse, consisting of:

Peltigera canina, Brachythecium spp., Dicranum strictum, and Cladonia spp..

Douglas fir growth is fair.

Pseudotsuga menziesii / Symphoricarpos albus Association

This association occurs in the Crowsnest Area, in more mesic conditions than the previous one: on deeper soils with more northerly aspects. The soil profile is as follows:

- | | | | |
|----------------------------------|------|--|-------------------|
| A ₀₀ + A ₀ | 0-1" | decomposing organic matter from needles and foliage; sparse mycelium. | pH 6.05 (6.0-6.1) |
| A ₁ | 1-3" | black; melanised; granular; loose. | pH 6.7 (6.25-7.1) |
| B ₁ | 3-7" | brown; granular to nutty; more compact; loam. | pH 6.7 (6.25-7.1) |

| | | | |
|----------------|-------|--|-------------------|
| B ₂ | 7-24" | yellow brown to gray brown; strong blocky; very compact. | pH 6.6 (5.95-6.9) |
| C | 24"- | yellow gray; massive; hard and compact; rock fragments. | pH 6.7 (5.95-7.4) |

Goodyera oblongifolia, Chimaphila umbellata var. occidentalis, Osmorhiza depauperata, and Calamagrostis rubescens.

The sparse bryophyte and lichen layer is composed mainly of: Cladonia spp., Drepanocladus uncinatus, Brachythecium spp., and Dicranum scoparium.

Aspen Stands

A number of aspen stands were examined for age, ground vegetation, and soil features. All of the aspen stands within the mountains are seral, with spruce and some Abies regeneration beneath. Most of the trees are young: 50 or 75 years, and rarely as old as 90 years. All of the stands examined had trees infected with Fomes ignarius. Most of the stands are seral variants, in the main subalpine area, of the Arctostaphylos association or Calamagrostis association; and in the southern area of the Calamagrostis - Lupinus association or Pachistima association.

Generally there is an increase in the abundance of herbaceous species with the change from a coniferous to broad-leaved overstorey. An aspen stand in Banff National Park, which is typical of the Calamagrostis type, has the following composition: Rosa acicularis, Lathyrus ochroleucus, Vicia americana, Senecio pseud aureus, Thalictrum occidentale, Aster ciliolatus, A. conspicuus, Fragaria virginiana var. glauca, and Calamagrostis rubescens.

A stand in the Crowsnest Area, which is typical of the Calamagrostis - Lupinus association, is composed of: Vaccinium caespitosum, Amelanchier alnifolia, Rosa acicularis, Spiraea lucida, Lupinus sericeus, Castilleja hispida, Senecio pseud aureus, Geranium viscosissimum, Fragaria virginiana var. glauca, Lathyrus ochroleucus, Vicia americana, Penstemon confertus, Aster conspicuus, Potentilla gracilis, P. arguta, Thalictrum occidentale, and Calamagrostis rubescens.

Black Spruce Habitat Types

Picea mariana occurs in Jasper National Park along the Athabasca drainage; it extends southward for about 50 miles from Jasper Town. It occurs also in Banff National Park, at Saskatchewan River Crossing.

Picea mariana / Carex Association

This is the most typical black spruce type, occurring on level alluvial-lacustrine terrain, with a heavy, calcareous clay substratum producing impeded drainage and fen conditions. The micro-relief is highly irregular, consisting of hummocks and hollows, with water standing in some of the latter.

A + C 0-7" humus and mineral material; dark brown; granular lime. pH 8.6

7-12" muck; mineral and organic matter; dark gray to brown.

C 12-17" light gray; fine sand to loamy sand; wet. pH 8.4

17-25" dark gray; some buried organic layers.

25-33" light gray, red mottling; clay loam with scattered

gravel and stones. pH 8.2

33" gray; clay loam with gravel and stones; water table. pH 8.3

The tree layer consists of Picea mariana.

The shrub layer is moderately developed, composed of: Salix arbusculoides, S. myrtillifolia, S. padophylla, Betula glandulosa, Rubus pubescens, and Rosa acicularis.

The herb layer is very abundant, dominated largely by Carex aquatilis, as well as containing: Equisetum arvense, Juncus tenuis, Carex spp., Deschampsia caespitosa, Elymus innovatus, Parnassia parviflora, Habenaria hyperborea, Spiranthes romanzoffiana, Triglochin maritima, Senecio pauperculus, and Viola

renifolia.

The moss layer is well developed, with: Aulacomnium palustre, Camptothecium nitens, and other hydric species.

Picea mariana - Larix laricina / Ledum groenlandicum - Sphagnum - Carex
Association

A stand of this type was studied near Miette Hot Springs, at 4400 feet elevation. The terrain is level, drainage is impeded, and there is deep accumulation of Sphagnum peat. A soil pit dug to 40 inches showed saturated peat throughout, without reaching a mineral substratum.

The tree layer is composed of large, 200-year-old Picea mariana, beneath which is short, 40-year-old Larix laricina.

The shrub layer is abundant, with: Ledum groenlandicum, Betula glandulosa, Salix myrtillifolia, Arctostaphylos rubra, Vaccinium oxycoccus, Rubus pubescens, Viburnum edule and Alnus tenuifolia.

The herb layer is highly developed, dominated by Carex aquatilis and Equisetum arvense, as well as containing Smilacina trifolia, Equisetum scirpoides, Pedicularis groenlandica, and Habenaria hyperborea.

The very abundant moss layer consists of: Sphagnum spp., Camptothecium nitens, and Aulacomnium palustre.

Picea mariana - Abies lasiocarpa / Ledum groenlandicum-Carex Association

This is a montane black spruce community, occurring at 5750 feet elevation along the Astoria River Valley, below Mt. Edith Cavell. Seepage is near or at the soil surface along much of this valley. The soil parent material is glacial till, composed of clay loam intermixed with stones and gravel.

| | | | |
|----------------------------------|--------|---|---------|
| | 0-3" | carpet of living moss (<u>Hylocomium</u>). | |
| A ₀₀ + A ₀ | 3-5½" | organic matter from moss and sedge; fibrous; wet | pH 4.4 |
| A + C | 6-11" | humified mineral material; charcoal; black; wet | pH 6.85 |
| C _G | 12-14" | brown gray; sandy loam with stones and gravel; wet | pH 7.3 |
| | 22-24" | yellow gray, red mottled; sandy clay loam with gravel and stones; wet, strong seepage begins at 18" | pH 7.6. |

The tree layer consists of Picea mariana, the hybrid Picea engelmanni X P. glauca, and Abies lasiocarpa.

A well developed shrub layer consists of: Ledum groenlandicum, Betula glandulosa, Empetrum nigrum, Arctostaphylos rubra, Salix vestita, S. pseudocordata, Kalmia polifolia, and Vaccinium vitis-idaea. Less abundant are the mountain heaths and blueberries: Cassiope tetragona, Phyllodoce glanduliflora, Vaccinium scoparium, and V. myrtillus.

The herb layer is composed of: Carex spp., Equisetum arvense, E. scirpoides, E. variegatum, E. pratense, Juncus albens, Petasites frigidus var. palmatus, Pinguicula vulgaris, Tofieldia pusilla, Pedicularis groenlandica, and P. bracteosa.

The very abundant bryophyte and lichen layer consists of: Hylocomium splendens, Cladonia spp., leafy liverworts, Dicranum sp., Camptothecium nitens, Aulacomnium palustre, and Sphagnum spp.

Picea mariana - Picea glauca / Arctostaphylos uva-ursi Association

A stand of this type was studied along the valley bottom of the Athabasca River. The soil parent material is calcareous glacial till. The soil horizons

are very weakly developed.

| | | | |
|----------------------------------|--------|---|---------|
| A ₀₀ + A ₀ | 0-1½" | litter from needles and shrubs. | pH 7.55 |
| A-B | 1½-3½" | brown to yellow brown; granular; lime. | pH 8.6 |
| B (?) | 5-11" | Yellow brown to brown; loam to clay loam, with scattered stones; blocky. | pH 8.7 |
| C | 11-14" | yellow gray; loam, gravel and stones; weak blocky; moist. | pH 8.2 |
| | 30-33" | gray; abundant gravel and stones; massive; wet. | pH 8.3. |

The tree layer is composed of Picea mariana and Picea glauca.

The well developed shrub layer is dominated by Arctostaphylos uva-ursi, and in addition there occurs: Shepherdia canadensis, Rosa woodsii, Potentilla fruticosa, and Juniperus communis.

The herb layer consists of: Elymus innovatus, Carex concinna, Geocaulon lividum, Antennaria parvifolia, Linnaea borealis var. americana, as well as the less abundant Tofieldia glutinosa, Parnassia parviflora, Juncus tenuis, Selaginella selaginoides, and Pinguicula vulgaris.

The bryophyte and lichen layer is composed of: Dicranum spp., Cladonia spp., Drepanocladus uncinatus, Brachythecium spp., and Peltigera canina.

This stand has a number of unusual features. The soil profile is very poorly developed: a thin humus horizon, no leached horizon, a very indefinite B horizon, and a highly calcareous parent material of stones, gravel, and loam, which becomes very wet with depth. The ground flora is composed of a rather mixed assortment of species: some which are normally associated with drier habitats, along with species of wet habitats. The successional status of

the stand is questionable. Complete age data of the trees were not obtained, but the data indicate that the trees are broadly even-aged, and that there is a small amount of reproduction of both spruce species. Charcoal in the surface soil horizons suggests a fire origin of this stand, which is in accord with the broadly even-aged stand structure. It is possible that, following a drastic fire, the site was heavily colonized by black spruce (a serotinous species similar to lodgepole pine), and was followed by white spruce, which may eventually replace the former species.

DISCUSSION

The reader is referred to pages 13-16, for a summary of the forest classification.

The Arctostaphylos type occurs in the valley bottoms on coarse alluvial material which is excessively drained, and moisture is frequently deficient during part of the growing season. The Calamagrostis type occurs on medium-textured alluvial and glacial-fluvial materials; it is well-drained and moisture conditions are more favourable. In the Hylocomium - Cornus type of the mid-slopes, the glacial parent material may be coarse, but this factor is offset by the northerly aspect, and moisture conditions are favourable. The Menziesia - Lycopodium type occurs on the upper valley slopes, often on coarse glacial parent material, but moisture conditions are favourable throughout the year, and there may be very deep seepage in the soil profile; in some profiles there is a deep cementation layer. There is deep snow accumulation in this type. The Vaccinium scoparium type occurs on the highest valley slopes, where there is abundant moisture and very deep snow accumulation; the soil remains frozen

late in the year. The Ledum - Empetrum association is a seepage type of the mid-valley slopes. The Picea - Abies / Equisetum type along tributary streams, and the Picea / Equisetum type of the broad valley bottoms, occur on fine alluvial soils with high water table and abundant moisture throughout the growing season. The Sphagnum - Ledum type occurs on fine, impervious materials with impeded drainage and excessive water.

In the Southern Area, the Calamagrostis - Lupinus type occupies the lower valley slopes, on medium-textured alluvial and glacial-fluvial materials which are well drained; moisture conditions may be suboptimal during the growing season. The Pachistima type and the Xerophyllum - Pachistima type, of the mid-valley slopes, have more favourable moisture conditions. The Menziesia - Tiarella type occurs on the upper slopes where moisture conditions are favourable throughout the growing season; seepage may occur deep in the profile, and cementation may be present. The Xerophyllum type and the Menziesia type have shallow soils underlain by bedrock which restricts rooting; there is deep snow accumulation in these types. The Heracleum - Equisetum type bordering streams occurs on medium-fine alluvium with high water table; moisture conditions are optimal throughout the growing season.

The site potential of the habitat types, for spruce and lodgepole pine, is summarized below:

Spruce

Good

P. - A. / Equisetum

P. - A. / Heracleum - Equisetum

P. - A. / Menziesia - Lycopodium

P. - A. / Menziesia - Tiarella

Picea / Equisetum

Medium

P. - A. / Hylocomium - Cornus

P. - A. / Pachistima

P. - A. / Ledum - Empetrum

P. - A. / Xerophyllum - Pachistima

Fair

P. - A. / Calamagrostis

P. - A. / Calamagrostis - Lupinus

Picea / Arctostaphylos

Poor

P. - A. / Vaccinium

P. - A. / Menziesia

P. - A. / Xerophyllum

Very Poor

P. - A. / Sphagnum - Ledum

Lodgepole Pine

Very Good

Hylocomium - Alnus

Good

Hylocomium - Cornus

Xerophyllum - Pachistima

Medium

Hylocomium - Vaccinium

Pachistima

Calamagrostis - Vaccinium

Calamagrostis - Cladonia

Fair

Hylocomium - Cladonia

Calamagrostis - Lupinus

Calamagrostis

Arctostaphylos

Arctostaphylos - Vaccinium

Arctostaphylos - Cladonia

Poor

Menziesia - Lycopodium

Xerophyllum

The classification accounts for most of the forest communities and habitat conditions of the mountain region. As a rule the mature spruce-fir stands have relatively little variability. The environmental conditions are more stable and any changes are proceeding only slowly over a long period of time. This is reflected in the greater uniformity and distinctiveness of the spruce associations. Consequently, the spruce-fir stands are most amenable to classification. The younger pine stands have more variability. Plant succession, soil development, and other habitat changes are occurring more rapidly. In general, classification of the younger pine stands is more complex.

This investigation was done of stands ranging from immature, fifty-year-old pine to old, mature spruce stands. The earliest stages of forest succession, prior to fifty years, have not been considered. A study of these early stages of succession following fire and logging would be valuable.

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