

# The Forests of Marmot Creek Watershed Research Basin

by  
C.L. Kirby and R.T. Ogilvie

DEPARTMENT OF FISHERIES AND FORESTRY  
CANADIAN FORESTRY SERVICE  
PUBLICATION NO. 1259

# THE FORESTS OF MARMOT CREEK WATERSHED RESEARCH BASIN

by

C.L. Kirby and R.T. Ogilvie

Published under the authority of the  
Minister of Fisheries and Forestry  
Ottawa, 1969

## ABSTRACT

A detailed forest and habitat inventory on a watershed designated for hydrology research is presented using computer compilation and mapping techniques. The forest cover is predominately spruce-fir, located on the east slopes of the Rocky Mountains 50 miles west of Calgary, Alberta, Canada.

## EXTRAIT

L'auteur effectua un inventaire détaillé de la forêt et des habitats dans un bassin versant choisi pour la recherche hydrologique, en utilisant des techniques définies de calculs et de cartographie. La forêt se compose surtout d'Épinettes et de Sapins, elle est située sur le versant est des Rocheuses à 50 milles à l'ouest de Calgary, Alberta, Canada.

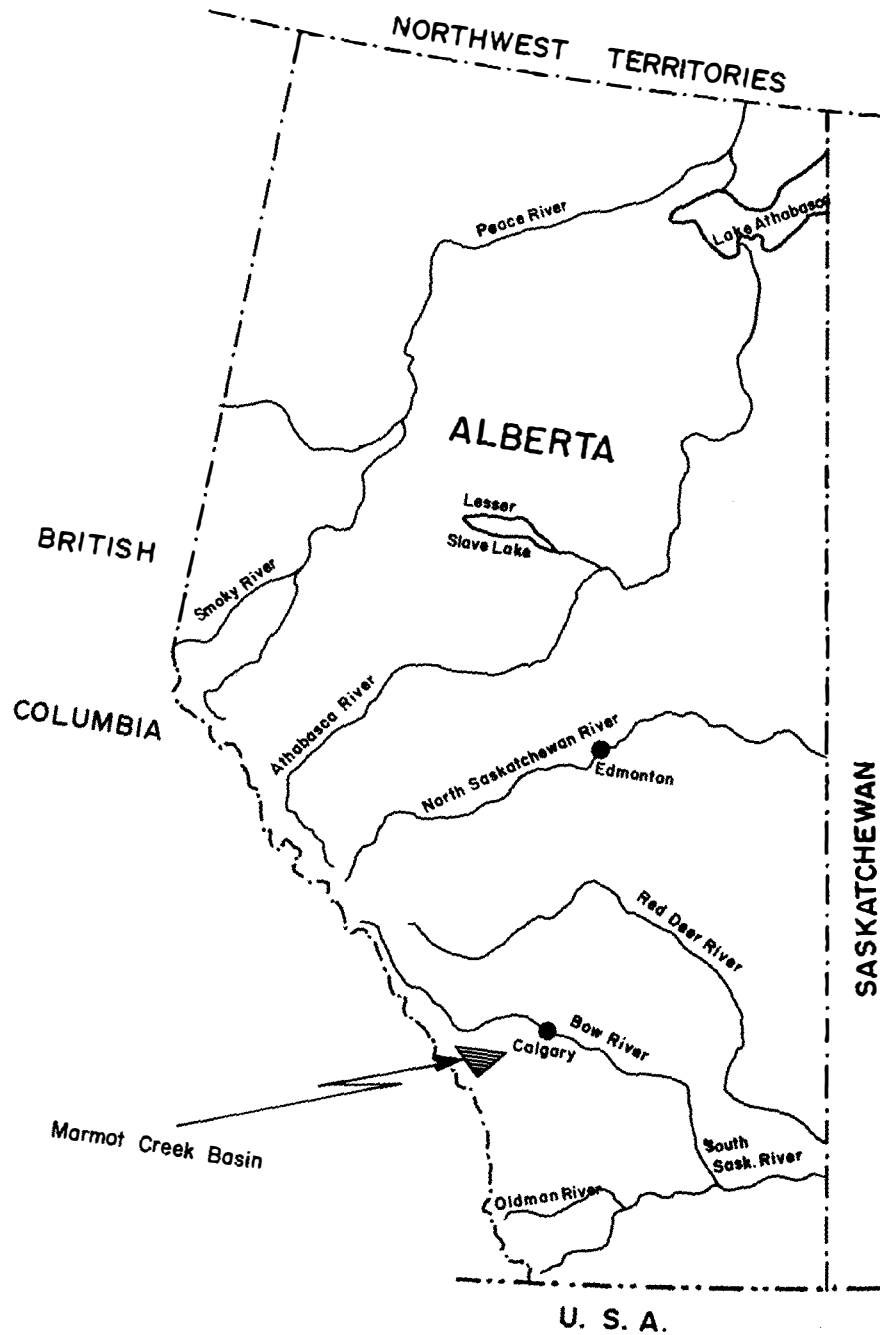
THE QUEEN'S PRINTER  
OTTAWA, 1969

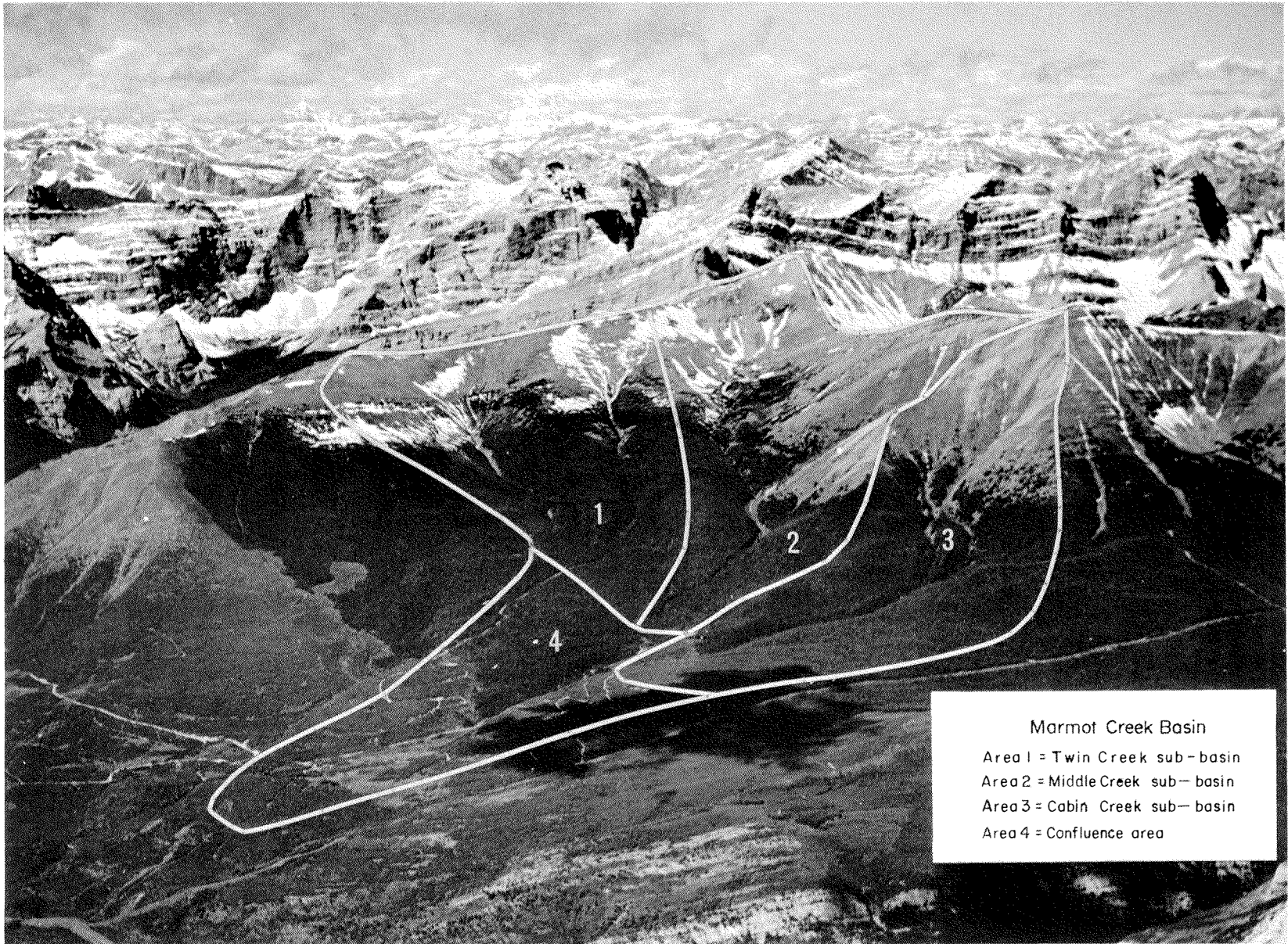
Catalogue No. Fo. 47-1259



## CONTENTS

	Page
MAP OF ALBERTA.....	iv
AERIAL VIEW OF RESEARCH AREA.....	v
GLOSSARY.....	vi
INTRODUCTION.....	1
LOCATION AND CLIMATE OF AREA.....	1
Location.....	1
Climate.....	2
INVENTORY METHODS.....	3
Sampling.....	3
Mapping.....	3
Computer Applications.....	4
FOREST INVENTORY.....	4
Forest Cover Types.....	5
Average Stand Characteristics and Volume Distribution.....	6
Computer Maps and Cumulative Tree Frequency Charts.....	7
HABITAT INVENTORY.....	13
Forest Habitat Types.....	14
Alpine Habitat Types.....	18
DISTRIBUTION OF HABITAT TYPES IN COVER TYPES.....	20
RECOMMENDATIONS.....	21
REFERENCES.....	22
APPENDIX I - HEIGHT-DIAMETER RELATIONSHIPS, LOCAL VOLUME TABLES, VOLUME-BASAL AREA RATIOS AND FORMULAE.....	23
APPENDIX II - SCIENTIFIC AND COMMON PLANT NAMES.....	24
APPENDIX III - STAND AND STOCK TABLES.....	28
APPENDIX IV - FOREST COVER TYPE AND HABITAT TYPE MAPS.....	map pocket





Marmot Creek Basin

Area 1 = Twin Creek sub-basin

Area 2 = Middle Creek sub-basin

Area 3 = Cabin Creek sub-basin

Area 4 = Confluence area

## GLOSSARY

- alpine - Mountainous regions lying above the coniferous forests and below the permanent snow.
- chernozemic - Soils with Ah and C horizons, and usually a B horizon of high base saturation.
- chinook - The warm dry Föhn type of wind experienced along the eastern side of the Rocky Mountains in Canada and the U.S.A. common in winter and spring. The chinook raises the atmospheric temperature rapidly, sometimes 30 to 40° in fifteen minutes.
- climax - A terminal, self perpetuating plant community of ecological succession which is in dynamic equilibrium with existing environmental conditions.
- colluvial - Rock fragments accumulated under gravity.
- forest cover type - A term used to differentiate forest stands on the basis of tree species composition.
- facies - A variant of a plant community type, or habitat type.
- gleysolic - Soil profiles with a high, fluctuating water-table, developed under anaerobic conditions.
- habitat type - Those parts of the landscape that support or have the potentiality of supporting the same type of plant community.
- hangmoor - Areas of peat accumulation in concave depressions on valley slopes where downslope drainage is impeded.
- krummholz - Dwarfed, crooked trees at timberline.
- point sampling - A forest sampling procedure where trees sampled are larger than a prescribed angle subtended from a point and rotated 360°.
- watershed - The terms watershed and basin are used synonymously in this report to mean catchment area for a drainage system.

# THE FORESTS OF MARMOT CREEK WATERSHED RESEARCH BASIN

by

C.L. Kirby<sup>1</sup> and R.T. Ogilvie<sup>2</sup>

## INTRODUCTION

Marmot Creek Watershed is the first in a series of research areas established on the east slopes of the Canadian Rocky Mountains to discover ways to maintain and improve the water quality and yield which are vital to the Prairie Provinces. The work is being done cooperatively by a number of provincial and federal government agencies (Redmond, 1964; Jeffrey, 1965).

The forest and habitat inventories of the Marmot Creek Watershed are a cooperative effort of the Forest Service of the Alberta Department of Lands and Forests, and the Alberta-Territories Region of the Department of Fisheries and Forestry. These inventories are required for development of the research basin. In addition, intensive study on the soils, geology, climate, and ground water is providing a wealth of information to be used by many disciplines of study.

This report presents inventories of forest and habitat types and some inter-relationships which, it is hoped, will be of use in improving forest and watershed management.

## LOCATION AND CLIMATE OF AREA

### LOCATION

The Marmot basin is approximately 50 miles west of Calgary, Alberta, and 0.5 mile west of the south end of the Department of Fisheries and Forestry's Kananaskis Forest Experiment Station (50°57'N, 115°10'W).

The basin is approximately 3.6 square miles in area, and comprises three major sub-basins which present a wide variety of aspects and slopes at elevations from 5200 to 9200 feet above mean sea level.

---

<sup>1</sup>Research Scientist, Department of Fisheries and Forestry, Alberta-Territories Region, Calgary, Alberta.

<sup>2</sup>Assistant Professor, Department of Biology, University of Calgary, Calgary, Alberta.



## CLIMATE

A preliminary assessment<sup>3</sup> of precipitation and temperature records for this watershed showed that because both precipitation and temperature vary considerably with elevation, aspect and slope, it is impossible to arrive at one precise figure for either parameter which will apply to all parts of this rugged watershed.

Precipitation is the more difficult parameter to measure accurately and also is the more variable in time and location. Snowfall is especially difficult to measure accurately, therefore the figures presented here must be treated with caution. A preliminary report (Storr, 1967) on the methods and first results of the precipitation measurement program gives a 3-year annual average of 35 inches for the basin. This varied over the basin from less than 26 inches in the lower area to over 45 inches in the Twin Creek headwaters. The driest year (prior to 1967 which was probably drier) had a basin average of 30 inches, and the wettest year, 38 inches.

Over the 3 years, 25 to 30% of the annual precipitation occurred as rain during the June - September period, with the remaining 70 to 75% as snow. Maximum snow depth varies from 2 to 4 feet in the lower area to 6 to 8 feet in the upper. Evaporation by chinooks and radiation may present some problems in moisture conservation.

Temperature variations have not been investigated as thoroughly as precipitation because of instrumentation and access difficulties during the winter months. Differences in average daily maximum and minimum temperatures during the summer months are approximately 10 F between the upper and lower areas. Variation from the coolest to the warmest July in 4 years was about 7 degrees on both the mean daily maxima (57 to 64 F) and minima (35 to 42 F).

During the winter, temperature measurements were confined to the area below 6000 feet until 1966-67 when one station was maintained at 6800 feet; therefore data is restricted areally. Mean daily maxima for January in the confluence area ranges from about 10 to 20 F and minima from near 0 to 10 F. Frequent thawing periods occur in all winter months and week-long periods with maxima in the 50's are not uncommon. The lowest recorded temperature was -45 F in December 1964 in the wake of a severe blizzard on the prairies. Sub-zero temperatures for more than 1 week are comparatively rare. It is suspected that winter minima at the higher levels will be higher than those in the confluence area where the cool air collects.

No data on the length of the frost-free period have been extracted, but for most years it appears to be from about mid-June to the third week in August.

---

<sup>3</sup>Prepared for this report by Mr. D. Storr, Meteorological Branch, Canada Department of Transport, Calgary.

# INVENTORY METHODS

## SAMPLING

The objectives of the forest survey are to provide current statistics and, with remeasurement of point samples in the future, to show growth and mortality of the forests. A systematic regular grid of samples was used so that samples could be easily located and re-located and so that sampling should not be tied to present forest stratification which will change with time. In addition, a grid of samples provides ground control for mapping soils, habitat types and topographic features.

Point sample locations are indicated on the lithographed map (Appendix IV) included with this report. On the ground, the sampling centres are marked with 18-inch lengths of aluminum angle and their locations are pin-pointed on aerial photographs. A 5-chain (330 feet) grid of sample plots was established except in the young lodgepole pine stands where travel was difficult. A hand compass, Abney level, and chain with trailer for slope corrections were used to locate the point samples.

At each point sample, the following procedures were followed:

- a) Point sampling was done by the Alberta Forest Service as described by Kirby (1964) using a basal area factor (BAF) 10 on the relascope.
- b) Trees selected in point sampling were calipered at breast height and diameters recorded to the nearest 1-inch diameter class.
- c) One sample tree of the main species at each sample location was selected, (usually a tree of mean size) and d.b.h. and total height were measured. Also age at 1.0-foot stump was determined from increment cores and corrected to obtain total age for this tree.
- d) The cover type, as observed in the field, was recorded.

## MAPPING

The cover type map is based on aerial photographs (scale 1:7920) taken in 1963. Preliminary field checking of the various cover types was done before the aerial photographs were typed. Cover types containing up to three species in their description were divided into 10-foot height classes and 10% crown density classes. This map was prepared by the Alberta Forest Service, and from this, a forest cover type map in color showing detailed and generalized cover type information was produced by the Department of Forestry of Canada (Appendix IV).

The habitat type map is based on field survey and aerial photography. The map presented in Appendix IV is based on a drafting prepared by the Alberta Forest Service.

## COMPUTER APPLICATIONS

Various analyses were done on an I.B.M. 360 Model 30. Programs were written to compile individual point sample data and to prepare average stand and stock tables. Height-diameter relationships and total volume-basal area ratios used in compiling tree volumes are presented in Appendix I.

Amidon's (1964, 1966) map information and display system (MIADS) was adapted by Kirby and Chow (unpublished report). Maps and printed tables showing stand area and total volume distribution were prepared.

Map and point sampling data are on I.B.M. cards for future correction or analysis. The forest and habitat inventories may be recompiled as desired for individual sub-basins or on other criteria.

## FOREST INVENTORY

The forest on this watershed is mainly over-mature spruce-fir-pine stands with white spruce<sup>4</sup>, Engelmann spruce, hybrids of these spruces, alpine fir, and lodgepole pine. These spruce-fir-pine stands are the climax condition in the east slopes region. Stands of predominantly lodgepole pine, the pioneer forest after fire, are also present. Aspen occasionally occurs in mixture with the young lodgepole pine and young spruce may form an understory. Alpine forests between 6400 feet and the timberline are characterized by the dominance of alpine larch associated with alpine fir.

### FOREST COVER TYPES

Four major forest cover types - lodgepole pine, lodgepole pine-aspen, spruce-fir-pine, and alpine - and 20-foot height classes within each of the cover types are used to present the results of this forest inventory. These cover types and height classes as well as alpine meadows and barren rock are identifiable on aerial photographs and correspond to color coding used on the lithographed map (Appendix IV).

The areas of the various forest cover types, and height and crown density classes are shown in Table 1. The crown density classes are of minor importance and are presented only to show the acreages in each class; results incorporating crown density classes may be compiled when required.

---

<sup>4</sup>Scientific names and authorities are given in Appendix II.

TABLE 1. AREA DISTRIBUTION OF FOREST COVER TYPES, BY HEIGHT AND DENSITY CLASSES.

Forest cover type and height class	Crown density (per cent)					Total area (acres)	Percentage of total area
	1-20	21-40	41-60 (acres)	61-80	81-100		
Alpine							
1-30	15	71	11	2	0	99	4.34
31-50	0	34	41	19	0	94	4.12
Spruce-fir-pine							
1-30	6	0	4	0	0	10	.44
31-50	3	34	116	59	6	218	9.55
51-70	7	20	138	340	55	560	24.54
71-90	0	0	15	140	0	155	6.79
Lodgepole pine							
1-30	8	11	41	32	72	164	7.19
31-50	4	0	0	0	0	4	.17
51-70	0	0	0	5	24	29	1.27
Pine-aspen							
1-30	0	13	16	13	0	42	1.84
Rock	--	--	--	--	--	148	6.49
Meadow	--	--	--	--	--	722	31.64
Stunted	--	--	--	--	--	37	1.62
TOTAL	43	183	382	610	157	2282	100.00

On this basin 48% is alpine forest, meadow and rock and is not considered productive forest area. The remaining 52% is in productive forest and is mainly old (170-270 years), 91% spruce-fir-pine cover types, with 9% occupied by 30-year-old lodgepole pine mixed with some spruce and aspen at lower elevations.

#### AVERAGE STAND CHARACTERISTICS AND VOLUME DISTRIBUTION

Averages based on the point sample data obtained in each cover type - height class combination are presented in Table 2, where the average number of trees, basal area, and total volume per acre for trees 0.6 and

TABLE 2. AVERAGE NUMBER OF TREES, BASAL AREA AND TOTAL VOLUME PER ACRE, BY FOREST COVER TYPES AND HEIGHT CLASSES.

Forest cover type and height class	All trees 0.6" & larger			All trees 4.6" & larger			Number of point samples
	Number of trees	Basal area (sq ft)	Total volume (cu ft)	Number of trees	Basal area (sq ft)	Total volume (cu ft)	
Alpine							
1-30	713.9	49.0	598.8	142.7	31.9	433.2	30
31-50	955.1	114.7	1926.7	325.1	87.0	1648.0	32
Spruce-fir-pine							
1-30	682.9	119.0	1638.4	325.6	95.9	1396.0	3
31-50	1558.6	166.8	3490.3	450.0	131.8	2804.2	94
51-70	1216.8	179.5	4516.3	401.8	157.5	4078.8	216
71-90	848.0	177.4	4587.0	340.4	161.8	4283.4	65
Lodgepole pine							
1-30	5694.5	57.2	487.4	-	-	-	34
31-50	11.3	4.9	103.6	11.3	4.9	103.6	10
51-70	1749.5	252.2	5794.4	935.4	179.3	4171.5	13
Pine-aspen							
1-30	1191.7	31.8	274.9	-	-	-	10
TOTAL number of point samples							507

4.6 inches d.b.h. and larger are given. In addition, the standard deviations of the basal area estimates for trees 0.6 inches and larger were calculated for selected cover types. The standard deviations indicate that the precision at the 95% probability level is between  $\pm 5$  and  $\pm 7\%$  for the basal area estimates for trees 0.6 inches d.b.h. and larger in spruce-fir-pine stands 31 to 90 feet high. In the lodgepole pine cover type 51 to 70 feet high there are only 13 point samples and the precision of the basal area estimate is  $\pm 11\%$ . The young lodgepole pine stand in the 1 to 30-foot height class is the most heterogeneous with the precision of basal area estimates  $\pm 32\%$ . Total volume estimates have precisions similar to those obtained for basal area estimates.

The total volumes per acre for all trees 0.6 inches d.b.h. and larger multiplied by the number of acres occupied by each cover type and height class, and the percentage distribution are given in Table 3. Of the total volume, 89% is in the spruce-fir-pine cover type, 51 to 70 feet high. Approximately 80% of the total volume would be merchantable with utilization

TABLE 3. DISTRIBUTION OF TOTAL VOLUME BY FOREST COVER TYPES AND HEIGHT CLASSES.

(all trees 0.6" d.b.h. and larger)

Forest cover type and height class	Area (acres)	Average volume per acre (cu ft)	Total volume (cu ft)	Percentage of total volume
Alpine				
1-30	99	598.8	59,281.0	1.31
31-50	94	1,926.7	181,109.8	4.02
Spruce-fir-pine				
1-30	10	1,638.4	16,384.0	.36
31-50	218	3,490.3	760,885.4	16.84
51-70	560	4,516.3	2,529,128.0	55.98
71-90	155	4,587.0	710,985.0	15.73
Lodgepole pine				
1-30	164	487.4	79,933.6	1.77
31-50	4	103.6	414.4	.01
51-70	29	5,794.4	168,037.6	3.72
Pine-aspen				
1-30	42	274.9	11,545.8	.26
TOTAL all types	1375		4,517,704.6	100.00

standards of a 1-foot stump and 4-inch top. Actual utilization may be considerably less because of cull in the 270-year-old timber.

#### COMPUTER MAPS AND CUMULATIVE TREE FREQUENCY CHARTS

For each major forest cover type and for each height class within that cover type a computer map was printed; where sampling was sufficient a stand and stock table and a cumulative tree frequency chart were also prepared. The computer maps presented have been reduced to show only the location of the various cover types: at their original size, code numbers indicated individual combination of cover type, height and density classes. The cumulative frequency charts on semi-logarithmic paper accurately describe tree frequency distribution by diameter classes and individual species, and emphasize differences and similarities in the forest cover type-height strata presented. Detailed stand and stock tables are presented in Appendix III.

Lodgepole Pine and Lodgepole Pine-Aspen Cover Types (See Figures 1 and 2)

Three height classes of this cover type are present.

1. 1 to 30-foot height class

The 1 to 30-foot height class is on an area that was burned in 1936. Two cover types within this height class are noted. The lodgepole pine cover type is dense, 5700 trees per acre, while the lodgepole pine-aspen cover type is less dense, 1200 trees per acre. In both cover types there are approximately 200 spruce trees per acre in the understory.

2. 31 to 50-foot height class

The area has been partially logged with the larger trees removed. No stand statistics have been compiled for this height class.

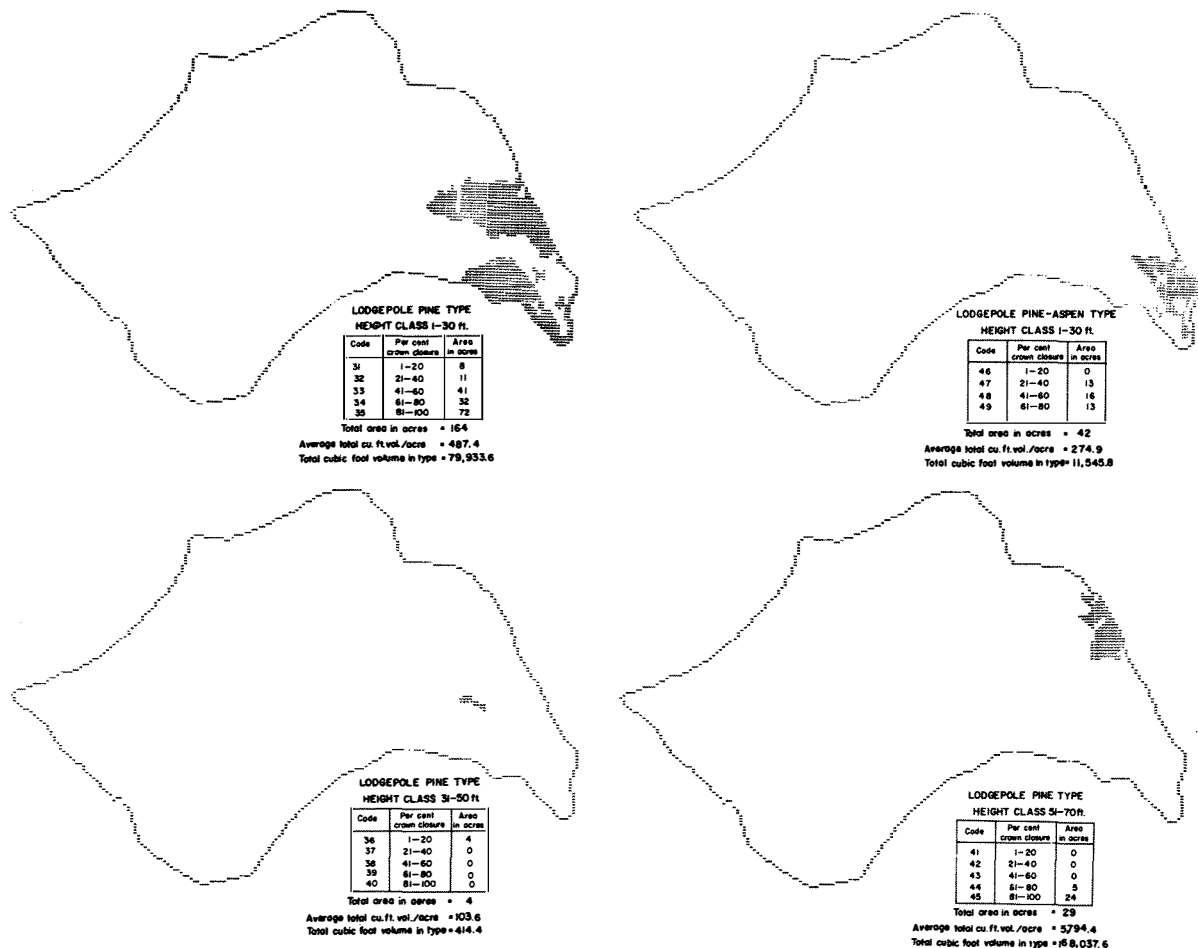


Figure 1. Computer maps showing location and area of lodgepole pine and lodgepole pine-aspen cover types.

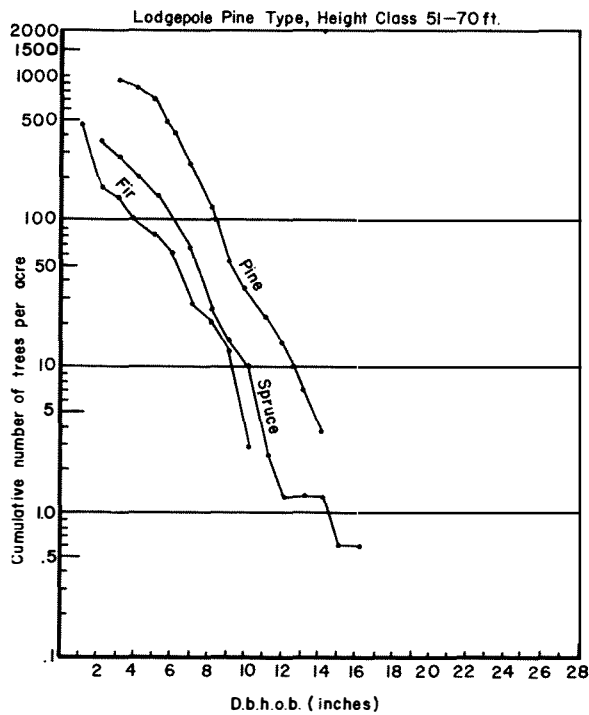
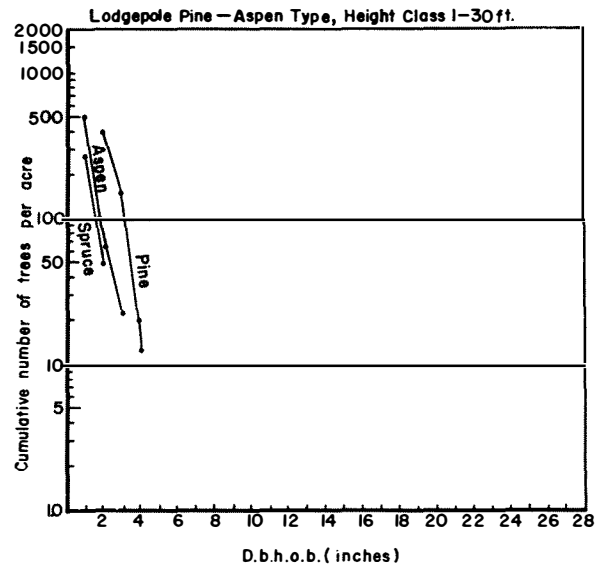
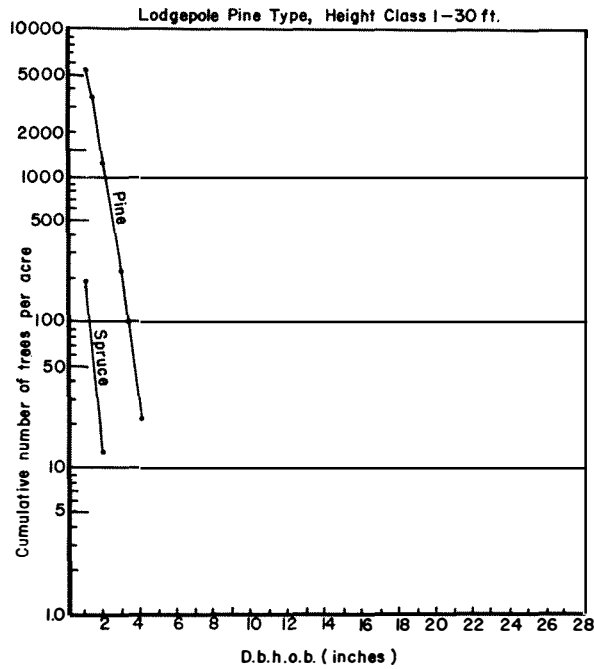


Figure 2. Cumulative tree frequency charts for lodgepole pine and lodgepole pine-aspen cover types.

### 3. 51 to 70-foot height class

This height class is notable for the high basal area and crown closure for a 165-year-old stand at 6000 feet. The alpine fir and spruce in the understory of this stand will form the climax forest with the continued absence of fire.



Spruce-Fir-Lodgepole Pine Cover Types (See Figures 3 and 4)

This is the oldest and most extensive cover type on the basin; veterans in most stands are approximately 270 years old. The stands are all-aged; spruce and alpine fir are shade-tolerant, and lodgepole pine and alpine larch are intolerant.

1. 1 to 30-foot height class

This height class is at elevations near 7000 feet.

2. 31 to 50-foot height class

This height class is partly related to past logging which removed the larger trees, but for the most part, poor site contributes to the smallness of these trees.

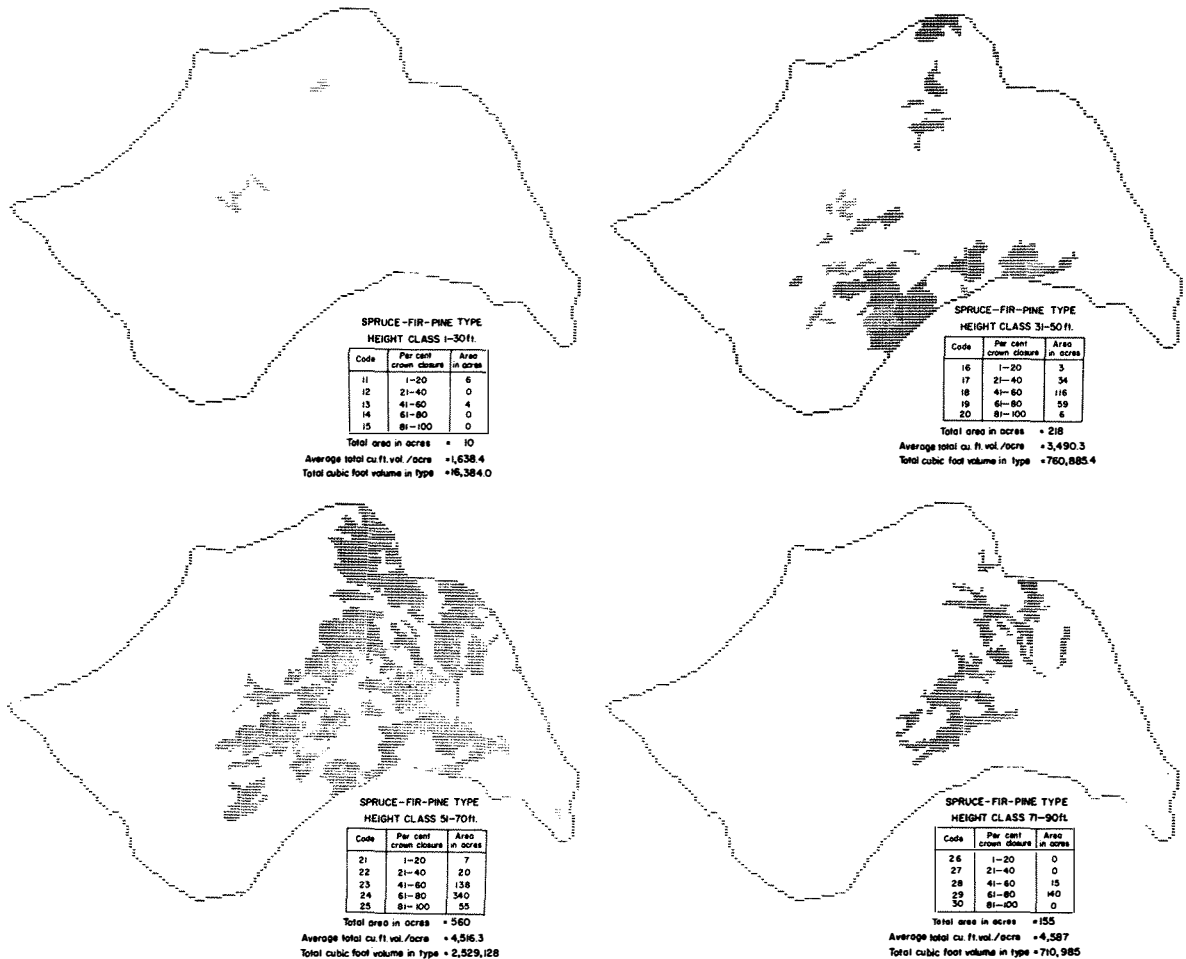


Figure 3. Computer maps showing location and area of spruce-fir-pine cover types.

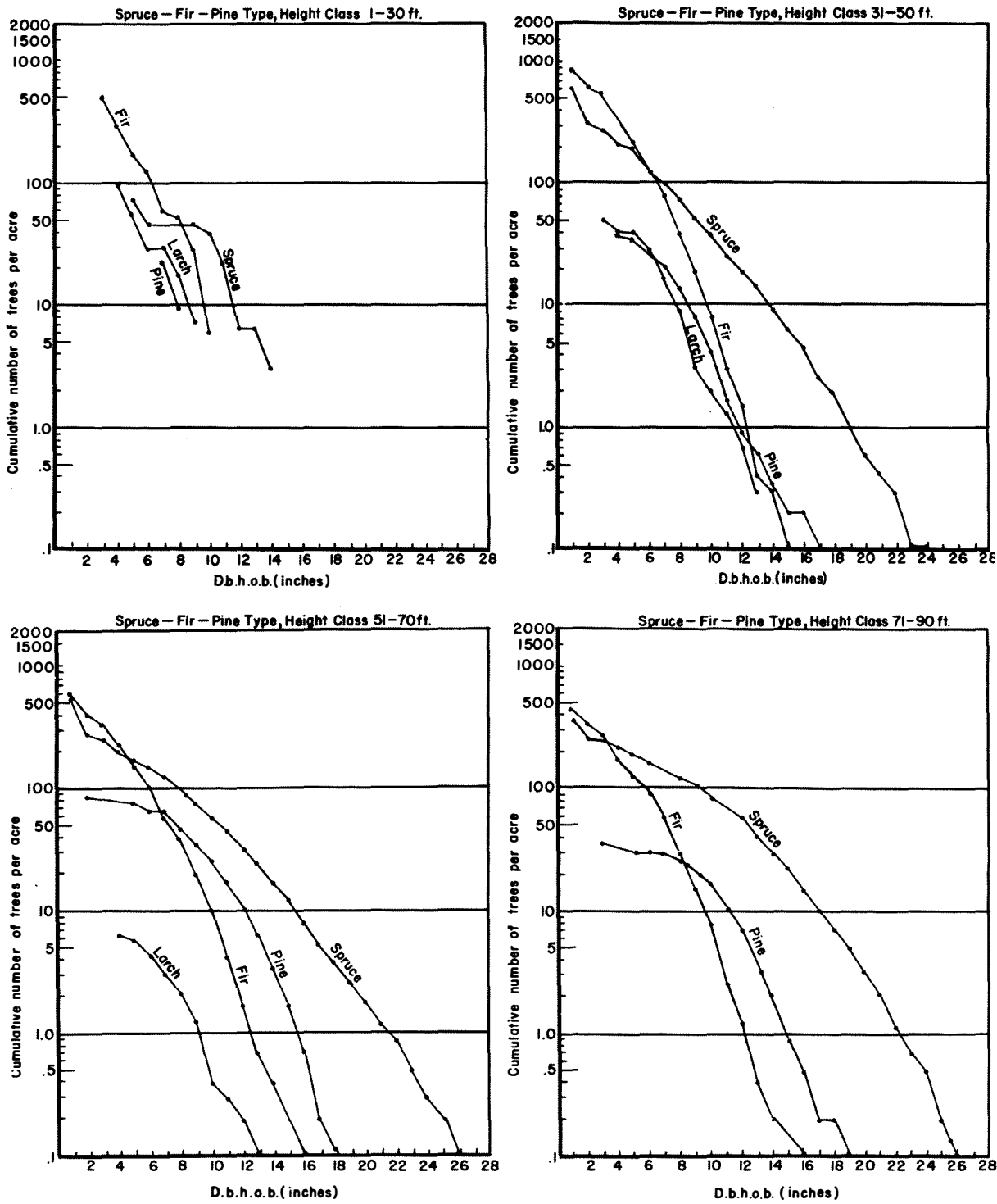


Figure 4. Cumulative tree frequency charts for spruce-fir-pine cover types.

TABLE 4. AREA DISTRIBUTION OF HABITAT TYPES.  
(Total area = 2282 acres)

Timber habitat types	Area (acres)	Percentage of total area	Alpine habitat types	Area (acres)	Percentage of total area
<i>Picea/Arctostaphylos</i>	-	-	Krummholz <i>Vaccinium scoparium</i>	31	1.36
<i>Picea-Abies/Calamagrostis</i>	89	3.90	<i>Phyllodoce</i>	318	13.93
Shallow Bedrock Facies of <i>Calamagrostis</i> habitat type	21	.92	<i>Salix</i>	65	2.84
<i>Picea-Abies/Hylocomium-Cornus</i>	82	3.59	<i>Dryas</i>	43	1.88
Young <i>Pinus contorta</i> Facies of <i>Hylocomium-Cornus</i> type	53	2.32	<i>Carex-Antennaria</i>	287	12.58
<i>Picea-Abies/Menziesia-Lycopodium</i>	553	24.23	<i>Danthonia-Deschampsia</i>	44	1.93
<i>Picea-Abies/Equisetum</i>	114	4.99	<i>Elymus</i>	24	1.05
<i>Picea/Sphagnum-Ledum</i>	6	.26	Seepage avalanche meadow	2	.09
<i>Picea-Carex</i>	10	.48	<i>Kobresia</i>	5	.22
<i>Picea-Abies/Vaccinium scoparium</i>	264	11.56	Rock and Talus	271	11.87
TOTAL Timber Types	1192	52.25	TOTAL Alpine Types	1090	47.75

#### FOREST HABITAT TYPES

Eleven forest habitat types are mapped for the Marmot Creek Watershed. The habitat types are based on those defined and described for the spruce-fir and lodgepole pine forests in the main Rocky Mountain region of Alberta (Ogilvie, 1963). Since much of Marmot Creek basin lies above 5500

feet elevation, the low-elevation habitat types, *Arctostaphylos*, *Calamagrostis*, and *Sphagnum-Ledum* types are restricted in area. The habitat types of Marmot Creek basin were mapped in sufficient detail to indicate subtypes or facies such as the wet habitat types, the seepage habitat types, the shallow soil bedrock habitats, and some of the young successional lodgepole pine types.

#### *Picea-Abies/Vaccinium scoparium* Habitat Type

This is one of the most extensive habitat types in Marmot basin. It extends from timberline down to approximately 6700 feet elevation, and on some slopes to as low as 6400 feet. Timberline here, as in the rest of the mountain region, is highly irregular: it averages about 7200 feet elevation, but in several places it extends up to 7400 feet, and on avalanche slopes it is depressed to as low as 6600 feet.

The ground vegetation of this habitat type is characterized by an abundant cover of *Vaccinium scoparium*, *V. myrtillus*, *Phyllodoce glanduliflora*, and *P. empetriformis*. Typical herbs are: *Arnica latifolia*, *Potentilla diversifolia*, *Pedicularis bracteosa*, and bryophyte and lichen species such as *Dicranum fuscescens*, *Barbilophozia* spp., and *Cladonia* spp. The soils are strongly acid, with high moisture status throughout the year. Snow accumulation is extreme and lasts late in the growing season.

In the upper part of this zone where the stands become more open, alpine larch is mixed with the alpine fir and Engelmann spruce. Above the timberline there are scattered colonies of stunted spruce and fir krummholz in which the ground vegetation and habitat features are quite similar to the *Vaccinium scoparium* forest type; these have been mapped with the alpine types as the Krummholz/*Vaccinium scoparium* habitat type.

#### *Picea-Abies/Menziesia-Lycopodium* Habitat Type

This forest habitat type is present on 1/4 of the basin, the largest area of any habitat type. Typically, it adjoins the *Vaccinium scoparium* type and extends down to 5500 feet in elevation. Relatively deep snow accumulates in this type, and soil moisture is good throughout the year. The soils have well-developed podzolic profiles with acid organic matter, a strongly developed Ae horizon, and a rich Bf horizon. The tree species consist of hybrid white X Engelmann spruce, alpine fir, and occasional lodgepole pine. There is a dense, tall shrub layer of *Menziesia ferruginea*, *Rhododendron albiflorum*, *Sorbus sitchensis*, and *S. scopulina* underlain by a low shrub layer of *Vaccinium myrtillus*, *V. membranaceum*, and *V. scoparium*. The herb layer consists of *Lycopodium annotinum*, *Pyrola uniflora*, *P. secunda*, and *Arnica latifolia*. The abundant bryophyte and lichen layer is composed of *Pleurozium schreberi*, *Hylocomium splendens*, *Dicranum* spp., and *Peltigera aphthosa*.

In the upper band of this habitat type, near where it meets with the *Vaccinium scoparium* type, there is increased dominance of *Rhododendron albiflorum* and *Menziesia ferruginea* decreases in importance.

### Picea-Abies/Hylocomium-Cornus Habitat Type

This occurs as a topographic forest type within the broadly-distributed *Menziesia* type. At the relatively high elevations of this basin this habitat type is restricted to the southwesterly-facing slopes where warmer temperatures, higher evapo-transpiration, and drier soil conditions prevail. The tree species consist of hybrid white X Engelmann spruce, alpine fir, and some old, residual lodgepole pine. A distinctive, continuous carpet of feather mosses: *Hylocomium splendens*, *Ptilium crista-castrensis*, and *Pleurozium schreberi*, is characteristic of this type. Typical herbs are *Cornus canadensis*, *Linnaea borealis* var. *americana*, *Arnica cordifolia*, *Pyrola virens*, *P. secunda*, and *Stenanthium occidentale*. Some of the shrub species are *Rosa acicularis*, *Shepherdia canadensis*, and *Lonicera involucrata*.

### Young Pinus contorta/Hylocomium-Cornus Facies

These stands are the result of fire approximately 30 years ago, and now have a dense cover of lodgepole pine. In terms of potential growth and productivity these stands would be considered as the *Picea-Abies/Hylocomium-Cornus* habitat type. However, there are certain differences of vegetation in the young lodgepole pine cover, for example an abundance of *Elymus innovatus*, *Arnica cordifolia*, *Aster conspicuus*, and *A. ciliolatus*. The soil has comparatively thin organic horizons and the Ae horizon is not conspicuous.

### Picea-Abies/Calamagrostis Habitat Type

This habitat type covers only a small area in the Marmot basin and is found on the lowest, south-facing slopes under lodgepole pine. The tree species also include some aspen and regenerating hybrid white X Engelmann spruce, and alpine fir. The soils are weakly podzolized and tend to be droughty. There is an abundant cover of *Calamagrostis rubescens*, with *Elymus innovatus*, *Vaccinium caespitosum*, *Spiraea lucida*, *Aster conspicuus*, *A. ciliolatus*, *Hedysarum sulphurescens*, *Arnica cordifolia*, and *Penstemon confertus*.

### Shallow Bedrock Facies of Calamagrostis Habitat Type

A shallow-soil facies of the *Calamagrostis* habitat type occurs on a south-facing slope above the creek where bedrock is close to the surface. The soils are dry and poor for tree growth. The ground vegetation is similar to the *Calamagrostis* type with the addition of certain more xeric species such as *Koeleria cristata*, *Bromus pumpellianus*, *Oxytropis campestris*, *Gentianella amarella*, and *Campanula rotundifolia*.

### Picea/Arctostaphylos Habitat Type

A very small patch of this habitat type occurs on a dry slope adjacent to a lodgepole pine stand of the *Calamagrostis* type. The soils

are coarse textured and dry. The common species are *Arctostaphylos uva-ursi*, *Juniperus horizontalis*, *Elymus innovatus*, *Solidago decumbens*, *Koeleria cristata*, and *Antennaria parvifolia*.

#### Picea-Abies/Equisetum Habitat Type

This type borders all branches of the creek, varying in width from a narrow, unmappable strip to a band several hundred feet wide. The soils are moist due to the high, fluctuating water-table and are distinctly gleysolic. The tree species consist of hybrid white X Engelmann spruce, and alpine fir. Diagnostic species are *Equisetum pratense*, *E. arvense*, *E. scirpoides*, *Ribes lacustre*, *Salix* spp., *Anemone parviflora*, *Mitella nuda*, *Aquilegia flavescens*, *Osmorhiza chilensis*, *Carex* spp., *Thalictrum occidentale*, *Timmia austriaca*, *Mnium affine*, and *M. spinulosum*.

#### Seepage Variants

Along all slopes and the banks of the creek, where lateral-moving groundwater occurs high in the soil profile, the prevailing habitat type is modified and the ground vegetation shows an increase in moist habitat species. The main diagnostic species of the prevailing habitat type are present but with the addition of such seepage indicators as *Equisetum scirpoides*, *Ribes lacustre*, *Empetrum nigrum*, *Ledum groenlandicum*, *Timmia austriaca*, *Anemone parviflora*, *Parnassia* spp., *Thalictrum occidentale*, *Senecio lugens*, *Carex* spp., *Salix* spp., and sparse *Equisetum arvense*. At high elevations, for example in the seepage variant of the *Vaccinium scoparium* type, there are some additional seepage indicators such as *Salix vestita*, *Polygonum viviparum*, *Senecio triangularis*, and *Valeriana sitchensis*. The tree species consist of hybrid white X Engelmann spruce and alpine fir. Windthrow is common in these habitats. The soil profiles show varying degrees of gleyzation depending on the amount and depth of seepage.

#### Picea/Carex and Picea/Sphagnum-Ledum Habitat Types

Occasionally, in places on the valley slopes where there is a local flattening or concavity in the topography, the downslope seepage is impeded and accumulates in boggy areas. The forest stands become very sparse with wide openings among the short trees. The center of these "hangmoors", where water is at the surface, is the *Sphagnum-Ledum* type which has a dense cover of peat mosses: *Sphagnum* spp., *Tomenthypnum nitens*, *Aulacomnium palustre*, and *Drepanocladus* spp., and an abundance of *Ledum groenlandicum*, *Betula glandulosa*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, and *Salix* spp. The surrounding area, where the water level is lower and somewhat more freely moving, is the *Picea/Carex* habitat type which has an abundance of *Carex* spp., *Juncus* spp., *Equisetum variegatum*, and *E. arvense*.

## ALPINE HABITAT TYPES

This zone extends from continuous forest line to 9000 feet, the highest elevation of the watershed. Ten map units are delimited. In addition to strictly alpine types, the map units include avalanche types which extend into the forest zone, as well as timberline types occurring where the forest breaks up into tree islands and krummholz colonies.

### Krummholz/Vaccinium scoparium Habitat Type

This type occurs in and among the tree islands and krummholz colonies where deep snow is blown in. The soils are minimal podzolic, moisture status is high, and there is only a short period in summer when the stands are free of snow. The dominant shrubs are *Vaccinium scoparium* and *V. myrtilloides*, with some occurrence of the mountain heaths, *Phyllodoce* spp. and *Cassiope* spp.

### Phyllodoce Habitat Type

This is a mesic heath type, occurring on cool, moist, northerly exposures where there is deep snow accumulation. The soils are minimal podzolic. Mountain heaths are dominant: *Phyllodoce glanduliflora*, *P. empetriflora*, *Cassiope mertensiana*, and *C. tetragona*, and there is an abundance of bryophytes, for example: *Dicranum fuscescens* and *Barbilophozia* spp.

### Salix Habitat Type

This tall willow shrub type occurs along the broader valley bottoms and extends down into the forest zone. Snow cover is relatively deep. The soils are strongly gleyzolic, with a high water-table. There is a dense shrub cover of *Salix glauca*, *S. barrattiana*, *Betula glandulosa*, with moist habitat species such as: *Trollius albiflorus*, *Equisetum* spp., *Carex* spp., and *Aulacomnium palustre*.

### Dryas Habitat Type

This is a dry, shrub-mat type occurring on the wind-scoured, snow-free crests of moraines and ridgebacks. The soils are dry, stoney lithosols. There is an abundance of *Dryas hookeriana*, with *Oxytropis podocarpa*, *Saxifraga bronchialis*, *S. oppositifolia*, *Agropyron latiglume*, and numerous lichens; *Cetraria* spp., *Cladonia* spp., *Thammodia* spp., and *Usnea* spp.

### Elymus Habitat Type

This is the avalanche meadow type of steep southwesterly-facing slopes. Snow cover is moderate and avalanching occurs regularly. The

soils are colluvial-chnozemic. The vegetation is dominated by dense grass cover: *Elymus innovatus*, *Festuca scabrella*, *Bromus pumpellianus*, and an abundance of herbs: *Hedysarum sulphurescens*, *Fragaria virginiana* var. *glauca*, *Oxytropis campestris*, *O. splendens*, *Campanula rotundifolia*, *Achillea millefolium*, and *Arctostaphylos uva-ursi*.

#### Seepage Avalanche Meadow Type

This is a local topographic variant of the preceding type in which the water-table is high and seepage is close to the surface. A number of moist species, in addition to those of the preceding type are diagnostic: *Heracleum lanatum*, *Thalictrum occidentale*, *Delphinium glaucum*, *Hackelia floribunda*, and *Actaea arguta*.

#### Danthonia-Deschampsia Habitat Type

This is a mesic meadow type of restricted occurrence, present on some southerly-facing slopes. The soils are chernozemic, and snow cover is moderate. Some of the characteristic species are *Danthonia intermedia*, *Deschampsia caespitosa*, *Agrostis* spp. and *Carex* spp.

#### Carex-Antennaria Habitat Type

This is a moist, herb meadow occurring in channels and depressions with very deep snow accumulation which remains late in the growing season. There is an abundance of herbs and grass-like plants; *Carex* spp., *Juncus* spp., *Luzula* spp., *Poa* spp., *Phleum alpinum*, *Antennaria lanata*, *Erigeron peregrinus* ssp. *callianthemus*, *Senecio* spp., and *Castilleja* spp.

#### Kobresia Habitat Type

This is the snow-free dry-sedge meadow type. It occurs on high, wind-exposed, south-facing slopes where snow is absent or shallow due to wind removal and melting. The soils are shallow, chernozemic lithosols. The characteristic species are: *Kobresia myosuroides*, *Elymus innovatus*, *Dryas hookeriana*, *Potentilla nivea*, *Tortula ruralis*, and *Cetraria* spp.

#### Rock and Talus Type

The rock and talus map unit is used to designate exposed bedrock and unstable, coarse colluvium which are not vegetated or have very sparse plant cover. The soils are shallow lithosols with little or no organic matter. There is sparse occurrence of lichens and scattered vascular plants such as *Saussurea densa*, *Taraxacum lyratum*, *Eriogonum androsaceum*, and *Crepis nana*.



## DISTRIBUTION OF HABITAT TYPES IN COVER TYPES

The percentage distribution of various forest-habitat combinations was determined by using the "combinations routine" of the computer mapping program, where maps and area calculations for specified combinations from two maps are produced.

The percentage distribution of habitat types in the various height classes of the spruce-fir-pine cover type, all approximately 270 years old, is shown in Table 5.

The 71 to 90-foot height class is located along the stream banks on the moister sites. The principal habitat types associated with these better spruce-fir forests are *Picea-Abies/Menziesia-Lycopodium*; *Picea-Abies/Equisetum*; and *Picea-Abies/Hylocomium-Cornus*.

The slower growing forests are associated with *Picea-Abies/Vaccinium scoparium* at elevations over 6000 feet and on very moist sites where aeration is limiting, for example the *Picea-Carex* habitat type at all elevations.

TABLE 5. THE DISTRIBUTION OF HABITAT TYPES IN THREE HEIGHT CLASSES OF SPRUCE-FIR FOREST.

Habitat type	Percentage of total area
<b>Spruce-Fir-Pine-Forests 71 to 90 feet high</b>	
<i>Picea - Abies/Menziesia - Lycopodium</i>	68.5
<i>Picea - Abies/Equisetum</i>	18.5
<i>Picea - Abies/Hylocomium - Cornus</i>	8.7
Others	4.3
	100.0
<b>Spruce-Fir-Pine-Forest 51 to 70 feet high</b>	
<i>Picea - Abies/Menziesia - Lycopodium</i>	63.9
<i>Picea - Abies/Vaccinium scoparium</i>	17.0
<i>Picea - Abies/Hylocomium - Cornus</i>	11.5
<i>Picea - Abies/Equisetum</i>	5.4
Others	2.2
	100.0
<b>Spruce-Fir-Pine-Forest 31 to 50 feet high</b>	
<i>Picea - Abies/Menziesia - Lycopodium</i>	46.2
<i>Picea - Abies/Vaccinium scoparium</i>	45.8
<i>Picea - Abies/Equisetum</i>	6.8
<i>Picea/Carex</i>	1.2
	100.0

Forest cover types with both good and poor forest growth are associated with the same habitat type. For example *Picea-Abies/Menziesia-Lycopodium* is the most prominent habitat type for spruce-fir forest in all height classes. Factors such as stand density are also limiting to tree growth, and potentially good growing areas may have reduced growth because of factors other than habitat.

## RECOMMENDATIONS

The maintenance of forest and habitat type maps is a continuous process and with further knowledge there will be refinements. Correcting and updating these two maps will require re-coding of only those areas where changes are made. New maps and tables of these corrected inventories can easily be produced using the computer mapping programs developed.

Complete revision of these inventories, by remeasurement of point samples on the ground from centers permanently marked with aluminum angle stakes, at 10-year intervals should be sufficiently frequent for most purposes. More frequent measurement of the point samples may not show significant differences from the previous survey.

The application of these forest and habitat inventories will be an interpretive process in which the most pertinent criteria will be selected and integrated for a specific problem or problems.

## REFERENCES

- Amidon, E.L. 1964. A computer-oriented system for assembling and displaying land management information. U.S. Dep. Agr., Forest Serv., Pacific S.W. Forest Range Exp. Sta., Res. Pap. PSW 17.
- Amidon, E.L. 1966. An alphanumeric map information and display system for a large computer. U.S. Dep. Agr., Forest Serv., Pacific S.W. Forest Range Exp. Sta., Res. Pap. PSW 38.
- Jeffrey, W.W. 1965. Experimental watershed in the Rocky Mountains, Alberta, Canada. Int. Ass. Sci. Hydrol., Symp. Budapest, Publ. 66(2):502-521.
- Kirby, C.L. 1964. An introduction to point sampling. Can. Dep. Forest. Forest Res. Br., Res. Rep. 64-A-15.
- Ogilvie, R.T. 1963. Ecology of the forests in the Rocky Mountains of Alberta. Can. Dep. Forest., Forest. Res. Br., Res. Rep. 63-A-12.
- Redmond, D.R. 1964. Organization of inter-agency watershed research programs for Canada. Nat. Res. Council. Can., Proc. 4th Hydrol. Symp., pp 299-304.
- Storr, D. 1967. Precipitation variations in a small forested watershed. Snow Conf. Proc. 35th Annu. Meeting pp 11-17.

## APPENDIX I

### HEIGHT-DIAMETER RELATIONSHIPS, LOCAL VOLUME TABLES, VOLUME-BASAL AREA RATIOS AND FORMULAE\*

D.b.h. o.b. (inches)	Total height (feet)	Total volume (cu ft)	T.V. B.A.	Species - height class, total volume, and volume-basal area formulae**	
1	12	0.03	7.00	Lodgepole pine in cover types up to 30' T.V. = .00746 + .00297D <sup>2</sup> H T.V. = 7.10 + 0.88D B.A.	
2	15	0.17	7.73		
3	18	0.47	9.59		
4	19	0.90	10.34		
5	37	2.62	19.26	Lodgepole pine in cover types 31' +  T.V. = .10260 + .00272D <sup>2</sup> H  T.V. = 11.40 + 1.71D B.A.	
6	42	4.22	21.53		
7	46	6.24	23.37		
8	50	8.81	25.24		
9	54	12.00	27.14		
10	58	15.88	29.13		
11	61	20.18	30.57		
12	64	25.18	32.07		
13	67	30.91	33.52		
14	70	37.43	35.01		
7	40	5.73	21.46		Spruce in cover types 31 to 50'  T.V. = 1.72670 + .00204D <sup>2</sup> H  T.V. = 19.00 + 0.20D B.A.
8	43	7.34	21.03		
9	45	9.16	20.72		
10	47	11.31	20.75		
11	49	13.82	20.94		
12	51	16.71	21.29		
13	52	19.65	21.31		
14	54	23.32	21.81		
15	55	26.97	21.98		
16	56	30.97	22.18		
17	57	35.33	22.42		
7	46	6.32	23.67	Spruce in cover types 51' +  T.V. = 1.72670 + .00204D <sup>2</sup> H  T.V. = 17.40 + 0.75D B.A.	
8	51	8.38	24.01		
9	54	10.65	24.09		
10	58	13.56	24.88		
11	61	16.78	25.42		
12	64	20.53	26.15		
13	67	24.83	26.93		
14	69	29.32	27.42		
15	72	34.77	28.33		
16	74	40.37	28.91		
17	77	47.12	29.89		
18	79	53.94	30.52		
19	82	62.11	31.54		
20	84	70.27	32.20		
21	87	79.99	33.25		
22	89	89.60	33.93		
23	91	99.93	34.63		
24	94	112.18	35.70		

\*Where: H = total height (feet). B.A. = basal area (square feet).

D = d.b.h.o.b. (inches). T.V. = total cubic foot volume.

\*\*The lodgepole pine volume formulae are based on the complete stem analysis of 50 dominant and codominant 100-year-old trees at the Kananaskis forest experiment station. The white spruce volume formulae are based on data for 1757 trees that were used to produce standard volume tables by A.W. Blyth (White spruce standard volume tables for the boreal and sub-alpine regions of Alberta. Can. Dep. Resources Develop., Forest. Br., Silvicult. Leaflet 60, 1952).

## APPENDIX II

### SCIENTIFIC AND COMMON PLANT NAMES

<i>Abies lasiocarpa</i> (Hook.) Nutt.	alpine fir
<i>Achillea millefolium</i> L.	common yarrow
<i>Actaea arguta</i> Nutt.	baneberry
<i>Agropyron latiglume</i> (Scribn. & Smith) Rydb.	wheat grass
<i>Agrostis</i> spp.	bentgrass
<i>Anemone parviflora</i> Michx.	anemone
<i>Antennaria lanata</i> (Hook.) Greene	everlasting
<i>Antennaria parvifolia</i> Nutt.	pussytoes
<i>Aquilegia flavescens</i> S. Wats.	columbine
<i>Arctostaphylos uva-ursi</i> (L.) Spreng.	bearberry
<i>Arnica cordifolia</i> Hook.	heart-leafed arnica
<i>Arnica latifolia</i> Bong.	arnica
<i>Aster ciliolatus</i> Lindl.	blue aster
<i>Aster conspicuus</i> Lindl.	showy aster
<i>Aulacomnium palustre</i> (Hedw.) Schwaegr.	moss
<i>Barbilophozia</i> spp.	leafy liverwort
<i>Betula glandulosa</i> Michx.	dwarf birch
<i>Bromus pumpellianus</i> Scribn.	brome-grass
<i>Calamagrostis rubescens</i> Buckl.	pine-grass
<i>Campanula rotundifolia</i> L.	bluebell
<i>Carex</i> spp.	sedge
<i>Cassiope mertensiana</i> (Bong.) G. Don	mountain heather
<i>Cassiope tetragona</i> (L.) D. Don	mountain heather
<i>Castilleja</i> spp.	Indian paintbrush
<i>Cetraria</i> spp.	lichen
<i>Cladonia</i> spp.	lichen
<i>Cornus canadensis</i> L.	bunchberry
<i>Crepis nana</i> Richards.	alpine hawk's-beard
<i>Danthonia intermedia</i> Vasey	oat-grass
<i>Delphinium glaucum</i> S. Wats.	tall larkspur

<i>Deschampsia caespitosa</i> (L.) Beauv.	tufted hairgrass
<i>Dicranum fuscescens</i> Turn.	moss
<i>Drepanocladus</i> spp.	moss
<i>Dryas hookeriana</i> Juz.	mountain avens
<i>Elymus innovatus</i> Beal	hairy wild rye grass
<i>Empetrum nigrum</i> L.	crowberry
<i>Equisetum arvense</i> L.	field horsetail
<i>Equisetum pratense</i> Ehrh.	meadow horsetail
<i>Equisetum scirpoides</i> Michx.	dwarf horsetail
<i>Equisetum variegatum</i> Schleich.	variegated horsetail
<i>Eriogonum androsaceum</i> Benth.	umbrella-plant
<i>Erigeron peregrinus</i> (Pursh) Greene ssp. <i>callianthemus</i> (Greene) Cronq.	blue daisy
<i>Festuca scabrella</i> Torr.	rough fescue grass
<i>Fragaria virginiana</i> Duchesne var. <i>glauca</i> S. Wats.	strawberry
<i>Gentianella amarella</i> (L.) Borner	gentian
<i>Hackelia floribunda</i> (Lehm.) I.M. Johnston	stickseed
<i>Hedysarum sulphurescens</i> Rydb.	yellow hedysarum
<i>Heracleum lanatum</i> Michx.	cow-parsnip
<i>Hylocomium splendens</i> (Hedw.) B.S.G.	feather moss
<i>Juncus</i> spp.	rush
<i>Juniperus horizontalis</i> Moench	creeping juniper
<i>Kobresia myosuroides</i> (Vill.) Fiori & Paol.	golden sedge
<i>Koeleria cristata</i> (L.) Pers.	june grass
<i>Larix lyallii</i> Parl.	alpine larch
<i>Ledum groenlandicum</i> Oeder	Labrador-tea
<i>Linnaea borealis</i> L. var. <i>americana</i> (Forbes) Rehd.	twin-flower
<i>Lonicera involucrata</i> (Richards.) Banks	bracted honeysuckle
<i>Luzula</i> spp.	woodrush
<i>Lycopodium annotinum</i> L.	club-moss
<i>Menziesia ferruginea</i> Smith	false azalea
<i>Mitella nuda</i> L.	mitrewort
<i>Mnium affine</i> Bland.	moss

<i>Mnium spinulosum</i> B.S.G.	moss
<i>Osmorhiza chilensis</i> H. & A.	sweet cicely
<i>Oxytropis campestris</i> (L.) DC.	yellow loco-weed
<i>Oxytropis podocarpa</i> A. Gray	alpine loco-weed
<i>Oxytropis splendens</i> Dougl.	showy loco-weed
<i>Parnassia</i> spp.	grass-of-parnassus
<i>Pedicularis bracteosa</i> Benth.	lousewort
<i>Peltigera aphthosa</i> (L.) Willd.	lichen
<i>Penstemon confertus</i> Dougl.	yellow beard-tongue
<i>Phleum alpinum</i> L.	alpine timothy
<i>Phyllodoce empetriformis</i> (Sm.) D. Don	red heather
<i>Phyllodoce glanduliflora</i> (Hook.) Cov.	yellow heather
<i>Picea engelmanni</i> Parry	Engelmann spruce
<i>Picea glauca</i> (Moench) Voss	white spruce
<i>Picea engelmanni</i> X <i>P. glauca</i>	hybrid spruce
<i>Pinus contorta</i> Dougl. var. <i>latifolia</i> Engelm.	lodgepole pine
<i>Pleurozium schreberi</i> (B.S.G.) Mitt.	feather moss
<i>Poa</i> spp.	blue grass
<i>Polygonum viviparum</i> L.	alpine bistort
<i>Populus tremuloides</i> Michx.	trembling aspen
<i>Potentilla diversifolia</i> Lehm.	cinquefoil
<i>Potentilla nivea</i> L.	cinquefoil
<i>Ptilium crista-castrensis</i> (Hedw.) De Not.	plume moss
<i>Pyrola secunda</i> L.	one-sided wintergreen
<i>Pyrola uniflora</i> L.	single delight
<i>Pyrola virens</i> Schweigg.	green-flowered wintergreen
<i>Rhododendron albiflorum</i> Hook.	white rhododendron
<i>Ribes lacustre</i> (Pers.) Poir.	bristly black currant
<i>Rosa acicularis</i> Lindl.	prickly rose
<i>Salix barrattiana</i> Hook.	mountain willow
<i>Salix glauca</i> L.	willow
<i>Salix vestita</i> Pursh	rock willow
<i>Saussurea densa</i> (Hook.) Rydb.	saw wort
<i>Saxifraga bronchialis</i> L.	prickly saxifrage

<i>Saxifraga oppositifolia</i> L.	purple mountain-saxifrage
<i>Senecio lugens</i> Richards.	groundsel
<i>Senecio triangularis</i> Hook.	brook ragwort
<i>Shepherdia canadensis</i> (L.) Nutt.	buffalo berry
<i>Solidago decumbens</i> Greene	goldenrod
<i>Sorbus scopulina</i> Greene	mountain rowan
<i>Sorbus sitchensis</i> Roem.	mountain rowan
<i>Sphagnum</i> spp.	peat moss
<i>Spiraea lucida</i> Dougl.	white meadow-sweet
<i>Stenanthium occidentale</i> A. Gray	bronze bells
<i>Taraxacum lyratum</i> (Ledeb.) DC.	alpine dandelion
<i>Thalictrum occidentale</i> A. Gray	meadow-rue
<i>Thammodia</i> spp.	lichen
<i>Timmia austriaca</i> Hedw.	moss
<i>Tomenthypnum nitens</i> (Hedw.) Loeske	moss
<i>Tortula ruralis</i> (Hedw.) G.M. & S.	moss
<i>Trollius albiflorus</i> (A. Gray) Rydb.	globe flower
<i>Usnea</i> spp.	lichen
<i>Vaccinium caespitosum</i> Michx.	dwarf bilberry
<i>Vaccinium membranaceum</i> Dougl.	black huckleberry
<i>Vaccinium myrtillus</i> L.	bilberry
<i>Vaccinium scoparium</i> Leiberg	grouseberry
<i>Vaccinium vitis-idaea</i> L. var. <i>minus</i> Lodd.	cranberry
<i>Valeriana sitchensis</i> Bong.	valerian



### APPENDIX III

#### COVER TYPE STAND AND STOCK TABLES

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species		
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)
	Pine Cover Type up to 30' in Height (per acre values)														
1	176.5	.9	7.1							4235.3	21.2	169.4	4411.8	22.1	176.5
2	13.4	.3	2.4							1042.8	22.9	187.7	1056.2	23.2	190.1
3										204.1	10.0	100.0	204.1	10.0	100.0
4										22.4	1.9	20.8	22.4	1.9	20.8
	-	-	-	Totals of trees 4.6" d.b.h. and larger						-	-	-	-	-	-
	189.9	1.2	9.5	Totals of trees 0.6" d.b.h. and larger						5504.6	56.0	477.9	5694.5	57.2	487.4
	Pine Cover Type 31' to 50' in Height (per acre values)														
1															
2															
3															
4															
5															
6															
7															
8															
9	11.3	4.9	103.6										11.3	4.9	103.6
	11.3	4.9	103.6	Totals of trees 4.6" d.b.h. and larger						11.3	4.9	103.6	11.3	4.9	103.6

STAND AND STOCK TABLE, ALPINE COVER TYPE UP TO 30' IN HEIGHT (PER ACRE VALUES)

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species		
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)
1				66.7	0.3	2.7	133.3	0.7	5.3				200.0	1.0	8.0
2	60.6	1.3	10.9	75.8	1.7	13.6	45.5	1.0	8.2				181.8	4.0	32.7
3	21.4	1.1	10.5	95.2	4.7	46.7							116.6	5.8	57.2
4	11.5	1.0	10.7	49.8	4.3	46.3	11.5	1.0	10.7				72.8	6.3	67.7
5	19.6	2.7	30.6	34.3	4.7	53.7	14.7	2.0	22.9				68.6	9.4	107.2
6	10.2	2.0	24.7	18.7	3.7	45.4	5.1	1.0	13.4				34.0	6.7	83.5
7	3.7	1.0	13.2	2.5	0.7	8.8	12.5	3.3	44.2				18.7	5.0	66.2
8				0.9	0.3	4.7	2.9	1.0	14.1				3.8	1.3	18.8
9	1.5	0.7	10.0	0.8	0.3	5.0	7.5	3.3	50.1				9.8	4.3	65.1
10	0.6	0.3	5.6	0.6	0.3	5.3	3.1	1.7	26.5				4.3	2.3	37.4
11				0.5	0.3	5.6	1.0	0.7	11.2				1.5	1.0	16.8
12							0.4	0.3	5.9				0.4	0.3	5.9
13							0.7	0.7	12.3				0.7	0.7	12.3
14							0.3	0.3	6.4				0.3	0.3	6.4
15	0.3	0.3	6.8				0.3	0.3	6.8				0.6	0.6	13.6
Totals of trees 4.6" d.b.h. and larger															
	35.9	7.0	90.9	58.3	10.3	128.5	48.5	14.6	213.8				142.7	31.9	433.2
Totals of trees 0.6" d.b.h. and larger															
	129.4	10.4	123.0	345.8	21.3	237.8	238.8	17.3	238.0				713.9	49.0	598.8

STAND AND STOCK TABLE, ALPINE COVER TYPE 31' TO 50' IN HEIGHT (PER ACRE VALUES)

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species		
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)
1				125.0	0.6	5.0							125.0	0.6	5.0
2	42.6	0.9	7.7	99.4	2.2	17.9	28.4	0.6	5.1				170.4	3.7	30.7
3	25.5	1.2	12.5	108.4	5.3	53.1	13.9	0.7	6.9				147.8	7.2	72.5
4	10.8	0.9	10.0	122.1	10.6	113.6	53.9	4.7	46.9				186.8	16.2	170.5
5	9.2	1.2	16.1	66.6	9.1	116.5	22.9	3.1	40.2				98.7	13.4	172.8
6	17.5	3.4	52.4	38.3	7.5	114.4	27.1	5.3	81.0				82.9	16.2	247.8
7	11.7	3.1	67.1	27.7	7.4	158.8	21.0	5.6	120.5				60.4	16.1	346.4
8	8.9	3.1	65.7	15.2	5.3	111.7	7.2	2.5	52.6				31.3	10.9	230.0
9	4.9	2.2	45.3	10.6	4.7	97.1	6.4	2.8	58.3				21.9	9.7	200.7
10	4.6	2.5	51.8	6.9	3.7	77.8	5.7	3.1	64.8				17.2	9.3	194.4
11	0.9	0.6	13.1	1.9	1.2	26.2	1.9	1.2	26.2				4.7	3.0	65.5
12	0.8	0.6	13.1	0.8	0.6	13.3	1.2	0.9	19.9				2.8	2.1	46.3
13	1.0	0.9	19.9	0.3	0.3	6.6	0.3	0.3	6.6				1.6	1.5	33.1
14	0.6	0.6	13.6	0.3	0.3	6.8							0.9	0.9	20.4
15	0.5	0.6	13.7	0.3	0.3	6.9							0.8	0.9	20.6
16	0.4	0.6	13.8				0.4	0.6	13.8				0.8	1.2	27.6
17	0.2	0.3	6.9				0.4	0.6	14.0				0.6	0.9	20.9
18															
19	0.2	0.3	7.1										0.2	0.3	7.1
20	0.3	0.6	14.4										0.3	0.6	14.4
	61.7	20.6	414.0	168.9	40.4	736.1	94.5	26.0	497.9				325.1	87.0	1648.0
	140.6	23.6	444.2	623.8	59.1	925.7	190.7	32.0	556.8				955.1	114.7	1926.7

STAND AND STOCK TABLE, SPRUCE FIR COVER TYPE UP TO 30' IN HEIGHT (PER ACRE VALUES)

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species		
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)
1															
2															
3				204.1	9.9	99.9							204.1	9.9	99.9
4				114.9	9.9	106.9	38.3	3.3	35.6				153.2	13.2	142.5
5	24.5	3.3	38.3	49.0	6.6	76.6	24.5	3.3	38.3				98.0	13.2	153.2
6				68.0	13.3	165.1							68.0	13.3	165.1
7				12.5	3.3	44.2	12.5	3.3	44.2	12.5	3.3	44.2	37.5	9.9	132.6
8				19.1	6.6	94.3	9.6	3.3	47.1	9.5	3.3	47.1	38.2	13.2	188.5
9	7.5	3.3	50.1	22.6	9.9	150.2	7.5	3.3	50.1				37.6	16.5	250.4
10	18.3	10.0	159.0	6.1	3.3	52.9							24.4	13.3	211.9
11	15.2	9.9	167.8										15.2	9.9	167.8
12															
13	3.6	3.3	61.8										3.6	3.3	61.8
14	3.1	3.3	64.7										3.1	3.3	64.7
Totals of trees 4.6" d.b.h. and larger															
	72.2	33.1	541.7	177.3	43.0	583.3	54.1	13.2	179.7	22.0	6.6	91.3	325.6	95.9	1396.0
Totals of trees 0.6" d.b.h. and larger															
	72.2	33.1	541.7	496.3	62.8	790.1	92.4	16.5	215.3	22.0	6.6	91.3	682.9	119.0	1638.4

STAND AND STOCK TABLE, SPRUCE FIR COVER TYPE 31' TO 50' IN HEIGHT (PER ACRE VALUES)

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species		
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)
1	289.5	0.9	18.2	231.6	1.3	24.2							521.1	2.2	42.4
2	48.2	1.1	20.4	86.9	1.9	36.8							135.1	3.0	57.2
3	64.3	3.2	61.9	188.1	9.3	181.6	6.2	0.3	6.2				258.6	12.8	249.7
4	51.6	4.5	89.6	131.4	11.6	229.3	4.8	0.4	8.3	6.0	0.5	9.6	193.8	17.0	336.8
5	32.2	4.4	88.4	80.5	11.1	221.0	9.3	1.3	25.3	6.4	0.8	16.8	128.4	17.6	351.5
6	28.8	5.7	114.8	61.0	12.0	242.4	12.9	2.5	51.0	6.4	1.3	27.4	109.1	21.5	435.6
7	25.9	6.9	141.7	39.4	10.5	214.7	7.9	2.1	42.9	7.5	2.0	46.7	80.7	21.5	446.0
8	20.5	7.2	147.4	19.9	6.9	143.1	5.4	1.9	39.0	5.4	1.9	47.5	51.2	17.9	377.0
9	14.9	6.6	137.9	10.5	4.6	96.3	1.4	0.6	23.4	3.8	1.7	45.1	30.6	13.5	302.7
10	10.6	5.8	121.6	5.2	2.8	59.7	0.6	0.3	6.6	2.5	1.4	39.0	18.9	10.3	226.9
11	6.9	4.5	95.9	1.3	0.8	17.9	0.6	0.4	8.9	0.8	0.5	15.9	9.6	6.2	138.6
12	4.6	3.6	76.6	1.1	0.8	18.0	0.4	0.3	6.7	0.3	0.2	6.7	6.4	4.9	108.0
13	4.2	3.9	84.1	0.1	0.1	2.3	0.3	0.3	6.8	0.3	0.3	10.6	4.9	4.6	103.8
14	3.3	3.6	78.0	0.2	0.2	4.6				0.1	0.1	3.7	3.6	3.9	86.3
15	1.8	2.2	48.6	0.1	0.1	2.3							1.9	2.3	50.9
16	1.9	2.6	58.4							0.1	0.1	4.0	2.0	2.7	62.4
17	0.7	1.2	25.9							0.1	0.1	4.2	0.8	1.3	30.1
18	0.9	1.6	35.7										0.9	1.6	35.7
19	0.4	0.7	16.8										0.4	0.7	16.8
20	0.2	0.5	12.1										0.2	0.5	12.1
21	0.1	0.2	4.9										0.1	0.2	4.9
22	0.2	0.4	9.9										0.2	0.4	9.9
23															
24	0.1	0.2	5.0										0.1	0.2	5.0
Totals of trees 4.6" d.b.h. and larger															
	158.2	61.8	1303.7	219.3	49.9	1022.3	38.8	9.7	210.6	33.7	10.4	267.6	450.0	131.8	2804.2
Totals of trees 0.6" d.b.h. and larger															
	611.8	71.5	1493.8	857.3	74.0	1494.2	49.8	10.4	225.1	39.7	10.9	277.2	1558.6	166.8	3490.3

STAND AND STOCK TABLE, SPRUCE FIR, COVER TYPE 51' TO 70' IN HEIGHT (PER ACRE VALUES)

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species		
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)
1	263.1	0.7	13.4	161.3	0.7	13.4							424.4	1.40	26.8
2	27.6	0.6	11.4	72.4	1.6	29.7				6.4	0.1	2.1	106.2	2.30	43.2
3	55.6	2.7	53.7	111.3	5.5	107.3				1.9	0.1	1.5	168.8	8.30	162.5
4	32.4	2.8	57.6	77.8	6.8	138.9	0.5	0.05	.9	4.8	0.4	7.6	115.5	10.05	205.0
5	18.3	2.5	52.9	47.7	6.5	138.1	1.4	0.19	3.7	8.1	1.1	22.2	75.5	10.29	216.9
6	24.8	4.9	107.6	39.3	7.7	169.4	1.4	0.28	5.6	7.8	1.5	33.1	73.3	14.38	315.7
7	27.8	7.5	168.9	25.3	6.8	153.1	1.0	0.28	5.7	11.8	3.1	73.6	65.9	17.68	401.3
8	23.3	8.1	190.7	19.2	6.7	157.1	0.8	0.28	5.7	13.1	4.6	115.1	56.4	19.68	468.6
9	15.0	6.6	159.9	9.2	4.1	98.4	0.9	0.42	8.7	9.6	4.3	114.1	34.7	15.42	381.1
10	14.1	7.7	191.4	6.2	3.4	84.1	0.1	0.05	1.0	8.9	4.9	138.6	29.3	16.05	415.1
11	12.0	7.9	203.2	2.6	1.7	43.9	0.1	0.05	1.0	5.7	3.8	114.7	20.4	13.45	362.8
12	8.8	6.9	182.2	1.0	0.8	20.8	0.1	0.05	1.0	5.3	4.2	133.1	15.2	11.95	337.1
13	7.0	6.4	174.7	0.3	0.3	7.5	0.1	0.05	1.0	2.9	2.6	88.7	10.3	9.35	271.9
14	4.7	5.0	139.5	0.3	0.3	7.7				1.7	1.9	65.4	6.7	7.20	212.6
15	4.4	5.5	156.6							1.0	1.2	44.6	5.4	6.70	201.2
16	2.7	3.8	111.6	0.1	0.1	2.7				0.5	0.6	25.1	3.3	4.50	139.4
17	1.5	2.4	72.6							0.1	0.1	5.6	1.6	2.50	78.2
18	1.2	2.1	64.4							0.1	0.1	3.9	1.3	2.20	68.3
19	0.8	1.6	51.3										0.8	1.60	51.3
20	0.6	1.2	39.0										0.6	1.20	39.0
21	0.3	0.8	27.6										0.3	.80	27.6
22	0.4	1.0	34.5										0.4	1.00	34.5
23	0.2	0.6	20.9										0.2	.60	20.9
24	0.1	0.2	8.2										0.1	.20	8.2
25	0.1	0.5	18.4										0.1	.50	18.4
26	0.025	0.093	3.4										0.025	.093	3.4
27	0.023	0.093	3.5										0.023	.093	3.5
28	0.011	0.046	1.8										0.011	.046	1.8
Totals of trees 4.6" d.b.h. and larger															
	168.159	83.432	2184.8	151.2	38.4	882.8	5.9	1.65	33.4	76.6	34.0	977.8	401.859	157.482	4078.8
Totals of trees 0.6" d.b.h. and larger															
	546.859	90.232	2320.9	573.8	53.0	1172.1	6.4	1.70	34.3	89.7	34.6	989.0	1216.759	179.532	4516.3

STAND AND STOCK TABLE, SPRUCE FIR COVER TYPE 71' TO 90' IN HEIGHT (PER ACRE VALUES)

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species				
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)		
1	112.8	0.6	11.2	141.0	0.8	14.0							253.8	1.4	25.2		
2				49.4	1.1	20.4							49.4	1.1	20.4		
3	43.9	2.2	42.3	81.5	4.0	78.6				3.1	0.2	2.5	128.5	6.4	123.4		
4	24.7	2.2	43.9	49.4	4.3	87.9				1.8	0.2	2.8	75.9	6.7	134.6		
5	21.4	2.9	61.8	23.7	3.2	68.3							45.1	6.1	130.1		
6	20.4	4.0	87.6	42.2	8.3	182.0				2.3	0.5	10.0	64.9	12.8	279.6		
7	16.7	4.5	101.0	27.7	7.4	167.2				3.4	0.9	21.7	47.8	12.8	289.9		
8	21.6	7.5	176.4	14.0	4.9	115.3				3.9	1.4	34.8	39.5	13.8	326.5		
9	19.8	8.8	211.8	8.0	3.5	85.5				4.5	2.0	53.7	32.3	14.3	351.0		
10	17.2	9.4	233.7	5.1	2.8	69.0				5.9	3.2	92.1	28.2	15.4	394.8		
11	11.9	7.8	201.3	1.4	0.9	23.7				4.0	2.6	79.1	17.3	11.3	304.1		
12	16.2	12.8	337.2	0.8	0.6	16.2				3.5	2.8	88.4	20.5	16.2	441.8		
13	10.4	9.5	258.9	0.2	0.2	4.2				1.7	1.5	51.7	12.3	11.2	314.8		
14	7.9	8.5	236.2	0.1	0.2	4.3				1.0	1.0	38.1	9.0	9.7	278.6		
15	7.4	9.1	260.0	0.1	0.2	4.4				0.4	0.5	17.1	7.9	9.8	281.5		
16	4.6	6.5	190.0							0.3	0.5	17.9	4.9	7.0	207.9		
17	3.1	4.9	148.4										3.1	4.9	148.4		
18	2.4	4.3	133.1							0.1	0.2	6.5	2.5	4.5	139.6		
19	1.8	3.5	112.0							0.1	0.2	6.8	1.9	3.7	118.8		
20	1.1	2.3	74.8										1.1	2.3	74.8		
21	1.0	2.3	76.5										1.0	2.3	76.5		
22	0.4	1.1	36.5										0.4	1.1	36.5		
23	0.2	0.5	16.0										0.2	0.5	16.0		
24	0.3	1.1	38.2										0.3	1.1	38.2		
25	0.1	0.5	16.7										0.1	0.5	16.7		
26	0.042	0.2	5.7										0.042	0.2	5.7		
27	0.077	0.3	11.6										0.077	0.3	11.6		
						Totals of trees 4.6" d.b.h. and larger											
	186.019	112.3	3025.4	123.3	32.2	740.1				31.1	17.3	517.9	340.419	161.8	4283.4		
						Totals of trees 0.6" d.b.h. and larger											
	367.419	117.3	3122.8	444.6	42.4	941.0				36.0	17.7	523.2	848.019	177.4	4587.0		

STAND AND STOCK TABLE, PINE ASPEN COVER TYPE UP TO 30' IN HEIGHT (PER ACRE VALUES)

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species		
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)
1	222.2	1.1	8.8	444.4	14.1	112.8							666.6	15.2	121.6
2	50.5	1.1	9.1	50.5	1.1	9.1				252.5	5.5	45.4	353.5	7.7	63.6
3				22.7	1.1	11.1				136.1	6.7	66.7	158.8	7.8	77.8
4										12.8	1.1	11.9	12.8	1.1	11.9

Totals of trees 0.6" d.b.h. and larger

272.7	2.2	17.9	517.6	16.3	133.0				401.4	13.3	124.0	1191.7	31.8	274.9
-------	-----	------	-------	------	-------	--	--	--	-------	------	-------	--------	------	-------



STAND AND STOCK TABLE, LODGEPOLE PINE COVER TYPE 51' TO 70' IN HEIGHT (PER ACRE VALUES)

D.b.h. breast height (in)	Spruce			Alpine fir			Alpine larch			Lodgepole pine			All species								
	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)	No. of trees	Basal area (sq ft)	Total vol. (cu ft)						
1				282.1	1.5	27.9							282.1	1.5	27.9						
2	70.5	1.5	29.1	35.3	0.8	14.5							105.8	2.3	43.6						
3	78.3	3.8	75.6	47.0	2.3	45.3				94.0	4.6	76.3	219.3	10.7	197.2						
4	44.1	3.8	78.5	17.6	1.5	31.4				149.9	13.1	238.5	211.6	18.4	348.4						
5	56.4	7.7	162.7	22.6	3.1	65.1				275.3	37.7	752.7	354.3	48.5	980.5						
6	35.3	6.9	151.6	31.3	6.2	134.8				174.2	34.6	752.1	240.8	47.7	1038.5						
7	40.3	10.8	243.9	5.8	1.5	34.8				115.0	30.8	719.2	161.1	43.1	997.9						
8	11.0	3.8	90.0	8.8	3.1	72.0				72.7	25.4	636.6	92.5	32.3	798.6						
9	3.5	1.5	37.2	10.4	4.6	111.5				22.4	10.0	268.6	36.3	16.1	417.3						
10	8.5	4.6	114.9	2.8	1.5	38.3				9.9	5.4	153.5	21.2	11.5	306.7						
11	1.2	0.8	19.7							8.2	5.4	162.7	9.4	6.2	182.4						
12										6.9	5.4	171.9	6.9	5.4	171.9						
13										3.3	3.1	103.5	3.3	3.1	103.5						
14	0.7	0.8	21.5							3.6	3.8	135.9	4.3	4.6	157.4						
15																					
16	0.6	0.8	22.6										0.6	0.8	22.6						
										Totals of trees 4.6" d.b.h. and larger											
										157.5	37.7	864.1	81.7	20.0	456.5	691.5	161.6	3856.7	930.7	219.3	5177.3
										Totals of trees 0.6" d.b.h. and larger											
										350.4	46.8	1047.3	463.7	26.1	575.6	935.4	179.3	4171.5	1749.5	252.2	5794.4

## APPENDIX IV

*(in map pocket on inside back cover)*

1. Forest cover type map.
2. Forest habitat type map.