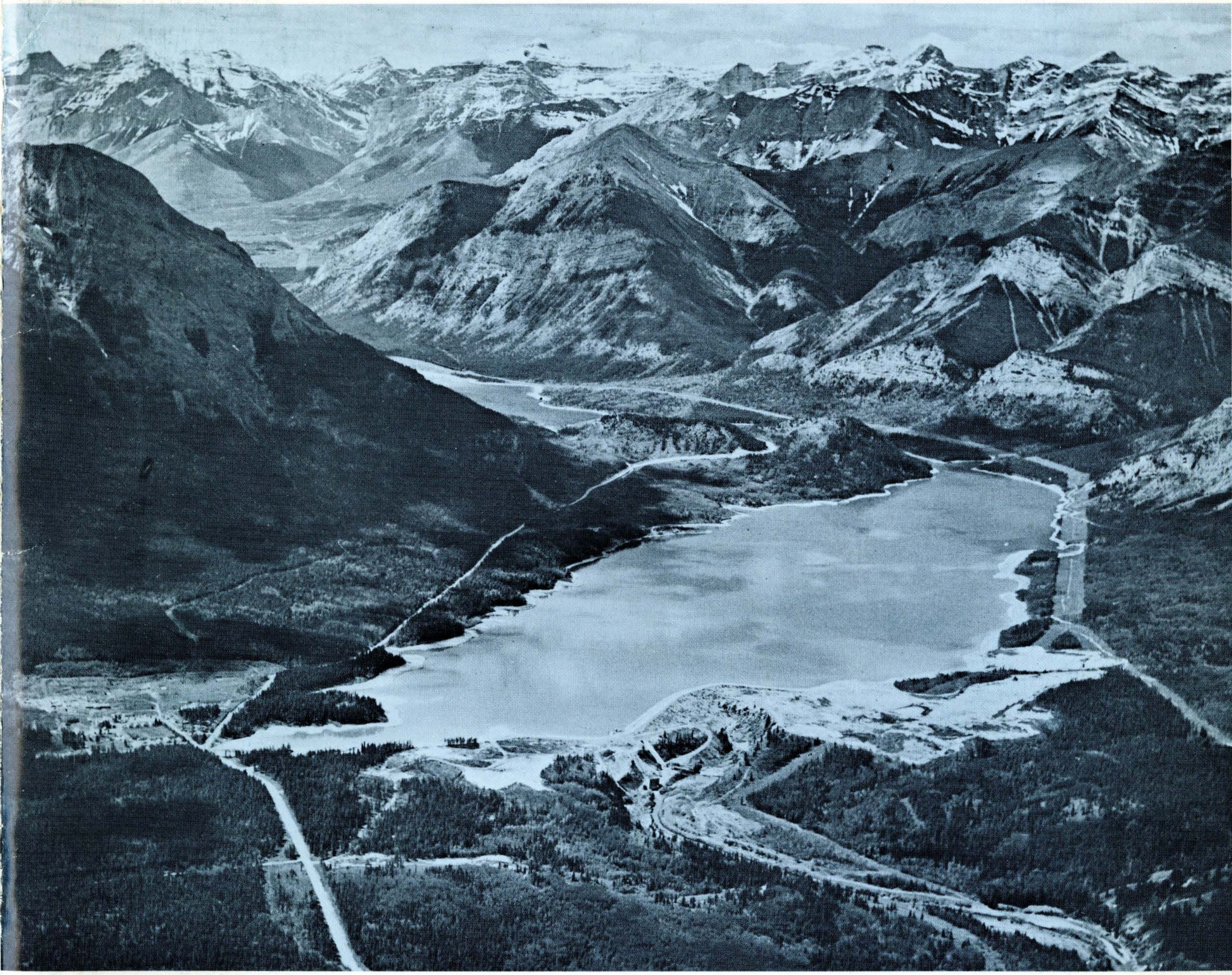
THE KANANASKIS FOREST EXPERIMENT STATION, ALBERTA (History, Physical Features, and Forest Inventory)

by C. L. Kirby



NORTHERN FOREST RESEARCH CENTRE
EDMONTON, ALBERTA
INFORMATION REPORT NOR-X-51
JANUARY, 1973

Environment Canada Environnement Canada
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CANADIAN FORESTRY SERVICE
ENVIRONMENT CANADA
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ABSTRACT

A brief history of the area over the past two hundred years with detailed records of activities at the Kananaskis Forest Experiment Station for the last forty years. Physical features include details on: climatic records; physiography and hydrology; and geology and soils. Well documented evidence on forest growth and yield, covertype maps and aerial photographs is included in this report.

CONTENTS

ABSTRACT ii
INTRODUCTION 1
HISTORY 1
Early History 1
Establishment and Revision of the Experiment Station Boundary 2
Use of the Experiment Station 2
Fires 2
Forest Utilization 2
PHYSICAL FEATURES 3
Climate 3
Physiography and Hydrology 5
Geology and Soils 7
FOREST INVENTORY 14
Establishment and Remeasurement 14
Lodgepole Pine Average Stand and Stock Tables 16
Growth and Yield 16
Forest Covertypes 27
CONCLUSION 27
REFERENCES 39

FIGURES

		Page
Figure 1	Physiographic features of the Kananaskis Forest Experiment Station and surrounding area	6
Figure 2	Surficial material map	8
Figure 3	Map overlay showing 500 foot contours and boundary of working plan and protection forest	15
Figure 4	Age class of dominant species at sample plot locations	17
Figure 5	Site index of dominant species at sample plot locations	18
Figure 6	Average number of stems per acre for lodgepole pine stands by average stand diameter classes	23
Figure 7	Cumulative frequency distribution of numbers of stems by diameter of lodgepole pine stands at various stand diameters	26
Figure 8	Changes in average stand diameter and number of stems per acre over a 25-year period for a thinning experiment	26
Figure 9	Distribution of cover types by height classes	29
Figure 10	Non-forest land	30
Figure 11	Lodgepole pine covertype	31
Figure 12	Lodgepole pine covertype	32
Figure 13	Spruce-lodgepole pine covertype	33
Figure 14	Spruce covertype	34
Figure 15	Aspen and black poplar covertype	35
Figure 16	Research at the Kananaskis Forest Experiment Station	36

TABLES AND APPENDICES

		Page
Table 1	Monthly and annual climatic summaries for Kananaskis, lat. 51°02'N., long. 115° 03'W. elev. 4,560 ft. MSL, for the period 1939 - 1970	4
Table 2	Distribution of surficial materials in working plan forest	9
Table 3	Description of surficial materials, soil, topography, drainage and forest stand conditions	10
Table 4	Coding used for description of surficial materials, drainage, soil, and topography	13
Table 5	Average basal area, number of trees, diameter, and volume by: covertype, height class, and year of measurement	19
Table 6	Average stand and stock tables (per acre values)	20
Table 7	Local height-diameter and total cubic-foot volume relationships, based on stem analysis	25
Table 8	Distribution of forest cover and non-productive land based on lithographed map of Kananaskis Forest Experiment Station	28
Table 9	Distribution of forest cover and non-productive land on working plan forest only of Kananaskis Forest Experiment Station	37
Table 10	Distribution of wood volume by forest covertypes on working plan forest only of Kananaskis Forest Experiment Station	38
APPENDIX I	— Plot codes	40
APPENDIX II	— Volume tables	41
APPENDIX III	— Check list of tree species	41
APPENDIX IV	— Table 1. Subcompartment covertype and age (1961 - 1962): with areas in working plan forest treated and untreated	42
	Table 2. Working plan forest sample-plot summary by subcompartment and year of measurement	43

THE KANANASKIS FOREST EXPERIMENT STATION, ALBERTA

(History, Physical Features, and Forest Inventory)

by

C. L. Kirby [1]

INTRODUCTION

The Kananaskis Forest Experiment Station (K.F.E.S.) is located on the east slopes of the Rocky Mountains in the subalpine forest region (Rowe, 1959) of Alberta, Canada. The station headquarters are at 51°02'N, 115°01'W on the Kananaskis River five miles from its confluence with the Bow River at Seebe, Alberta. Seebe is forty-five miles west of Calgary on Highway No. 1A somewhat more than half way to Banff National Park.

Here there exists a wide variety of conditions for research into the protection, management and improvement of forest and land resources where conflicts over use of land to obtain wood products, water, hydroelectric power, recreation and mineral deposits such as coal are increasing. It is apparent that forest and land users must become more aware of the impact of their actions on the total environment. For example, the recent controversy over forest management in the Bitteroot National Forest in the Rocky Mountains of the United States has precipitated a number of government sponsored investigations. These have indicated that the public is concerned about the economics and methods of timber harvesting, especially the possible adverse effects of clear-cutting on soil stability and regeneration of desirable tree species, in areas where the aesthetic appeal and suitability for recreation is high. In future, costing of various alternatives to clear-cutting, or modification of cut size and shape will receive more attention.

It takes only a moment's reflection to realize that a given area of forest will have to be managed for values other than timber or pulp. It may be simultaneously managed for water, flood and erosion-control, fish and wildlife production, and recreation; it may also absorb agricultural areas, surface mining, villages and hamlets, recreational communities, and second homes. Therefore, improvement in establishment of priorities and integration of uses on the east slopes is required. In future any major developer of public lands will probably be required to file an impact statement. The situation may be summed up best by direct quotes from McHarg (1969): "We have become accustomed to think of single function land use, and the concept of zoning has done much to confirm this — a one-acre residential zone, a commercial or industrial zone — but this is clearly a most limiting concept. If we examine a forest, we know that there are many species — and thus, that many cooperative roles coexist". . . . "The same concept can apply to the management of resources — that there be dominant and codominant land uses, coexisting with subordinate, but compatible ones."

This report presents information on the history, climate, topography, hydrology, geology, soils and forest growth and yield at the K.F.E.S. It is based on thirty-eight years of observation and measurement by many individuals in different disciplines. The information obtained is now assembled for the first time. It is a patchwork quilt: there are incongruities; the seams are imperfect; but we have the beginnings of an information system suitable for multiple-use planning. The information presented is aimed at understanding processes that forest-land managers must cope with, such as the interrelationships of forest cover, soils and topography. It also provides a yardstick against which to measure future change.

HISTORY

Early History

A popular interpretation is that early in the 18th century, the general area in which the Experiment Station is located was under the control of the Sarcee Indians. The Sarcees lost the country to the Stoney Indians towards the end of the 19th century and it is the Stoneys who occupy the Reserve which adjoins the north boundary of the Experiment Station.

Bow River Fort at the mouth of Old Fort Creek, on the north bank of the Bow River was built about 1802 by the North West Company, and may have been closed about 1823 after the union of this Company with the Hudson's Bay Company in 1821 (Voorhis, 43). The post may have been closed before this, since it is not shown on a map drawn by Thompson indicating all the Company's posts in 1812. David Thompson in an expedition from Rocky Mountain House to the Bow River and the Rocky Mountains had been through this area late in 1800, but the relationship between his trip and the establishment of the Fort is not clear. Thompson might have left some men in the vicinity or sent some there after his return to Rocky Mountain House (Coves, 704-5). Another post-Peigan Post may have been built on the same site in 1833 and used that year and the following. There were certainly the remains of a post when Palliser explored this area in 1858 (Wallace, 13-15).

As early as the 1840's the Rev. R. T. Rundle began Methodist missionary work among the Stoney Indians. The Rev. T. Woolsey continued this work in the 1850's, and the Rev. George McDougall and his son John carried it forward through the 1870's. George McDougall established a school near Morleyville in 1864 and from 1873 John acted both as missionary and trader in the area (Sharp, 138-40, MacInnes 266, 274). In 1871 John and his brother David introduced the first range cattle into the area (MacInnes, 193). The treaty establishing the Indian Reserve was signed on September 22, 1877, the Reserve Lands being surveyed in 1879 and 1889 (Sharp, 139).[2]

Eau Claire Sawmills Ltd. began logging in the Kananaskis Valley in 1883 and continued operations for a number of years. Logs were floated down the Kananaskis and Bow rivers to their sawmill in Calgary. This company continued to float the Bow River to Calgary until 1944.

The main line of the Canadian Pacific Railway, which follows the Bow River, was built through Seebe in 1883. The first legal survey in the township in which the K.F.E.S. is located was made in 1884 by T. Fawcett. Dominion Land

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[2] Dr. V. Bruce Proudfoot, Professor of Geography, University of Alberta, provided assistance in preparation and historical references for this section.

Surveys were carried out until 1910. The first hydro-electric plant on the Bow River began operating at Seebe in 1911 followed in 1913 by a second plant 1½ miles upstream from the first.

Establishment and Revision of the Experiment Station Boundary

During 1932 and 1933, the Alberta staff of the Dominion Forest Service made an investigation to choose an experimental area representative of the forests of the east slope of the Rocky Mountains. The forest of the lower Kananaskis Valley satisfied the conditions as then understood. Representation was made to the Province of Alberta and negotiations were completed on November 6, 1934. The Province of Alberta retains all mineral rights on the land of the Experiment Station. The agreement also specified that the lands shall be used solely for the purpose of a forest experiment station.

At the time of establishment, the K.F.E.S. comprised 62.60 square miles straddling the Kananaskis River for 17½ miles. On February 5, 1952, eighteen square miles were returned to the Province of Alberta. At the same time, 1¾ square miles from the Province were added resulting in a net area of 46.35 square miles. Of this, 27 square miles were considered to be productive forest land, the remainder being non-productive and protection forest.

The construction of the Barrier power development of Calgary Power Limited on the Kananaskis Forest Experiment Station removed a total of 1045 acres for borrow-pits, structures and reservoir. The work was begun in the late summer of 1945. On February 4, 1961, the area of the Station was further reduced to 23.86 square miles when all the lands lying west of the Kananaskis River were returned to the Province of Alberta. Of this area, approximately ten square miles are considered to be suitable for forest management.

Uses of the Experiment Station

Immediately upon its establishment in November 1934, the Kananaskis Forest Experiment Station became the site of an unemployed relief camp under the Department of National Defence. Buildings were erected adjacent to what was then the headquarters at the north boundary of the Station. Eventually, four camps were established and operated until June 1936. A large and useful program was carried out under the guidance of the District Forest Officer and the Superintendent of the Station.

One of the first projects was the thinning of about 641 acres of lodgepole pine. The road construction program was given high priority and about 20 miles of road was built. An administrative office and superintendent's cottage were created. A telephone pole line was built from Seebe to the headquarters and a line on trees carried on up the valley. The closing of the relief camps curtailed the work drastically. During the following three years, a small labor crew carried on the program of road construction and the erection of permanent camp buildings and tourist shelters.

In the autumn of 1936, Mr. H. A. Parker was appointed research forester. Initially, he established a number of permanent sample plots and transect plots in various stands. Studies at that time included nursery work, planting of exotic species, experimental thinnings, tree volumes, phenology, reproduction after fire, mistletoe eradication, soils and sites. A climatological station was established at the site of the present Headquarters in August 1939.

Two National Forestry Program camps were established on the experiment station in the summer of 1939. They were part of a Youth Training Program, intended to alleviate unemployment among single men, provide an opportunity for useful work away from the cities, and provide training in a trade. On the Station, the men did the manual work on survey parties, research projects and road construction.

In September 1939, an internment camp for enemy civilian aliens was opened at the site of the present Headquarters. The internees were employed in road construction, improvement and maintenance, nursery and planting work, building maintenance and landscaping. Logging and thinning operations produced pit props, posts and power poles. The camp remained in operation until July 1941 when the internees were moved. The site then became a prisoner-of-war camp which remained in operation until the early summer of 1946. During this same period (September 1941 to the spring of 1946), the area was also used as an Alternative Service Camp.

Fires

All the early explorers and travellers recorded the large and frequent burned areas in this region. Dr. James Hector went beyond bare observations to conclude that lightning is the cause. Writing about the forests of the region he said, "We saw whole masses of forest isolated in mountain cliffs, fallen by fire, the mountain trees burned in places so precipitous that no human hand could ever have reached them."[3]

The last fire of any significance to the Forest Experiment Station occurred in August 1936 during a season of very high fire hazard. This fire, of lightning origin, broke out in the Provincial Forest south of the Station and was a raging crown fire when detected. The whole southern part of the K.F.E.S., since deleted, was burned. Since this time, fires due to lightning strikes and other causes have started, but have fortunately been contained in small areas. Forest fire hazard studies on the K.F.E.S. and in adjacent national parks were begun by H. W. Beall in the summer of 1939 and continued by J. C. MacLeod (MacLeod 1948). Forest fire hazard on the Station is calculated each day during the fire season.

Forest Utilization

Immediately after the fire of 1936, an agreement was made with Eau Claire Sawmills of Calgary to salvage sawlog material from the Ribbon Creek valley. This company began the cleanup in the late autumn of 1936 and continued operating each winter until 1945-46. In addition, several permits were issued each year to pitwood contractors for the cutting of burned timber for pit props.

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[3] File report Department of Interior

Increased coal production during World War II created a demand for pit props. From the autumn of 1941, Alternative Service labor was used on the Station for the production of pit props from the 1936 fire killed material which remained sound. Four-foot fuel wood was also supplied to the lime kiln at Kananaskis. Material not suitable for either pulpwood or kiln fuel was used as firewood on the Station.

A small area of large Douglas Fir in the north-east corner of the Station was cut in 1934-35. At the same time, some spruce and Douglas fir were cut along the lower Lusk Creek. Approximately 30 acres of mature spruce in the south-east part of the Station were clear-cut and burned (for preparation of improved seedbeds) in 1940-41. Another 300 acres of mature spruce at the headwaters of the west fork of Lusk Creek were cut over in 1951, 1952 and 1953.

PHYSICAL FEATURES

Climate[4]

The main climatic characteristic of the Kananaskis Valley is its variability, typical of most mountain regions in continental locations. This variability is only now becoming more accurately determined through the increase in the number of climatological stations in the valley, and especially through the intensive instrumentation associated with the Alberta Watershed Research Program in the basin of Marmot Creek (Munn and Storr 1967) just to the southwest of the present Research Forest, and other specialized projects (MacHattie 1966, 1968, 1970). The headquarters' meteorological station at K.F.E.S. (elevation 4,560 feet MSL, latitude 51°02'N, longitude 115°03'W), is the only station with a relatively long climatological record upon which acceptable average conditions can be based, but even some of the parameters recorded at this station are based on short-term and sometimes irregular periods. Instrumentation is located on a knoll on the edge of a large grassed clearing, open to the south and east, with 40-foot trees immediately to the north. Table 1 gives the climatic summaries for the meteorological parameters recorded at Kananaskis from 1939 to 1970.

The winter climate is characterized by an alternation of cold, dry, rather still periods, with periods of comparitively warm, dry, windy Chinook air, which gives to the general area of southwestern Alberta a large winter temperature range. In December 1968, Kananaskis experienced a 108°F temperature fluctuation. Week-long periods of thawing may occur in all winter months when maritime polar air enters the region, with temperatures in the 50's not being uncommon. Longley (1967) found that Kananaskis, on average, had 29 Chinook days (above 40°F during the winter months December to February), which was two more than Calgary, and 19 more than Banff. In contrast, periods of sub-zero temperatures of a duration of a week or more are comparitively rare. Extreme low temperatures occur when stable continental Arctic air stagnates over the eastern slopes of the Rockies and western Prairies. Often temperatures in the valley are lower than on the higher slopes as cool air collects in the valley under inversion conditions, and warm air under subsidence is only experienced at the higher levels. The Chinook is characterized by a strong westerly flow of air over the mountains with lee waves forming troughs and crests roughly parallel to the mountain ranges. The dry air descends the leeward side of the mountains at the dry adiabatic lapse rate which brings high temperatures and low humidities to the areas where the Chinook reaches the ground. The temperature change is often rapid and may be as much as 40° in two hours. Much of the red-belt conifer foliage injury observed on valley slopes, which is very prominent in some seasons, has been attributed to the abrupt alternations of cool Arctic air and warm Chinook air (Henson, 1952; MacHattie, 1963).

There is generally less variation in summer temperatures than in winter temperatures. Temperatures above 80°F are experienced in several months, but the high elevation of the area, is responsible for cool summer nights and lower daytime temperatures than occur on the hot, dry Prairies to the east. Maximum temperatures usually occur near the end of July. Differences in the average daily maximum and minimum temperatures during the summer months are approximately 10 to 15°F between the upper and lower slopes of the valley (Munn and Storr, 1967). A temperature inversion forms in the valley bottom almost every night. On clear summer nights inversions of 5 to 10°F are usual in the lowest 300 feet of the valley, and only above 1000 feet does temperature decrease appreciably with elevation (MacHattie 1970). MacHattie also found that a valley bottom inversion in daily maximum temperature occurs especially on sunny days, and attributed this mainly to evapo-transpiration differences between the moist valley bottom and the drier slopes. A comparison of mean monthly temperatures for the period 1963 to 1970 showed that Kananaskis had warmer summer months than Kananaskis Boundary, a station in the valley about one mile south of the Research Forest, by about 1°, and warmer winter months by as much as 7°, being more frequently affected by Chinook air. Summer temperatures at Pigeon Lookout, a forest fire lookout 1440 feet above Kananaskis, were 1° cooler in July and August, and 3 to 4° cooler in June and September than Kananaskis.

Frosts can occur in any month, and the average frost-free period for the years 1951 to 1964 at Kananaskis was 62 days, with the average date of the last spring frost, June 21, and the first autumn frost, August 22 (Longley 1967b).

The winters are relatively dry, only about 30% of the annual precipitation (Table 1) occurs during the six winter months, October to March. Snow accounts for nearly 40% of the annual precipitation of about 25 inches at Kananaskis, but much of this falls in April which is the highest snowfall month. The heaviest single snowfall on record at Kananaskis occurred in June 1951 when 33 inches fell in two days. At the higher levels of the valley, Storr (1967) found that 70 to 75% of the annual precipitation occurred as snow or a mixture of rain and snow. Maximum snow depth varied from 2 to 4 feet on the lower slopes, to 6 to 8 feet on the upper (Storr, 1969). June is the wettest month of the year, and August the month of greatest precipitation variability. Valley bottom stations receive less precipitation than valley slope stations. Ferguson

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[4]by Dr. J. M. Powell, Research Scientist, Northern Forest Research Centre, Edmonton, Alberta.

TABLE 1. MONTHLY AND ANNUAL CLIMATIC SUMMARIES FOR KANANASKIS, LAT. 51°02' N., LONG. 115°03' W., ELEV. 4,560 FT. MSL, FOR THE PERIOD 1939-1970.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE °F[1]													
Daily mean	14.2	20.6	24.9	33.1	44.9	51.5	55.4	54.1	47.1	39.8	26.7	21.5	36.1
Extreme maximum	59	61	64	75	82	88	93	92	86	80	66	64	93
Extreme minimum	-50	-42	-41	-24	- 7	23	23	28	14	- 8	-32	-44	-50
PRECIPITATION inches[1]													
Total	1.11	1.37	1.40	2.57	3.03	4.30	2.46	2.55	2.11	1.59	1.03	1.13	24.65
Snowfall	10.9	13.7	13.3	20.9	7.2	1.3	0.0	0.14	3.2	10.4	10.5	10.7	102.2
SUNSHINE DURATION hours[2]													
Average	65	130	154	246	214	229	308	254	163	121	71	61	2016
Per cent of possible	26	49	41	59	45	48	62	57	43	37	27	25	43
Years of data	2	3	3	1	2	5	5	5	5	2	1	1	
WIND SPEED mph[3]													
Mean	6.5	6.7	5.9	5.9	5.3	5.3	5.0	4.8	5.1	7.1	7.2	7.7	6.0
WIND DIRECTION FREQUENCY %[3]													
North	8	9	10	8	8	8	7	8	5	5	6	6	7
Northeast	9	10	9	5	9	10	7	9	9	6	7	8	8
East	13	15	11	10	14	13	14	14	14	10	9	9	12
Southeast	9	6	6	3	8	10	10	9	9	8	8	10	8
South	4	4	6	4	6	5	8	9	7	5	4	5	6
Southwest	28	27	28	39	23	24	26	26	29	39	38	37	30
West	18	16	21	18	26	19	17	15	15	15	18	17	18
Northwest	5	5	10	9	8	8	9	7	7	6	5	5	7
Calm	10	9	6	4	4	3	2	3	5	5	6	6	5
Years of wind data	13	14	12	10	17	21	22	23	15	16	11	12	-

[1]Data for period August 1939 to December 1970. [2]Data for 1939-1941, 1946-1947 and 1968-1969. Largely summers only. [3]Data for 1939-1941, 1946-1969 (summers only 1946-1954).

and Storr (1969) found that on the average summer rainfall increased about 2 inches, and mean annual precipitation about 10 inches per thousand feet in the east-facing Marmot Creek basin. A comparison between Pigeon Lookout and Kananaskis for the months June to August in the years 1963 to 1970 showed an increase of about 1.4 inches per thousand feet. During the months October to March Kananaskis received 18% less precipitation than Kananaskis Boundary, but 14% more during the summer months.

During the summer months there are many occurrences of low night relative humidities (MacHattie, 1966) when Chinook-type winds occurred. MacHattie also found that daily minimum humidities were remarkably independent of vegetation cover, site, and topography, and that the increase with elevation was very slight from valley bottom to 1000 feet. Nightly maximum humidities were more variable and frequently decreased abruptly with elevation just above valley bottom (11% in 300 feet) with a more gradual decrease above this level (less than 1% per 100 feet).

Although the years of record of sunshine are short, the low total hour values for May and June, when less than 50% of the possible duration was recorded (Table 1), reflect the passage of lows which bring cloudy, moist air to the region. The low percentages of the possible in the mid-winter months may result from the station being in the shadow of the mountains at this time of year. The total number of sunshine hours during the summer (April to September – 1421) compares favourably with the 30-year average for Calgary (1439).

The mean monthly wind speeds are higher in the winter months (Table 1), than in the summer months. December had the highest mean wind speed and July, closely followed by August, the lowest. January and February have the highest percentage of calm (9%). The strongest winds come from the southwest or west at all times of the year. The maximum mean one-hour of wind recorded was 44 m.p.h. The dominant wind direction in practically all months of the year was from the southwest, although in certain years winds from the southeast or east were dominant in some of the summer months. MacHattie (1968) indicated that this southeast wind component was dominant at night, although of only low speed, and was typical of a downvalley wind coming from the Lusk Creek sub-valley. He showed that the wind components across the main valley had a more pronounced day-night cycle than the wind components along the valley, both at Kananaskis and in Marmot Creek at 5,680 feet. No appreciable diurnal oscillation of winds occurred up and down the valley at Kananaskis in summer, but he found that the southwest component could be dominant for most of the day, or under certain conditions, during only the daylight hours. In the summer months there was usually a marked maximum wind speed in mid- and late-afternoon, with a minimum occurring around sunrise. At stations in and near the Marmot Creek basin both MacHattie (1968) and Munn and Storr (1967) found a morning-evening slope wind cycle in summer. A wind speed maximum occurred just before sunrise with a downvalley wind, and another maximum in the early afternoon with an upvalley wind. The minima, about 0800 and 1800 hours, were associated with winds shifts from downvalleys to upvalleys and vice versa. Records from a ridge station at 8000 feet in Marmot Creek Basin indicate that winds were predominantly from the southwest in the months for which records are available (July to December), and at a monthly mean velocity two or more times those of a lower station at 5600 feet.[5]

Physiography and Hydrology

The Station lies on the eastern edge of the Rocky Mountains on the transition from mountains to foothills (Fig. 1). The north peak of Barrier Mountain, lying 1¼ miles south-west of the Headquarters is the highest point on the Station. At 7170 feet, the peak is several hundred feet above the timberline which is 6500 feet and about 1000 feet above any tree growth site that can be considered to have merchantable potential. To the south of the Station, the timberline is as high as the 7000-foot contour in several places. Mountains rising to 10,000 feet are to be found close to the south boundary of the Station. On the north-east corner of the Station, a hill rising to 6000 feet is tree covered and is the only true foothill on the Station.

The north part of the Station is characterized by steeply rolling topography interspersed by gentle slopes and muskeg areas. One main stream, Lusk Creek, with several of its tributaries, has continuous flow. Many small tributaries flow until early summer. Stony Creek is a dry rocky gulch after the peak of snowmelt. A number of springs flow continuously but in some cases the water sinks below the surface within a short distance of emergence.

The south part of the Station along the river is characterized by terraces and beaver impoundments. The valley bottom at some points is 1½ miles wide. In the higher country, above 5,000 feet, precipitious narrow canyons open into outwash fans or wide braided watercourses of boulder material.

The Kananaskis River forms the west boundary of the Station. From an altitude of about 4600 feet on the south boundary of the Station it flows in a north-easterly direction for nearly eleven miles to an altitude of 4300 feet on the north boundary.

The Kananaskis River at its source is fed by glaciers and snowfields. This is reflected in the picture of average monthly discharge. January through April is the period of low water. There is a sharp rise in May to a peak in June. The flow decreases uniformly from July through October to a near-low in November and December. Annual discharge fluctuates widely. In the thirty-one-year period from 1912 to 1942 the discharge trend was downward, with sharp peaks at intervals of 4 or 5 years. During this period, for those years in which complete records are available, the flow was less than average four times during the first 15 years and 8 times during the second 15 years. Since the construction of Barrier Dam in 1942, the flow of the Kananaskis River has been closely regulated. Barrier Lake is allowed to empty during the winter and early spring to accommodate the peak run-off period usually occurring in June.

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[5]Data from "Compilation of Hydrometeorological Record, Marmot Creek Basin" Volume I-III. Water Survey of Canada, Department of Energy, Mines and Resources, Calgary, Alberta.

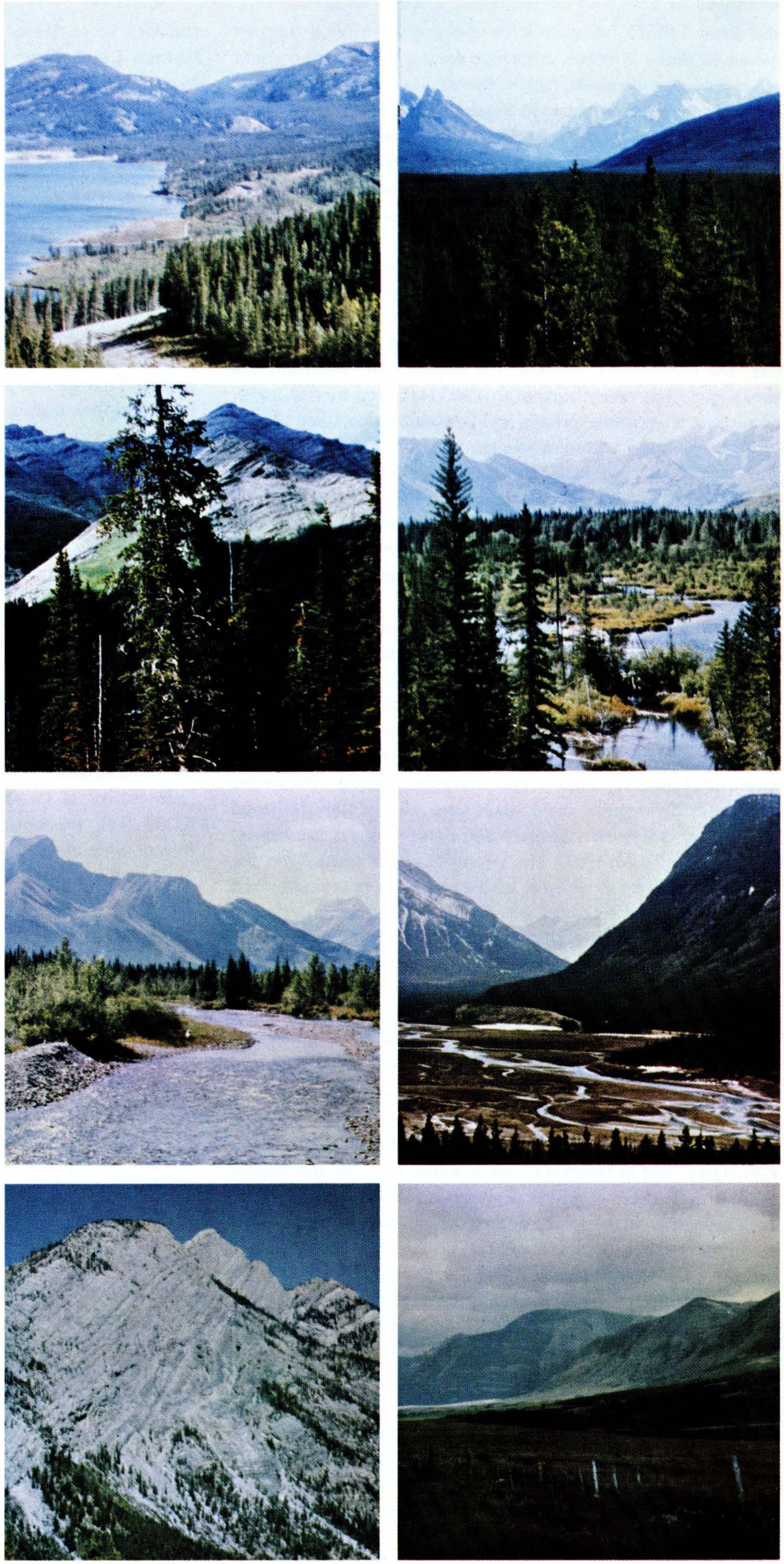


Fig. 1
Physiographic features of the Kananaskis Forest Experiment Station and surrounding area.

a. Looking northeast across Barrier Lake. The cleared area in the background is the site of a hydroelectrical development.

b. A succession of fires that has swept the valley in the past created extensive, even aged lodgepole pine stands at the lower elevations.

c. Higher up the mountain sides one finds mature stands of spruce-fir and other alpine types.

d. Beaver activity in the backwaters of the Kananaskis River has created a succession of trout stocked ponds.

e. Except for the peak of the run-off season, the Kananaskis River has a low sediment load and the gravelly river beds afford good fishing.

f. View of the Upper Kananaskis River and its extensive flood-plain.

g. Thick bedded, fossiliferous limestone is utilized by the local cement industry with plants near Exshaw in the Bow Valley.

h. Very thin topsoil, a gravelly subsoil, coupled with high chinook winds limit growth on the Morley Flats, east of the mountains in the Bow Valley.

Geology and Soils
[This section on geology is partly based on a report by Crossley, 1951.]

The north half of what is now the Experiment Station was included in a geological survey of the Morely and Moose Mountain map sheets (Beach 1943). Stalker (1963), also of the Geological Survey of Canada, conducted additional surveys of the K.F.E.S. Areas to the south-west, including land formerly within the Station, were studied in various surveys of the Cascade Coal Basin (Dowling, 1905).

The Kananaskis valley lies in what was originally the Cordilleran Trough and therefore contains many deposits of sedimentary origin. The trough was destroyed by the Laramide Revolution which formed the Rocky Mountains.

The extensive folding and faulting of the massive upheaval (Fig. 1) and the marked difference of resistance to erosion of the various types of bedrock has influenced the topography and the relief. Resistant Paleozoic limestone forms the mountain summits, outcrops of the massive sandstone and conglomerate beds mark the ridges, and shales predominate in the flat-bottomed valleys.

The Cordilleran Ice Sheet of the Pleistocene Era covered much of the mountain region of Alberta. Ice advances and retreats laid down deep beds of boulder till, lacustrine, and alluvial deposits throughout the valleys. This material also forms the unconsolidated surface deposits.

A small coal seam is to be found on the Station. It has never been worked. Another small seam is known outside the Station west of the present headquarters. A coal seam on land formerly within the Experiment Station and now near the Marmot Creek Watershed Research Basin has been worked by both open pit and tunnel methods.

Valley bottom soils exhibit up to three well-developed profiles (paleosols), each overlaid by lacustrine deposits. The leached horizon of the buried profile is much better developed than anything at the surface at the present time. This may be due either to a warmer and more humid climate at the time of formation of the buried profile or to an insufficient time for comparable development of the present profile.

The bulk of the mountain material is limestone, which predominates in the parent material of the soils of the region. Such soils resist eluviation of clays.

Lithosolic soils less than 6 inches deep are generally confined to the steeper slopes at higher elevations, but the converse is not always true. When the whole soil mantle available for tree roots is considered, and not just the weathered portion, most of the soils of the Station may be regarded as deep (i.e. more than six inches deep). Because of seepage, some of the shallow soils lying on bedrock at higher elevations sometimes support good forest stands. Coarse till may permit percolation beyond the reach of tree roots, resulting in poor tree growth.

The most readily erosive soils are shallow soils with little incorporated organic matter lying on steep slopes. These mountain lithosols should not be disturbed.

The following map (Fig. 2) and Tables 2, 3 and 4 are based on Duffy and England's (1967) report. A redrafting of their map of surficial materials is presented (Fig. 2). The map is based on photo interpretation of 1962, 1:15,840, black and white photography, and from subsequent field checks at 148 selected sites. A compilation of the aerial distribution of the surficial materials is given in Table 2. In addition, data (Table 3) concerning covertype, age, basal area, number of stems, vegetation and mean annual increment (from the 1961-62 working plan survey described later in this report) are presented together with descriptions of various surficial materials, soil, topography and drainage. Table 4 gives a description of the coding and classifications used in this work (National Soil Survey Committee of Canada, 1965).

Duffy and England's (1967) conclusions were:

1. That the best forests occur on soils of deep till, and on till and colluvium mixture, where summer drought periods are offset by the effects of seepage water. These areas support tree growth with mean annual increment of 51 to 70 cubic feet. The mean annual increment in total cubic feet per acre per year is based on stand yields at 80 years of age.

2. Sandy clay loam textures are associated with till soils and are also highly productive when seepage moisture is present, but where the till deposit is capped with coarse-textured alluvial deposits, the productivity is often lower, with a mean annual increment of 31 to 50 cubic feet.

3. Mean annual increments of less than 31 cubic feet were found on sites with extreme moisture conditions, either too wet or dry. Colluvial materials, dry coarse alluvium, deep organic soils and bedrock situations are examples.

4. The relationship between forest growth and aspect also became apparent in this study. Sites on steep north-facing slopes are more productive for a given surficial material than those on south-facing slopes.

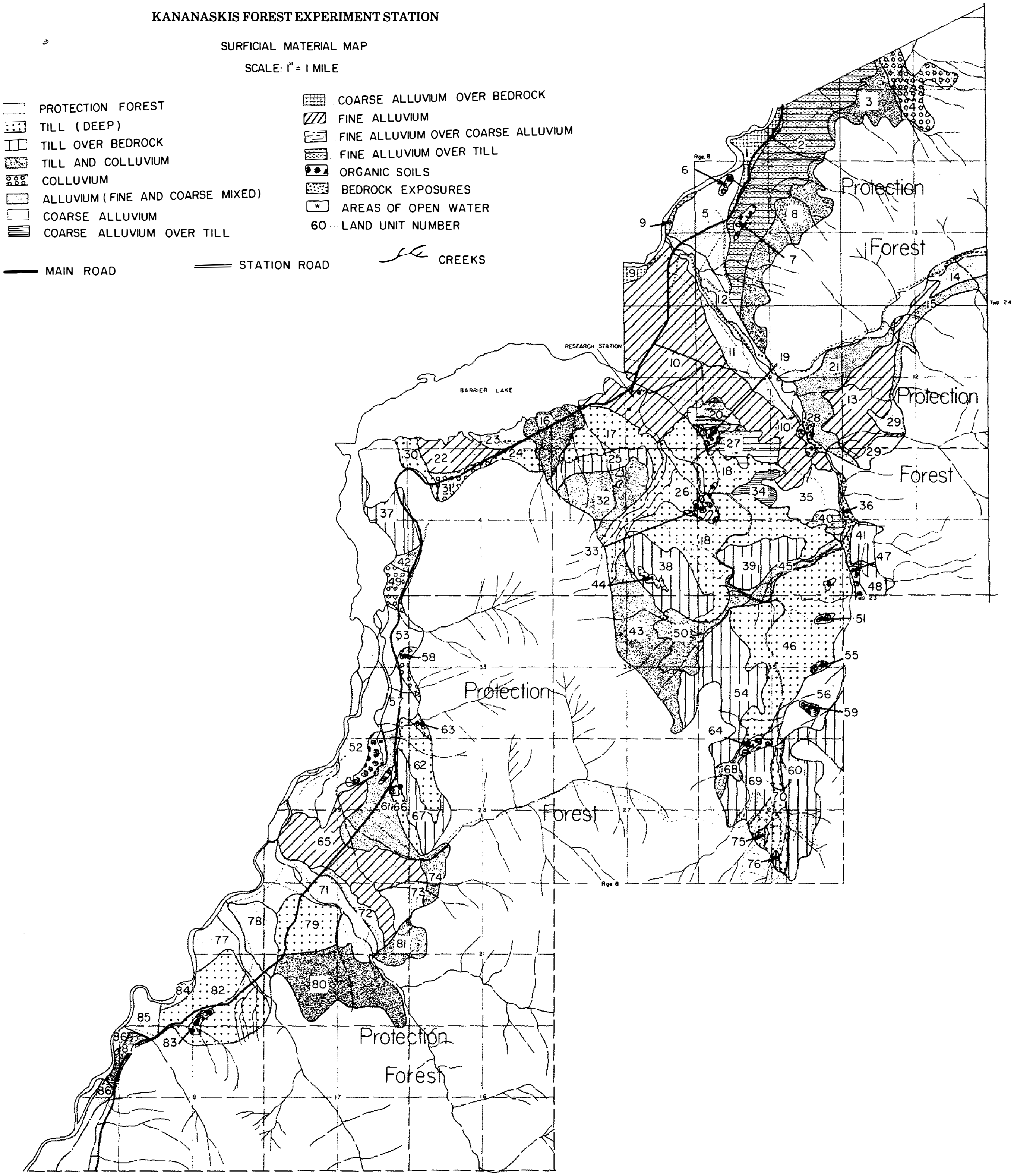


Figure 2. Surficial material map.

TABLE 2. DISTRIBUTION OF SURFICIAL MATERIALS IN WORKING PLAN FOREST.

Surface Material	Area (acres)	Percentage of total area
Till (deep)	1428	20
Till over Bedrock	890	13
Till and Colluvium	965	14
Colluvium	159	2
Alluvium (fine and coarse mixed)	338	5
Coarse Alluvium	1391	20
Coarse Alluvium over Till	26	1
Coarse Alluvium over Bedrock	66	1
Fine Alluvium	1045	15
Fine Alluvium over Coarse Alluvium	38	1
Fine Alluvium over Till	370	5
Organic Soils	146	2
Bedrock Exposures	33	1
Totals	6895 acres	100%

TABLE 3. DESCRIPTION OF SURFICIAL MATERIALS, SOIL, TOPOGRAPHY, DRAINAGE AND FOREST STAND CONDITIONS*

Land Unit	Surface Material Code No.	Soil	Topography	Drainage	Cover Type	Stand Age	B.A./Acre	Trees/Acre	MAI at 80 Years	ARDA Class	Vegetation
1	09	sl	l	rd	PlTa					5	
2	12	l	ss	wd	TaPl	80	150	500	70	4-5	Alnus, Shepherdia, Salix
3	03	sl	ss	rd	PlSwTa						
4	05	sl	ss	rd	PlSwTa	All	150	700	40	5	Alnus, Rosa
5	07	sg	gs	rd	PlTa					5	Grass
6	13	o	l	vpd	SwTa					6	
7	13	o	l	vpd	Sw					6	Salix
8	03	l-cl	ms	wd	Pl	70	180	1000	60	4	Alnus
9	09	sg	l	rd	SwPlBp					5	
10	10	sl	ms	rd	Pl	75	180	1200	60	4	Shepherdia, Juniper
11	07	sl	gs	rd	Pl	83	115	700	40	5	Shepherdia, Alnus
12	07	sl	gs	rd	PlSw					5	Salix
13	10	sl	ms	rd	Pl	60-90	180	460	57	4-5	Shepherdia, Juniper
14	07	sl	gs	wd	SwPl		200	450	60	4	Shepherdia
15	06	sg	ss	rd	PlSw					4-5	Shepherdia
16	03	cl	ms	mwd	PlTa	67	160	1080	50-60	4	Alnus, Salix, Rosa
17	01	scl	ms	mwd	Pl	68	160	700-1600	50-60	4	Alnus, Shepherdia,Salix
18	01	sl	ms	wd	Pl	60	160	800-1900		4	Alnus
19	13	o	gs	vpd	Sw					7	Ledum
20	11	s	ms	rd	Pl	60				5	Shepherdia, Alnus, Rosa
21	06	sl	ss	rd	Pl	78	150	500	40	5	Shepherdia, Juniper
22	10	sl	gs	wd	Ta					4	Grass, Salix
23	07	sg	ss	rd	PlTa					6	Grass, Shepherdia
24	01	sl	ss	rd	PlSa	53	170	1000	70	4	Alnus, Salix, Tosa
25	02	cl	ss	wd	Pl	65	180	1000	70	4	Alnus
26	01	sl	ss	wd	Pl					4	Alnus
27	12	sl	ms	wd	Pl					5	Alnus, Shepherdia
28	14	sl	ss	rd	Pl						Juniper
29	07	sg	ms	rd	Pl					5	Shepherdia
30	01	scl	ss	wd	TaPl					4-5	Alnus, Grass

* See table 4 for explanation of symbols.

TABLE 3. CONTINUED

Land Unit	Surface Material Code No.	Soil	Topography	Drainage	Cover Type	Stand Age	B.A./ Acre	Trees/Acre	MAI at 80 Years	ARDA Class	Vegetation
31	05	sl	ss	rd	Ta					5	
32	03	scl	ss	wd	Pl	65	225	1700	75	4	Alnus
33	13	o	gs	vpd	Sw					6	Ledum
34	08	sg	ms	wd	PlSw					5	
35	07	sg	ms	rd	PlSw	65	150	300	60	4	Alnus
36	14	sl	ss	rd	SwPl						Alnus
37	02	scl	ss	rd	PlTa					5	
38	02	scl	ss	rd	Pl	65	160	3740	50	5	Alnus
39	02	sl-cl	gs	mwd	PlSw	87	150	2180	50	5	Alnus, Salix
40	12	scl	gs	mwd	Pl	52	170		70	4	Shepherdia, Juniper, Alnus, Salix
41	02	scl	ss	rd	Pl					5	
42	03	scl	ss	rd	PlTa					6	
43	03	sl	ss	rd	SwPl					5	
44	14	sl	ss	rd	Pl	45	150		40	6	
45	06	sl	gs	wd	TaPl					5	Grass
46	01	l-cl	gs	mwd	SwPl	150	170	500	60	4	Shepherdia, Juniper, Alnus
47	13	o	l	vpd	Sw						Ledum
48	02	scl	ss	rd	PlSw					5	
49	05	sl	ss	rd	PlTa					6	Arctostaphylos, Juniper
50	03	sl	ss	rd	PlSw						
51	13	o	l	vpd	Sw					6	
52	07	s-sl	l	rd	PlSw					5	Salix
53	07	sl	ms	rd	Pl	82	170	1000			Shepherdia, Rosa
54	02	sl	ss	rd	PlSw					5	
55	13	o	l	vpd	Sw					6	
56	07	sg	gs	rd	PlSw	55	170	1100	60	4	Salix
57	07	slg	gs	rd	Pl	80	150	1900	40	5	Shepherdia

TABLE 3. CONTINUED

Land Unit	Surface Material Code No.	Soil	Topography	Drainage	Cover Type	Stand Age	B.A./ Acre	Trees/Acre	MAI at 80 Years	ARDA Class	Vegetation
58	05	sl	ss	rd	Pl	82	170	1350	40	5	Shepherdia
59	13	o	l	vpd	Sw					6	
60	02	sl	ss	rd	SwPl	50	170		40	5	Alnus
61	06	sil	gs	wd	Pl	80	180		50	5	Cornus
62	01	cl	ms	wd	Pl	88	170		40	5	
63	05	sl	ss	rd	Pl	80			40	5	Shepherdia
64	13	o	l	vpd	Sw					6	
65	10	l-sl	gs	wd-rd	PlSw	96	180		50	5	Salix, Rosa, Cornus
66	01	l	ms	mwd	PlSw	92	200	1400	50	5	Salix
67	02	cl	ss	wd	Pl	93	170	2390	40	5	Shepherdia
68	03	sil	gs	mwd	PlSw					5	Ledum
69	02	scl	ss	wd	PlSw	65	180	1110	60	4	Alnus
70	01	cl	ms	wd	Sw					4	
71	07	sg	gs	rd	SwPl					6	
72	07	sl-l	gs	rd	Pl	86	180	1000	50	5	Shepherdia, Juniper
73	07	sl-l	gs	mwd	SwPl	72	160	1400	50	5	Ledum
74	03	sl	ss	rd	Pl				50	5	Shepherdia
75	02	scl	ss	rd	Sw					4	Alnus
76	02	scl	ss	rd	Sw					4	Alnus
77	07	sg	gs	rd	Sw					6	
78	07	ls-sl	gs	rd	Pl	95	180	1500	40	5	Shepherdia, Salix
79	01	sil-l	gs	wd	Pl	87	180		40	5	Shepherdia
80	03	l-cl	ms-ss	wd	Pl	74	150	3400	40	5	Alnus
81	03	sl-sil	ss	wd	Pl	80	170	1530	50	5	Alnus, Shepherdia
82	01	sl-l	ms	wd	PlTa					5	Shepherdia, Salix
83	13	o	l	vpd	Ta					6	
84	07	sg	l	rd	SwPl					5	
85	07	sg	ss	rd	TaPb					6	
86	07	sg	l	rd	SwTa					5	
87	03	sl	ss	rd	SwTa					5	

TABLE 4. CODING USED FOR DESCRIPTION OF SURFICIAL MATERIALS, DRAINAGE, SOIL, AND TOPOGRAPHY

Surficial Materials

01 – till (deep)
02 – till over bedrock
03 – till and colluvium

05 – colluvium
06 – alluvium (mixture of fine and coarse materials)
07 – coarse alluvium
08 – coarse alluvium over till
09 – coarse alluvium over bedrock
10 – fine alluvium
11 – fine alluvium over coarse alluvium
12 – fine alluvium over till
13 – organic soils
14 – bedrock

33 – water

Drainage

Drainage is described using these abbreviations (NSSCC, 1965):

r	(rapidly drained)	id	(imperfectly drained)
wd	(well drained)	pd	(poorly drained)
mwd	(moderately well drained)	vpd	(very poorly drained)

Soil

The soil notation refers to the texture in the apparent tree rooting zone. The abbreviations are as follows:

s	(sand)	scl	(sandly clay loam)
si	(silt)	sg	(sand and gravel)
l	(loam)	slg	(sandy loam and gravel)
sl	(sandy loam)	ls	(loamy sand)
sil	(silt loam)	o	(organic material)

Topography

Topography is described using the following abbreviations from the National Soil Survey Committee of Canada, (1965).

l	(depressional to level)	ss	(strongly sloping)
vgs	(very gently sloping)	ses	(steeply sloping)
gs	(gently sloping)	vss	(very steeply sloping)
ms	(moderately sloping)	es	(extremely sloping)

Cover type

Pb	(balsam poplar)	Pl	(lodgepole pine)
Ta	(trembling aspen)	Sw	(white spruce)

FOREST INVENTORY

The management of any forest area requires a knowledge of forest growth and yield and forest covertype location.

Establishment and Remeasurement

A "continuous forest inventory" (C.F.I.) system based on permanent sample plots in the forested areas was established during a period from 1936 to 1938. Nearly one thousand tenth-acre plots were placed on a square grid pattern of 10 X 10 chains (660 feet square).

The data collected on each plot included:

1. A tally by species of living and dead trees by one-inch diameter classes from 0.6 inches d.b.h. Dead trees were blazed.

2. Diameter, height, age and increment measurements made on two or three trees per plot. Tree increment borings were made at breast height.

3. Notes of ground vegetation, presence of seedlings, shrubs, surface soil were taken.

The first measurement of the working plan survey was done in 1946, repeating the forest stand measurements of tree d.b.h., height by species, and in addition, blazing and recording dead trees by one-inch diameter classes. Checks on sites descriptions were also included.

The second remeasurement — in 1961 and 1962 — was begun by reblazing the lines of the Working Plan Survey. The wood post at the northeast corner of each plot was replaced by a numbered aluminum angle-stake. A 6-inch by 6-inch numbered aluminum plate was placed on the tree nearest the stake and oriented to face the stake. The relocation of lines and plot corners in the recent spruce cutover was difficult and required careful chaining.

The first step in plot remeasurement was to establish the remaining three corners of each plot by staff compass and chain. The corners were permanently marked by 18-inch aluminum angle-stakes. Because of the variation in direction and steepness of the slopes, some plots are not square.

The data collected on each plot included:

1. A tally by species and one-inch diameter classes over 0.6 inches of living, living-defective, and dead trees. Defect was based on the presence of cankers, rate of growth and evidence of cull. The classification is subjective and was not used in the summaries presented in this report. Compilations of living, dead and defective are available for further analysis if required.

2. A tally of reproduction by the stocked quadrant method of 10 milacre quadrants located inside the east edge of each plot. The largest seedling of each species in each quadrant was recorded under the following classes:

a) up to 0.5 foot in height
b) 0.5 foot to 3.0 feet
c) 3.1 feet to 0.5 inches d.b.h.

A total count of seedlings by the above classes was made on the fifth quadrant.

3. Total height to the nearest foot and diameter at breast height to the nearest tenth-inch of five trees in four crown classes (D, CD, I, S) of each species on each plot which comprised one-third or more of the tally. On some plots, a minor species was tallied exclusively in order to accumulate sufficient data for a curve of that species to be drawn.

A total of 552 plots were tallied in the last remeasurement. Thirty-four check tallies were made, mostly during the training and "shakedown" period. These checks were made within 24 hours of the plot measurement. Most check tallies showed an error of less than 1% of basal area, and errors of 2% were allowed before plots were remeasured. The participation of the chief-of-party in the tallying of many plots served as a further check of accuracy of the students' work.

The delineation of Working Plan Forest and Protection Forest, made in 1946, was based to a great extent on contour and on the presence of bare rock.

In 1961 - 62, the following factors were considered in revising the boundary between protection and working plan forest: watershed protection, growth potential and harvesting feasibility. Watershed protection was evaluated on the basis of steepness of slope and the type of soil. Growth potential was judged by a consideration of the soil, aspect, steepness of slope, the vigor and size of the tree growth on the site and, in other cases, the failure of the site to regenerate in the interval since the last disturbance whether this was by fire or logging. Harvesting feasibility was considered on the basis of the following factors: ease of road building, amount of road necessary, the value of merchantable material that can be removed in a reasonable rotation and the ease of reforesting the area under the intensity of management presently practiced in such situations. Above the Protection Forest is a zone having various amounts of tree cover but for the most part is described as bare rock and talus. This zone is of no value for wood production. (See Fig. 3).

Data Processing

Machine data processing with unit record and computer equipment in Ottawa was used to compile the data. All plot measurements taken on the present 10-square-mile area of Working Plan Forest in the three measurement periods were placed on a standard form (Appendix I) for subsequent transfer to punch cards.

Local total cubic-foot volume and height-diameter relationships were recalculated for each species and measurement period. References for the standard total cubic-foot volume tables from which the local volume tables were derived are given in Appendix II.

Tree species and their Latin names are given in Appendix III. Detailed description of minor vegetation has been given for the Marmot Creek Watershed Research Basin (Kirby and Ogilvie, 1969), and many of the plant associations on the K.F.E.S. are similar to those.

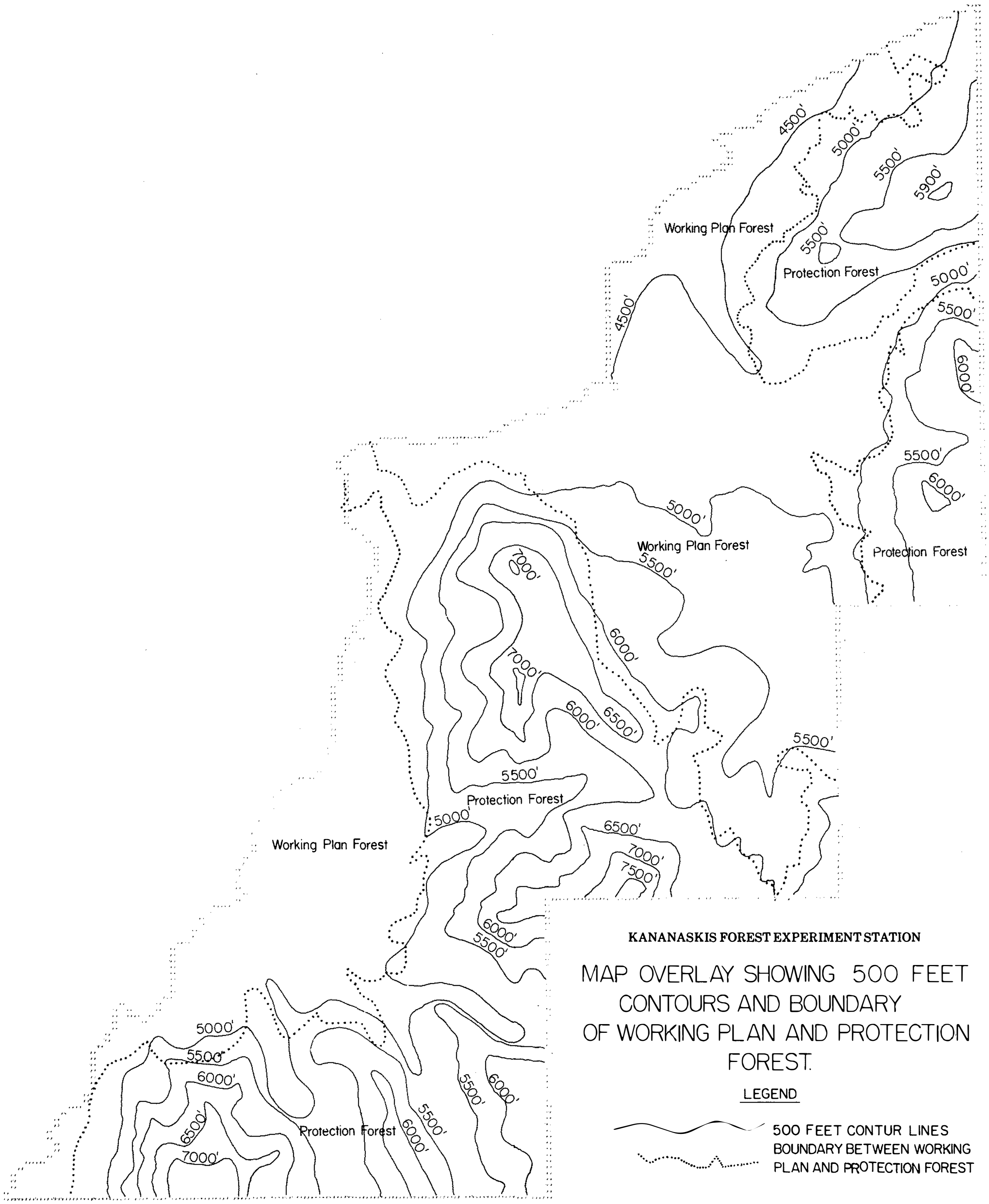


Figure 3. Map overlay showing 500 foot contours and boundary of working plan and protection forest.

Subcompartments were drawn in 1936 - 38 in rather uniform covertypes, site, and age classes based on a 10-chain grid of ground samples. Tables 1 and 2 in Appendix IV and a map of the subcompartments (in the pocket on the back cover) are presented for those wishing to have greater detail on age, species composition, and growth and yield. In addition individual plot tabulations are available at the Northern Forest Research Centre for compilation of the data by any stratification of interest. The stratification by subcompartments indicates that lodgepole pine stands 61 to 80 years old (Subcompartment 88) are growing faster than 100-year-old lodgepole pine stands (Subcompartment 116). Some inconsistency in the results presented in Appendix IV is evident, especially where there is only one plot in a subcompartment, because of difficulties in exact relocation of plots at time of remeasurement.

Lodgepole Pine Average Stand and Stock Tables

The average number of stems for one-inch average diameter classes for lodgepole pine stands plotted on semi-logarithmic paper defines average stocking (Figure 6). Stand density index (S.D.I.) (Mulloy, 1944), or number of stems per acre when a stand reaches an average diameter of 10 inches, is 300 for the K.F.E.S. and slightly higher for some other areas in Alberta. Larger or smaller number of stems per acre for a given average stand diameter indicates different carrying capacity when stands are at equilibrium with their site. For the most part, the sample plots on the Experiment Station are in close agreement with this average trend line. The trend line has approximately the same slope as that defined by Reineke (1933). A similar stocking was found for the Province of Alberta (Smithers, 1961).

The sample plot information was also used to construct average stand and stock tables given in Table 6. Figure 7 shows the cumulative frequency distribution in percent (from Table 6) plotted on probability paper where normal distributions plot as straight lines. The lodgepole pine stands are almost normally distributed except for the one plot for average stand diameter of 9 inches. This is attributed to the small size of the sample and to its old age which caused the distribution to be more erratic. The average stand diameter and volume per unit of basal area for each one-inch average diameter class (as indicated in Table 6) shows how the ratio of volume to basal area changes with average stand diameter. These ratios, related to average stand diameter, may be used to estimate lodgepole pine stand volume at the K.F.E.S. from measures of average diameter and basal area per acre.

Total cubic-foot volumes for the stock tables were derived from tree-volume equations and a height-diameter curve based on the complete stem analysis of fifty 95-year-old crop trees. These trees were cut into five-foot sections, and measurements on an average radius were made at ten-year intervals from the last complete growth ring to the centre of the tree. Corrections for inside bark measurements to outside bark measurements were made. Tree volume, d.b.h., and height for each ten-year interval were calculated using a computer program developed to compile this stem analysis data. The height-diameter relationship and total volume equations determined are given in Table 7.

Growth and Yield

Forest covertypes and height classes determined on the sample plots in 1961 and 1962 are given in Table 5. The height and cover type classes are the same as those used by the Alberta Forest Service. From this table, estimates of growth for the various covertypes and height classes are possible. For lodgepole pine stands that are 46 to 60 feet high, the most frequently sampled stratum, the average yield in 1961 - 62 was 3039 total cubic feet. The periodic annual increment for the period of 1937 to 1946 was 48.6 cubic feet and for the period 1946 to 1962, it was 45.5 cubic feet, indicating a slight slowdown in growth during the period from 1946 to 1962.

Growth and yield of a forest by covertype and height class do not indicate the large variation attributable to age and site conditions. For more precise estimates of growth and yield, the age class and site index as indicated in Figures 4 and 5 must be taken into consideration. The age class and site index given for each plot location are based on the dominant species present. Site index is based on total tree height of dominants and co-dominants at a stump age of 70 years.

Five acre-plots that were part of a lodgepole pine thinning experiment, started in 1938 in a 70-year-old stand, provide additional evidence (shown in Figure 8) on the rate of average stand diameter increase and the rate that number of stems per acre decreases with time. Some irregularity in Plot 4-38A for the 1953 to 1963 period has been caused by illegal cutting in the experiment. For the most part, the trends of increase in average stand diameter and the decrease of number of stems with time are linear. It is interesting to note that, regardless of number of stems per acre, the increase in average stand diameter was about two inches during the 25 years of observation — approximately 1/10 inch per year, indicating the effect of thinning on growth to be minimal at this age — but rates of mortality varied with density.

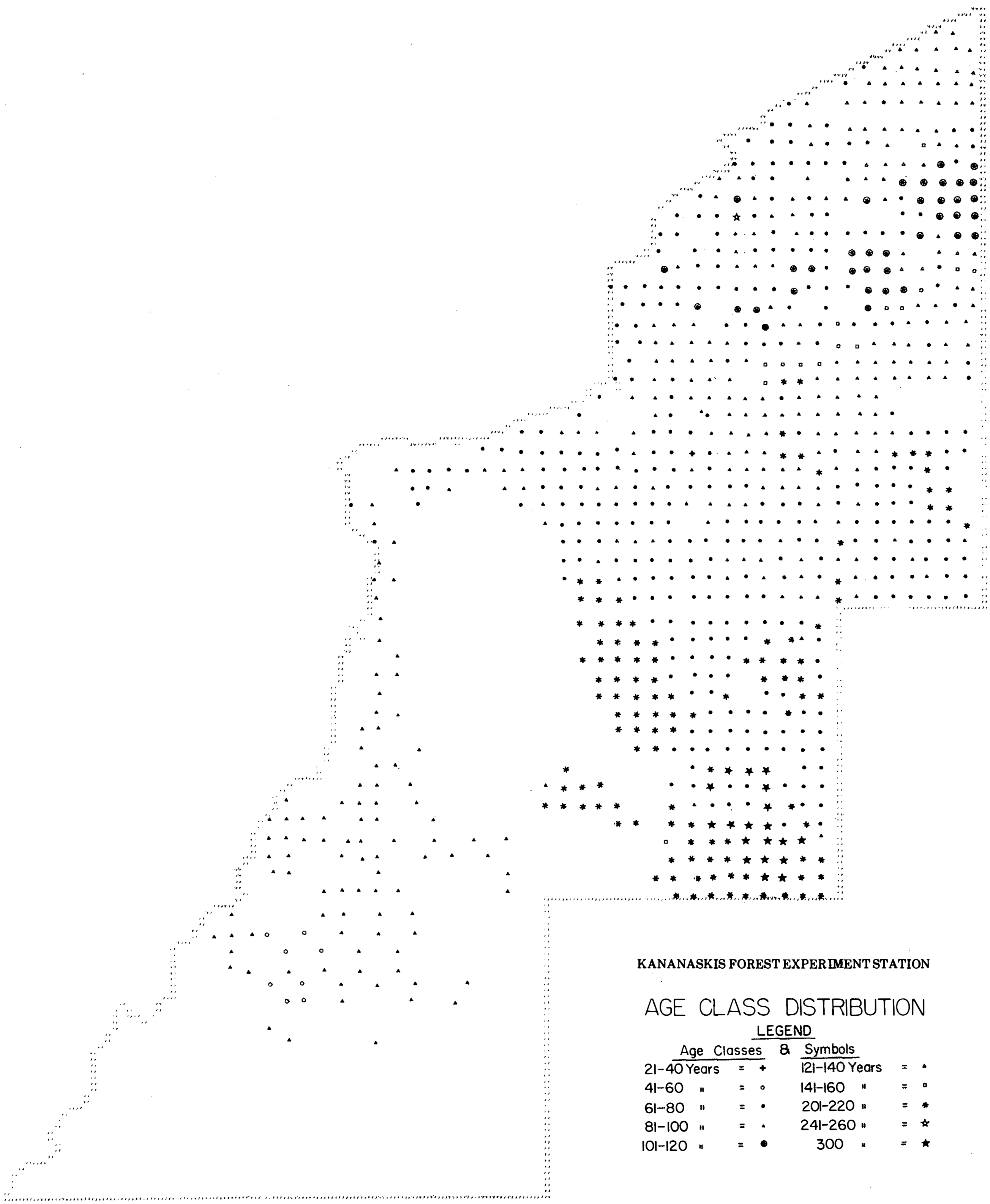


Figure 4. Age class of dominant species at sample plot locations.

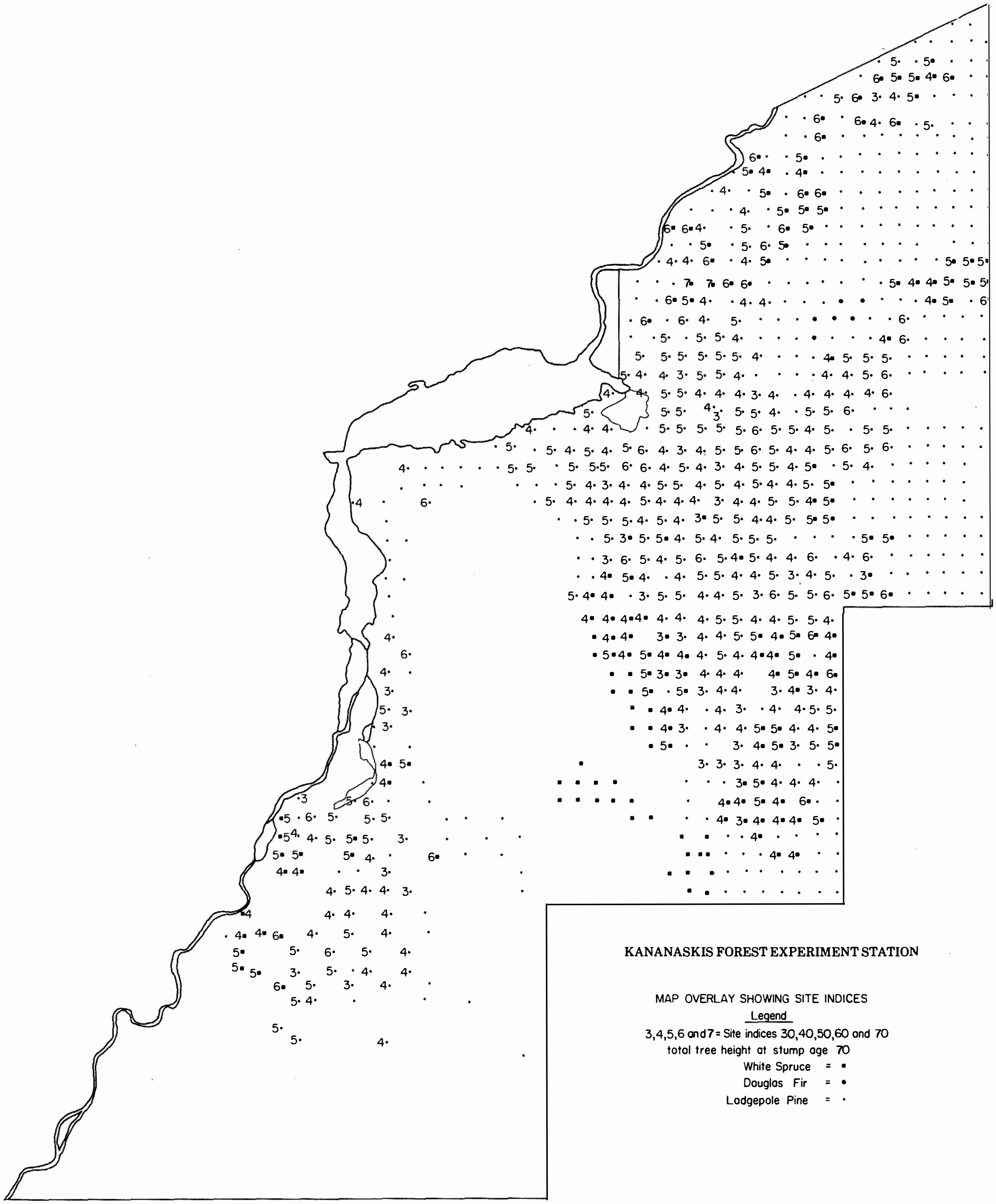


Figure 5. Site index of dominant species at sample plot locations.

TABLE 5. AVERAGE BASAL AREA, NUMBER OF TREES, DIAMETER AND VOLUME BY: COVERTYPE, HEIGHT CLASS AND YEAR OF MEASUREMENT

(per acre values)

Cover Type	Height Class (feet)	Number of Samples 1936 1939	Number of Samples 1946	Number of Samples 1961 1962	Basal Area 1936 1939	Basal Area 1946	Basal Area 1961 1962	Number of Trees 1936 1939	Number of Trees 1946	Number of Trees 1961 1962	Average Diameter 1936 1939	Average Diameter 1946	Average Diameter 1961 1962	Total Cubic Foot Volume 1936 1939	Total Cubic Foot Volume 1946	Total Cubic Foot Volume 1961 1962
Lodgepole Pine	> 30	5	8	9	79	119	108	8882	9285	3569	1.4	1.5	2.4	1030	1607	1144
" "	31-45	58	66	66	93	115	138	3424	3112	1986	2.2	2.6	3.5	1403	1843	2185
" "	46-60	135	137	137	109	127	144	2215	1728	1132	3.0	3.7	4.8	1826	2312	3039
" "	61-80	24	24	24	141	158	173	1582	1299	922	4.0	4.7	5.9	2705	3258	4631
" "	81-100	1	1	1	92	102	139	700	550	530	5.9	5.8	6.9	1838	2231	3035
Lodgepole Pine & Spruce	> 30	1	1	1	12	33	103	600	1130	1460	2.0	2.3	3.6	154	442	1291
" " "	31-45	5	12	12	69	88	123	1402	1709	1711	3.0	3.1	3.6	1253	1564	2013
" " "	46-60	25	37	37	115	105	132	1827	1270	1098	3.9	3.9	4.7	1959	1889	2705
" " "	61-80	10	11	11	128	148	176	1425	1134	996	4.1	4.9	5.7	2398	3017	4424
White Spruce-Lodgepole Pine	> 30		1	1		67	117		3050	5160		2.0	2.0		1043	1189
" "	31-45	6	9	10	64	85	130	1125	1343	1546	3.2	3.4	3.9	1246	1508	2096
" "	46-60	9	10	10	86	119	142	1893	1176	1075	2.9	4.3	4.9	1404	2226	2939
" "	61-80	3	5	5	178	207	204	2383	1604	1104	3.7	4.9	5.8	3896	4937	5080
White Spruce	> 30		2	2		2	35		30	925		3.4	2.6		30	340
"	31-45	5	10	10	31	47	100	1292	1340	1532	2.1	2.5	3.5	375	592	1410
"	46-60	11	14	14	123	118	110	822	770	701	5.2	5.3	5.4	2519	2582	2207
"	61-80	15	15	16	155	152	159	755	709	631	6.1	6.3	6.8	3298	3267	3864
"	81-100	1	1	1	115	123	176	670	730	790	5.6	5.5	6.4	2044	2167	4797
Lodgepole Pine-Poplar	31-45	3	3	3	47	68	107	1217	1203	1173	2.7	3.2	4.1	740	1164	1938
" "	46-60	10	10	10	66	88	121	1228	965	835	3.1	4.1	5.1	1155	1676	2577
" "	61-80	2	2	2	104	125	145	970	795	530	4.5	5.4	7.1	2005	2604	3865
White Spruce & Poplar	> 30	1	1	1	1	2	18	40	190	510	2.5	1.4	2.5	17	22	207
" "	31-45	1	1	1	83	114	148	730	710	670	4.6	5.4	6.4	1513	2314	2944
" "	46-60	4	5	5	45	69	101	735	930	920	3.4	3.7	4.5	690	1053	1987
" "	61-80	2	2	2	85	45	78	490	495	525	5.6	4.1	5.2	576	795	1613
" "	81-100	1	1	1	153	123	191	240	160	170	10.8	11.9	14.4	4781	4281	6254
White Spruce & Alpine Fir	31-45	7	7	7	116	118	74	731	840	921	5.4	5.1	3.9	2727	2697	1161
" "	46-60	3	7	7	103	107	111	643	734	874	5.4	5.2	4.8	2226	2335	2316
" "	61-80	3	4	4	137	130	139	517	770	923	7.0	5.5	5.3	3453	3095	3221
Douglas Fir	31-45	2	2	2	51	53	103	1160	1320	1455	2.8	2.7	3.6	641	660	1270
"	46-60	8	8	8	94	128	172	1066	1009	1000	4.0	4.8	5.6	1540	2229	3224
"	61-80	4	4	4	79	102	142	710	568	745	4.5	5.8	5.9	1166	1692	2952
Aspen	> 30	5	6	7	7	30	47	384	1760	1559	1.7	1.8	2.4	74	350	523
"	31-45	14	14	14	43	67	109	1474	1457	1331	2.3	2.9	3.9	573	998	1743
"	46-60	16	16	16	85	102	132	1084	908	787	3.7	4.6	5.5	1380	1838	2672
"	61-80	2	2	2	91	112	168	1150	845	795	3.7	4.9	6.2	1450	2076	3903
Black Poplar	> 30	1	1	1	5	43	59	140	960	860	2.5	2.9	3.5	59	685	809
"	31-45	2	2	2	68	96	131	795	820	875	4.0	4.6	5.3	1038	1616	2300
"	46-60	5	5	5	61	93	143	774	932	920	3.8	4.3	5.4	909	1489	2994
"	61-80	1	1	1	237	225	221	1050	910	560	6.4	6.7	8.5	4708	4695	4415
Average all covertypes		411	468	472	100	115	136	1944	1717	1251	3.1	3.5	4.5	1716	2109	2736

TABLE 6. AVERAGE STAND AND STOCK TABLES (per acre values)

D.b.h.o.b. (inches)	Number of trees	Total volume (cubic feet)
Average stand diameter class (0.6-1.5") Based on the average of 16 tenth-acre plots		
1	5950.6	78.5
2	1422.5	170.7
3	157.5	120.0
4	20.0	32.6
5	5.0	14.1
6	/	/
7	/	/
8	/	/
9	/	/
10	/	/
11	/	/
12	/	/
13	/	/
14	/	/
15	/	/
Totals	7555.6	415.9

Average d.b.h. = 1.3 inches

T.C.F.V./B.A. = 5.6 cubic feet per unit of basal area

D.b.h.o.b. (inches)	Number of trees	Total volume (cubic feet)
Average stand diameter class (1.6-2.5") Based on the average of 97 tenth-acre plots		
1	1978.3	59.4
2	1711.5	205.4
3	863.4	690.7
4	253.4	413.1
5	44.4	125.3
6	7.7	34.1
7	1.0	6.6
8	0.8	7.7
9	/	/
10	/	/
11	/	/
12	/	/
13	/	/
14	/	/
15	/	/
Totals	4860.5	1542.3

Average d.b.h. = 2.1 inches

T.C.F.V./B.A. = 12.7 cubic feet per unit of basal area

D.b.h.o.b. (inches)	Number of trees	Total volume (cubic feet)
Average stand diameter class (2.6-3.5") Based on the average of 166 tenth-acre plots		
1	428.7	12.9
2	701.2	84.1
3	658.8	527.0
4	425.7	693.9
5	175.5	495.0
6	46.4	204.4
7	10.4	65.9
8	2.8	24.7
9	1.0	11.9
10	0.5	6.3
11	/	/
12	/	/
13	/	/
14	/	/
15	/	/
Totals	2451.0	2126.1

Average d.b.h. = 3.0 inches

T.C.F.V./B.A. = 17.1 cubic feet per unit of basal area

TABLE 6. AVERAGE STAND AND STOCK TABLES (per acre values) (continued)

Average stand diameter class (3.6-4.5")
Based on the average of 197 tenth-acre plots

D.b.h.o.b (inches)	Number of trees	Total volume (cubic feet)
1	178.6	5.4
2	236.2	28.3
3	286.3	229.0
4	284.1	463.0
5	222.4	627.3
6	124.9	550.7
7	47.2	300.1
8	17.7	155.7
9	6.9	81.4
10	2.3	34.4
11	1.1	21.1
12	0.5	2.8
13	/	/
14	/	/
15	/	/
Totals	1408.2	2499.2

Average d.b.h. = 4.0 inches

T.C.F.V./B.A. = 20.2 cubic feet per unit of basal area

Average stand diameter class (4.6-5.5")
Based on the average of 129 tenth-acre plots

D.b.h.o.b (inches)	Number of trees	Total volume (cubic feet)
1	86.0	2.9
2	101.5	12.2
3	128.8	103.1
4	165.2	269.2
5	179.2	505.3
6	153.7	677.8
7	97.2	618.2
8	44.1	388.6
9	17.2	202.7
10	7.1	107.6
11	2.4	45.4
12	0.6	14.4
13	0.3	8.7
14	/	/
15	/	/
Totals	983.3	2956.1

Average d.b.h. = 5.0 inches

T.C.F.V./B.A. = 22.0 cubic feet per unit of basal area

Average stand diameter class (5.6-6.5")
Based on the average of 68 tenth-acre plots

D.b.h.o.b (inches)	Number of trees	Total volume (cubic feet)
1	55.0	1.6
2	55.5	6.7
3	69.1	55.3
4	83.5	136.2
5	104.2	293.7
6	125.2	552.0
7	108.1	687.6
8	69.1	609.1
9	37.5	441.9
10	16.0	241.6
11	7.9	149.7
12	4.3	99.0
13	2.3	66.1
14	0.4	14.8
15	0.2	5.8
Totals	738.3	3361.1

Average d.b.h. = 5.9 inches

T.C.F.V./B.A. = 23.9 cubic feet per unit of basal area

TABLE 6. AVERAGE STAND AND STOCK TABLES (per acre values) (continued)

D.b.h.o.b. (inches)	Number of trees	Total volume (cubic feet)
Average stand diameter class (6.6-7.5")		
Based on the average of 15 tenth-acre plots		
1	36.0	1.1
2	26.7	3.2
3	32.0	25.6
4	48.0	78.3
5	54.0	152.3
6	75.3	332.2
7	95.3	606.3
8	77.3	681.4
9	50.0	589.0
10	34.7	522.5
11	13.3	251.5
12	8.7	201.1
13	4.0	112.5
14	0.7	22.5
15	1.3	51.6
Totals	557.3	3631.1

Average d.b.h. = 6.9 inches

T.C.F.V./B.A. = 25.1 cubic feet per unit of basal area

Average stand diameter class (7.6-8.5")		
Based on the average of 5 tenth-acre plots		
1	14.0	0.4
2	12.0	1.4
3	24.0	19.2
4	24.0	39.1
5	22.0	62.0
6	40.0	176.4
7	74.0	472.0
8	72.0	634.3
9	84.0	989.5
10	46.0	693.2
11	18.0	239.3
12	8.0	185.5
13	8.0	224.0
14	4.0	134.6
15	4.0	152.4
Totals	454.0	4023.3

Average d.b.h. = 7.8 inches

T.C.F.V./B.A. = 26.6 cubic feet per unit of basal area

Average stand diameter class (8.6-9.5")		
Based on the average of 1 tenth-acre plot		
1	--	--
2	10.0	1.2
3	20.0	16.0
4	50.0	81.5
5	50.0	141.0
6	30.0	132.3
7	30.0	190.8
8	30.0	264.3
9	20.0	235.6
10	50.0	753.5
11	30.0	565.5
12	20.0	463.8
13	50.0	1406.5
14	10.0	336.5
15	--	--
Totals	400.0	4588.5

Average d.b.h. = 8.6 inches

T.C.F.V./B.A. = 28.4 cubic feet per unit of basal area

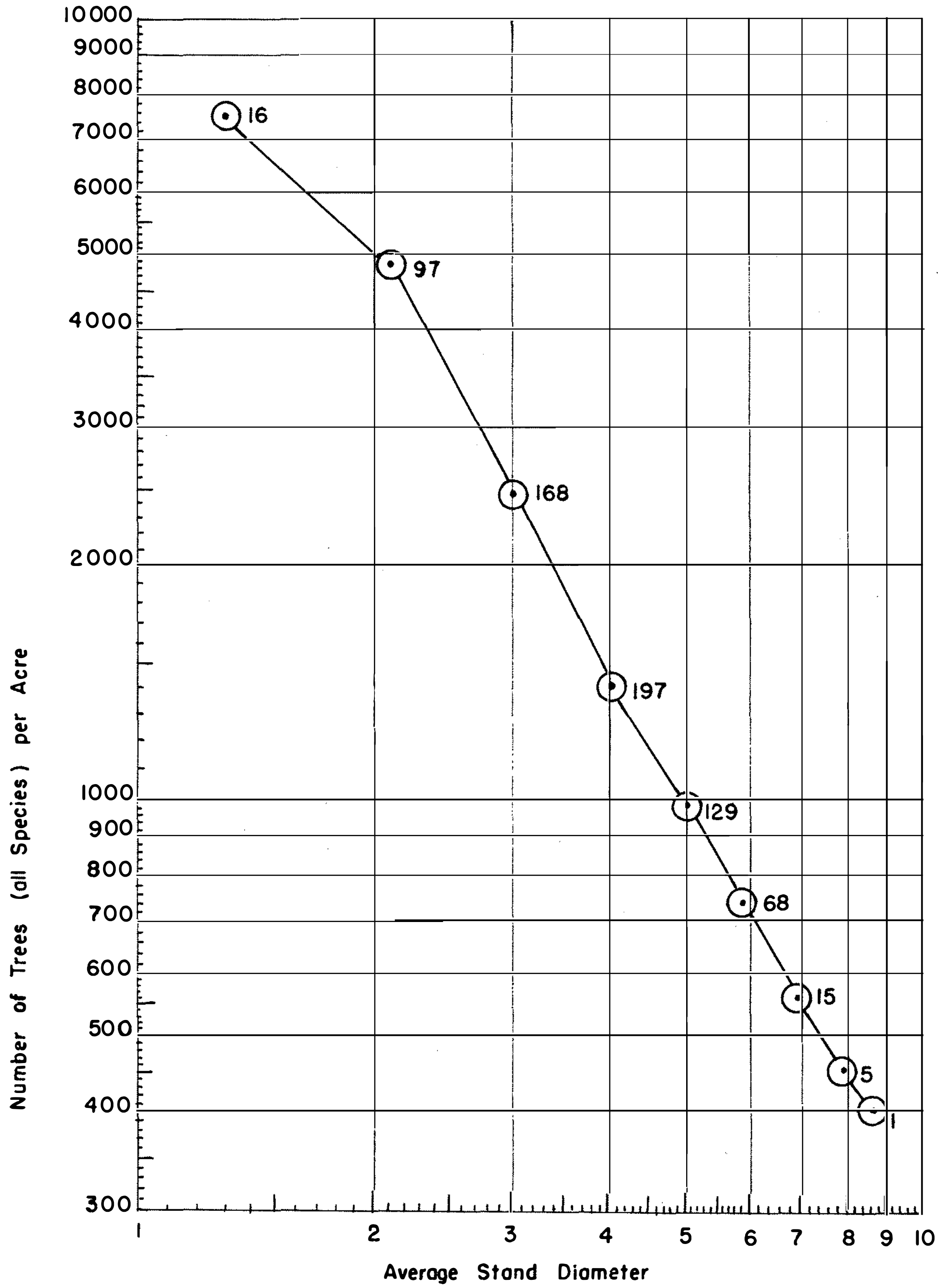


Figure 6. Average number of stems per acre for lodgepole pine stands by average stand diameter classes.

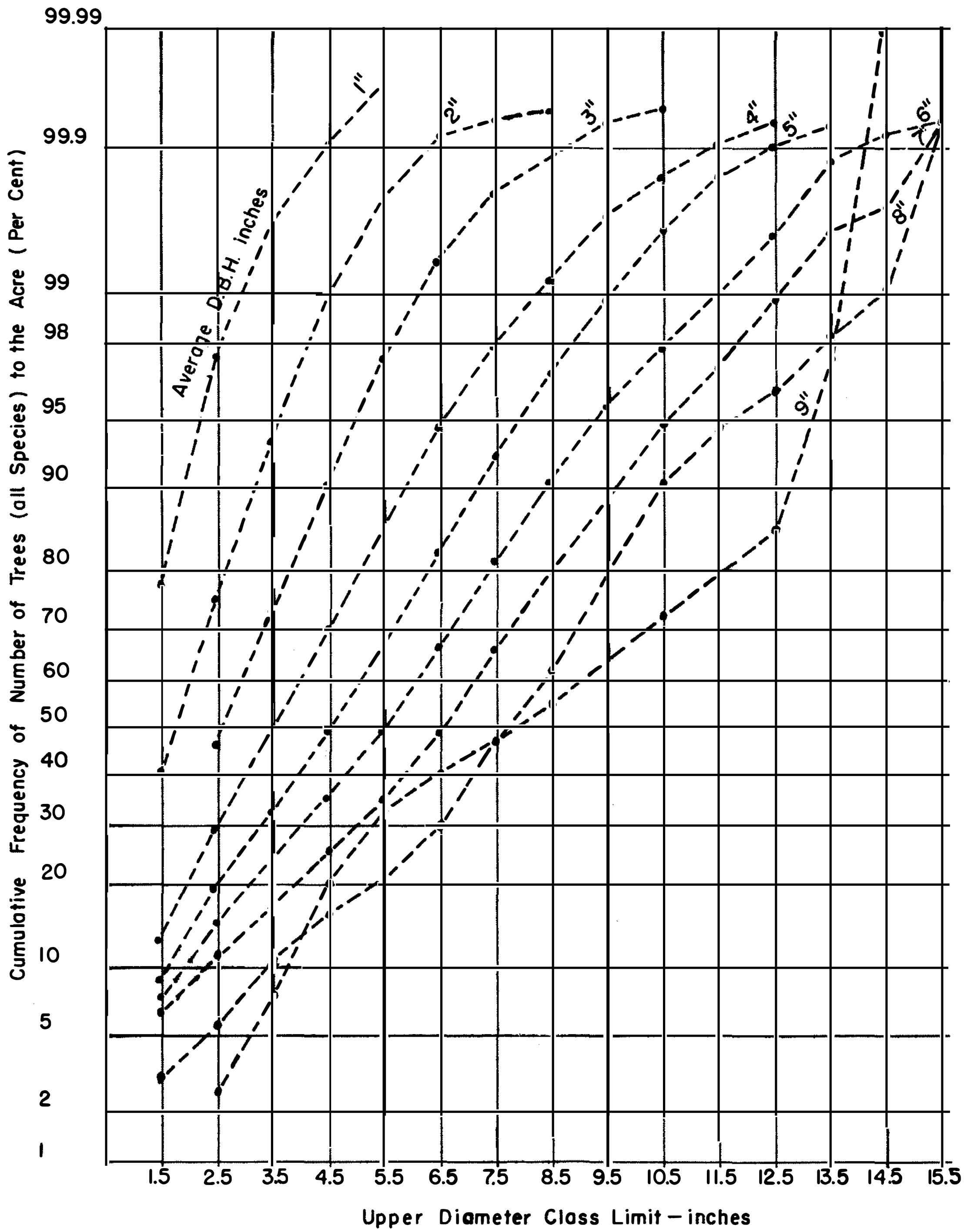


Figure 7. Cumulative frequency distribution of number of stems by diameter class of lodgepole pine stands at various average stand diameters.

TABLE 7. LOCAL HEIGHT-DIAMETER AND TOTAL CUBIC FOOT VOLUME RELATIONSHIPS, BASED ON STEM ANALYSIS

D.b.h. (inches)	Total height (feet)	Total volume* (cubic feet)
1	12	.03
2	22	.12
3	30	.80
4	35	1.63
5	40	2.82
6	44	4.41
7	47	6.36
8	50	8.81
9	53	11.78
10	55	15.07
11	57	18.85
12	59	23.19
13	61	28.13
14	63	33.65
15	65	38.82

*Local total cubic foot volumes were calculated from the following standard volume equations:

T.C.F.V. for trees $< 3.56 = -.007462 + .002975\ (D^2H)\ R^2 \doteq .97\ SE_E = 8.2\%$

T.C.F.V. for trees $\geqslant 3.56 = .102600 + .002721\ (D^2H)\ R^2 \doteq .99\ SE_E = 5.9\%$

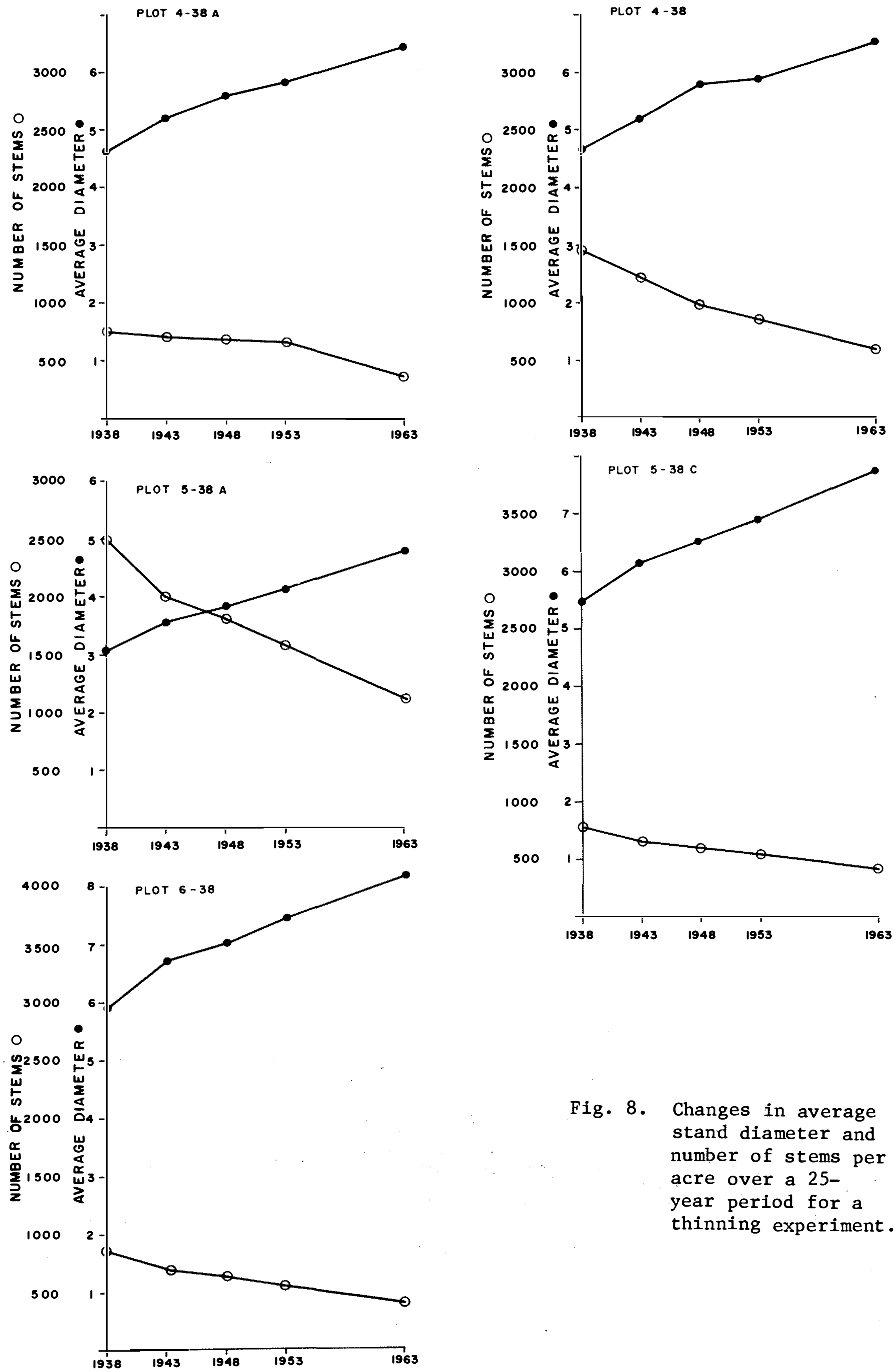


Fig. 8. Changes in average stand diameter and number of stems per acre over a 25-year period for a thinning experiment.

Forest Covertypes

A lithographed forest covertype map of the Experiment Station is in the pocket on the back cover. This color map is based upon black and white aerial photography at a scale of 1:15,840 completed by a private aerial survey company in 1962. These photographs were interpreted and transferred to a base map by the Alberta Forest Service in 1963. The map was field-checked and 500-foot contours and permanent sample plot locations were added to it by the Canadian Forestry Service.

A map information and display system (MIADS) adapted by Kirby and Chow (1969) was used to compile forest cover area and wood volume statistics. Each coded cell represented 1.33 acres or 30 cells per square inch of original map. This gave the area determinations similar accuracy to that obtained with a dot grid with 30 dots per square inch. Table 8 gives the acreages of forest covertypes by height and density classes as well as areas of non-forest land. In addition to tables, maps were also obtained from the computer mapping program. Photo reduction and graphical enhancement of the computer maps for the purposes of this report are presented to assist the forest-land manager to comprehend the large amounts of information available to him. Instead of a conventional pie chart, the computer maps were greatly reduced to show aerial distribution by covertype and height class for a rapid comprehension of how much and where various forest stratifications are located (Figure 9). For more detailed information on forest cover and non-forest land, computer maps, Figures 10 to 15, are presented.

The forest cover map and the surficial materials map (Figure 2) are on punch cards and other maps may be placed on punch cards for processing by the computer mapping program described by Kirby and Chow (1969). The combinations subroutine may be used to print maps showing where desired combinations of forest, soil and other site features are located.

The computer mapping system was also used to generate Tables 9 and 10 showing the area and total cubic-foot volume of wood for the Working Plan Forest only, as designated in Figure 3.

CONCLUSION

Past forest resources research on the Experiment Station has focused on regeneration, thinning, pruning, forest insect and disease studies and inventory techniques (Figure16). Some clearcutting in strips has been done in the last three years (see back cover for location) to obtain more varied conditions on the station and to demonstrate various practices to obtain desirable regeneration after cutting and burning. The cutting program is reviewed annually and other objectives will be introduced into the program. Cutting in strips is not always aesthetic and may not even be the most economical pattern. With increasing demand for recreation, there is a need to improve descriptions and inventories of landscapes from an aesthetic point of view and possibly blend logging with recreational requirements.

The prime use of the east slopes, as defined by the "Eastern Rockies Conservation Board", is to preserve the east slopes for the production of water. Consequently, a large amount of research has gone into water production, timing and quantity, on the adjacent Marmot Creek Watershed Research Basin (Kirby and Ogilvie, 1969).

The station is a "ground truth" area for testing of multispectral and other remote sensing instrumentation from aircraft and spacecraft, starting in 1972 with the Earth Resources Technology Satellite program (ERTS). New instrumentation (which can be used both from aircraft or satellite) offers considerable promise to make many resource inventories more timely and economical by automating some of the interpretations based on spectral signatures. In addition, new parameters describing the east slopes are possible. For example, it may be feasible to map snowmelt patterns and to develop energy budgets that will assist in the prediction of floods.

There is seen to be an increasing need for K.F.E.S. to serve as an educational centre for a public concerned with its environment. It is a demonstration area intended to show that the use of our natural resources does not necessarily mean the destruction of our environment.

TABLE 8. DISTRIBUTION OF FOREST COVER AND NON-FOREST LAND BASED ON LITHOGRAPHED MAP OF K.F.E.S.

Cover Type	Height Class feet	Acreage by Density Class			Total Acreage	Percentage of Total Acreage
		A	B	C		
Lodgepole Pine	up to 30'	104.0	138.0	1115.4	1357.5	8.9
"	31 - 45'	455.6	256.9	1579.2	2291.7	15.0
"	56 - 60'	63.6	584.1	1707.6	2355.2	15.4
"	61 - 80'	-	20.3	-	20.3	0.1
Total:		623.2	999.3	4402.2	6024.7	39.4
Lodgepole Pine White Spruce	up to 30'	29.7	-	-	29.7	0.2
	31 - 45'	169.0	429.9	151.4	750.3	4.9
"	46 - 60'	78.4	507.0	238.0	823.4	5.4
"	61 - 80'	-	114.9	77.1	192.0	1.3
Total:		277.1	1051.8	466.5	1795.4	11.8
White Spruce Lodgepole Pine	up to 30'	55.4	35.2	-	90.6	0.6
	31 - 45'	173.1	192.0	18.9	384.0	2.5
"	46 - 60'	255.5	612.5	63.5	931.5	6.1
"	61 - 80'	56.8	87.9	-	144.7	0.9
Total:		540.8	927.6	82.4	1550.8	10.1
White Spruce	up to 30'	47.3	16.2	-	63.5	0.4
"	31 - 45'	104.1	144.7	-	248.8	1.6
"	46 - 60'	252.8	193.3	-	446.1	2.9
"	61 - 80'	236.6	193.4	18.9	448.9	2.9
"	81 - 100'	-	4.0	-	4.0	0.03
Total:		640.8	551.6	-	1211.3	7.9
Aspen Black Poplar	up to 30'	102.7	114.9	-	217.6	1.4
	31 - 45'	74.4	36.5	91.9	202.8	1.3
"	46 - 60'	12.2	102.7	127.1	242.0	1.6
"	61 - 80'	6.7	-	-	6.7	0.04
Total:		196.0	254.1	219.0	669.1	4.3
Total of all Cover Types:					11251.3	73.6
Non Forest Land						
Rock Outcrops					3050.2	19.9
Sand and Gravel (Gravel Pit, Treed Gravel)					453.0	3.0
Cut-over					121.7	0.8
Potential Productive					39.2	0.3
Treed Meadow					106.8	0.7
Muskeg					28.4	0.2
Water					36.5	0.2
Clearings					81.1	0.6
Erosion					101.4	0.7
Total of Non Forest Land:					4018.3	26.4
Total: Forest and Non-Forest Land					15269.6	100.0

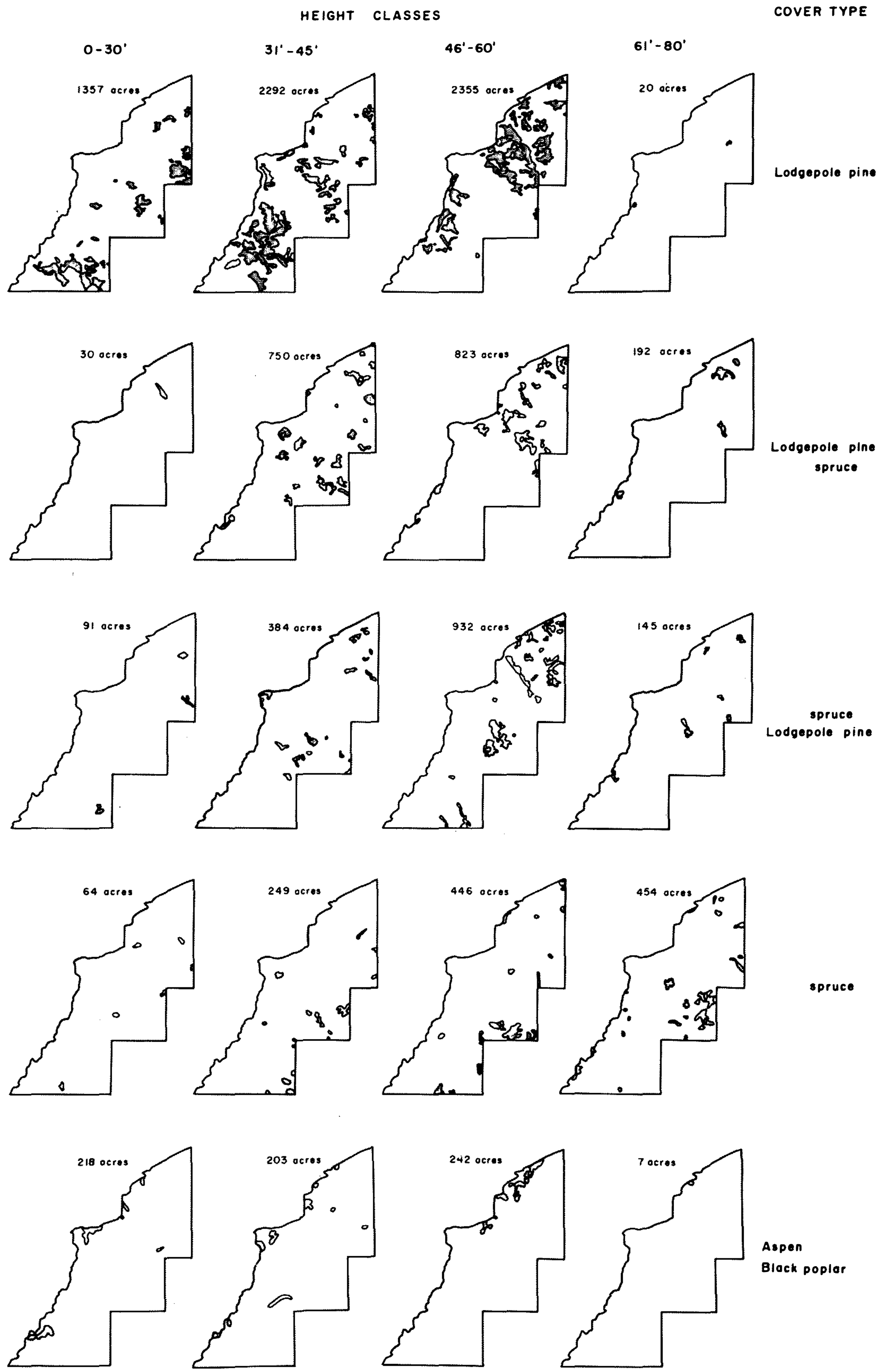


Figure 9. Distribution of cover types by height classes.

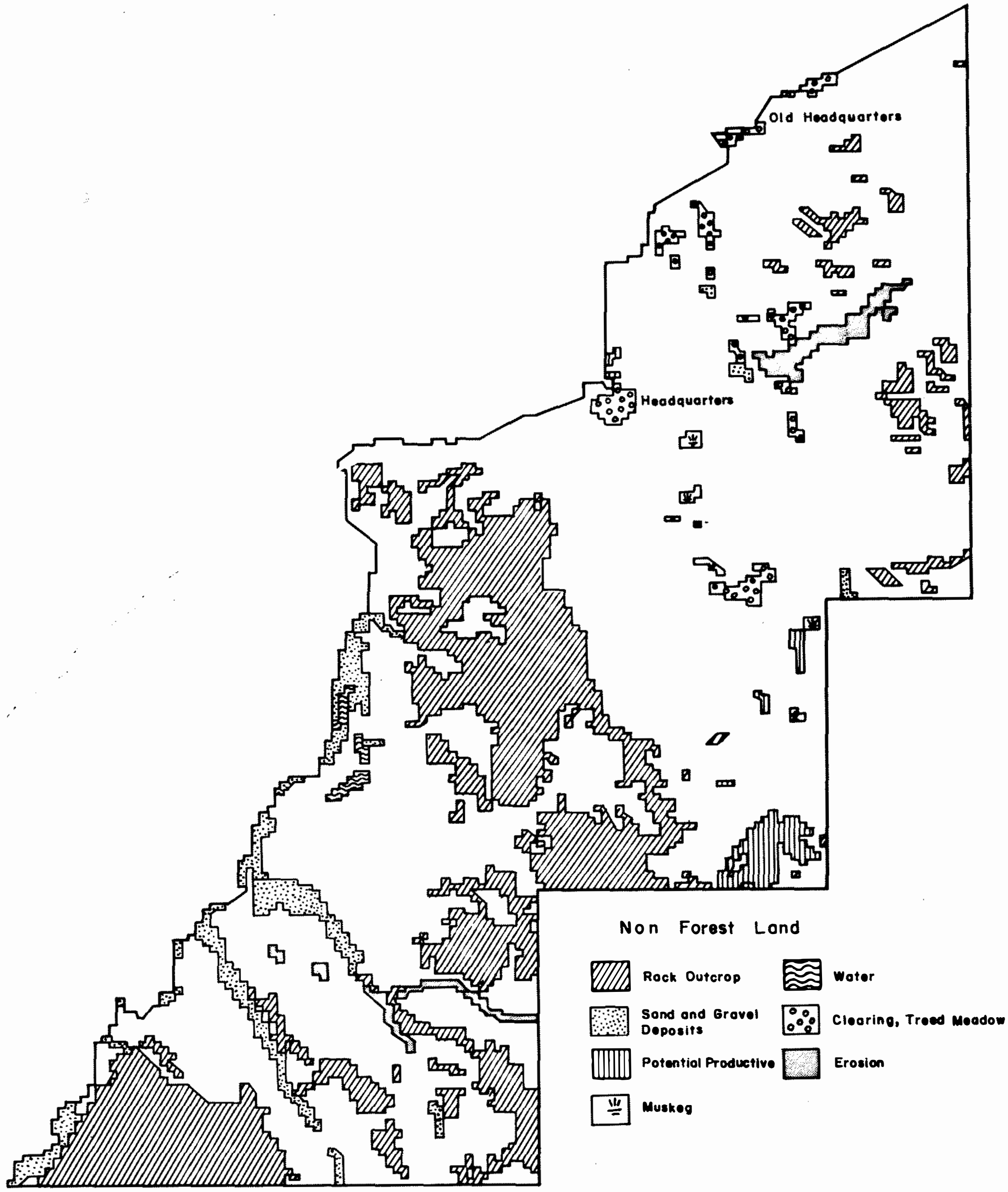


Figure 10. Non-forest land.

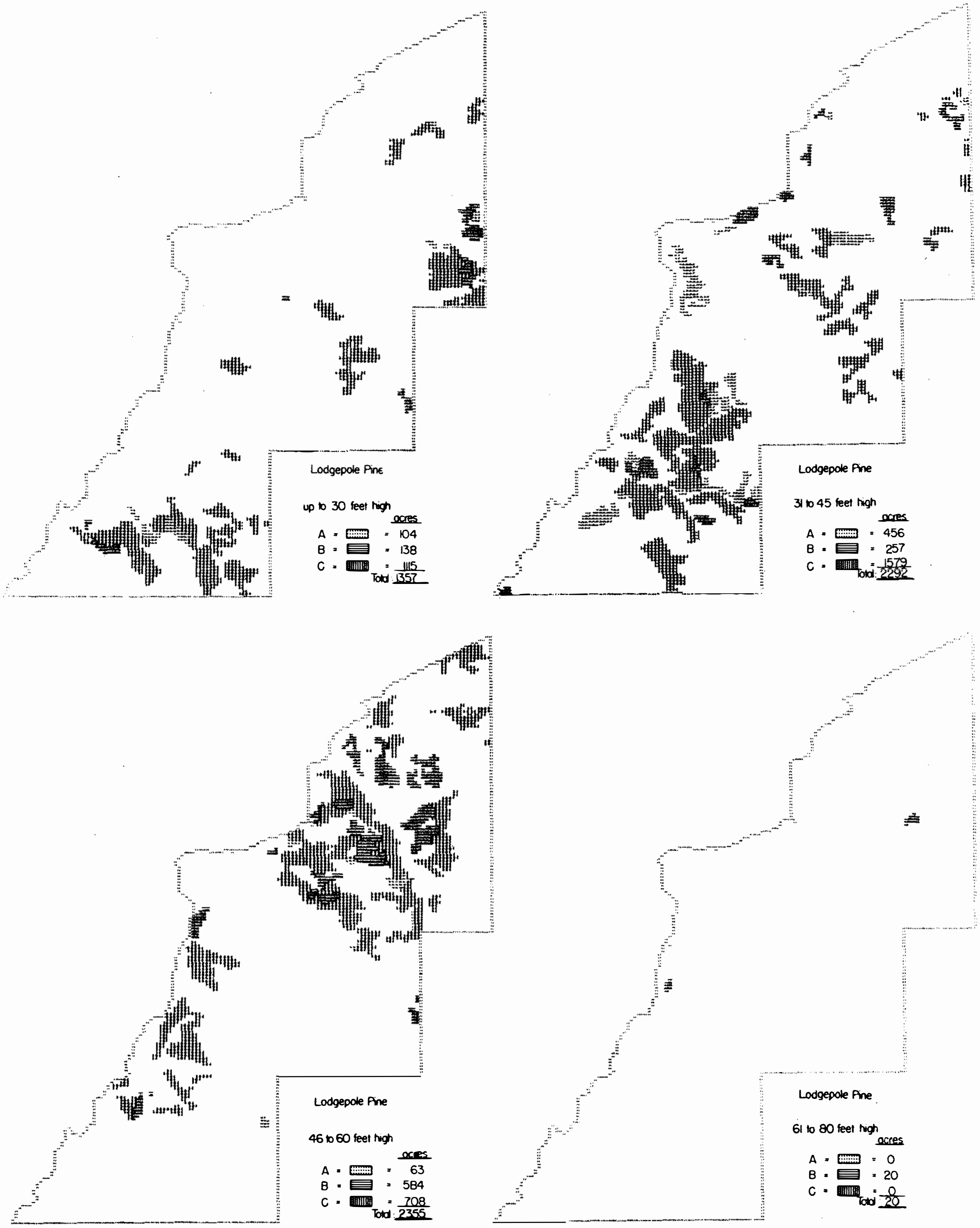


Figure 11. Lodgepole pine covertype.

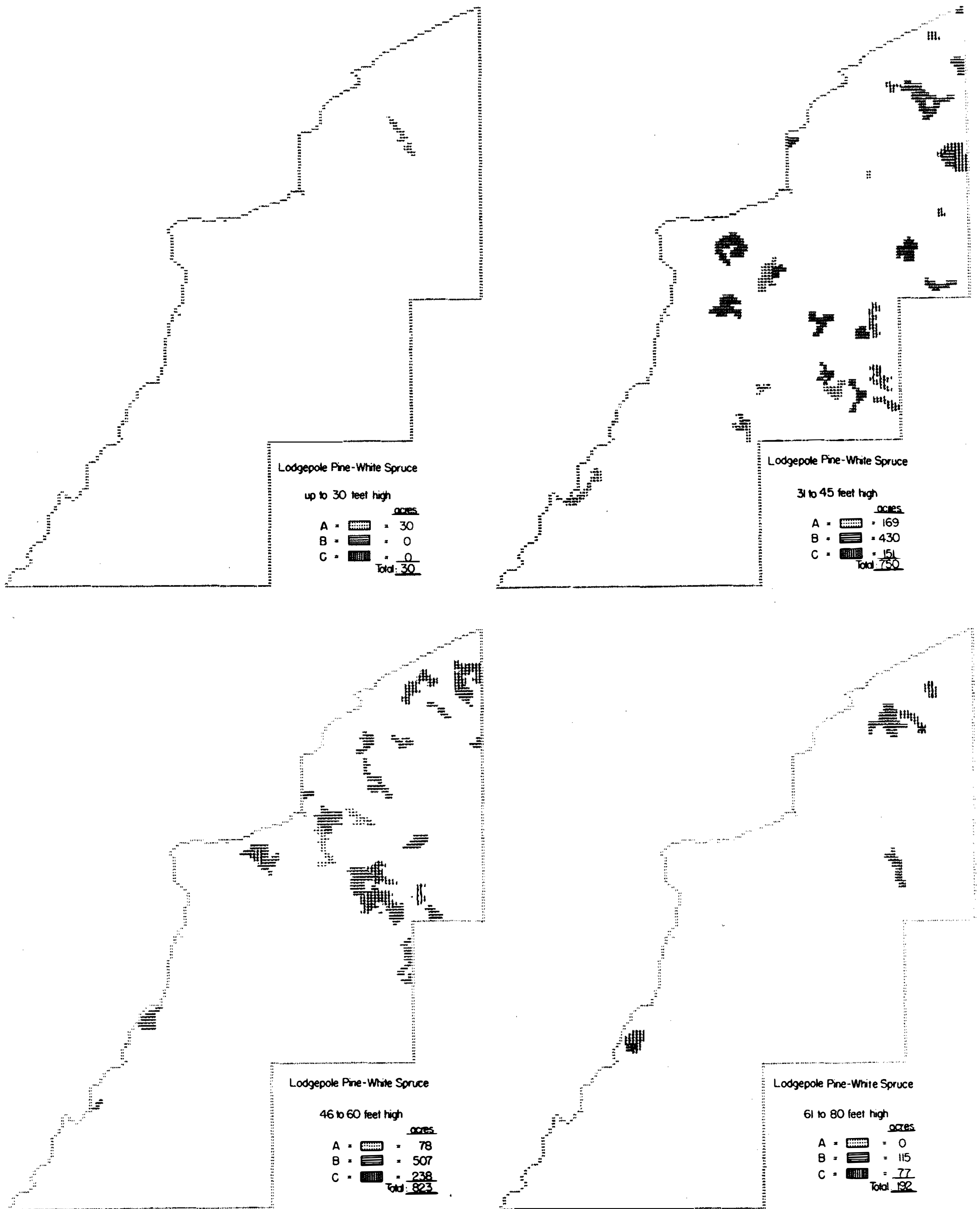


Figure 12. Lodgepole pine-spruce covertype.

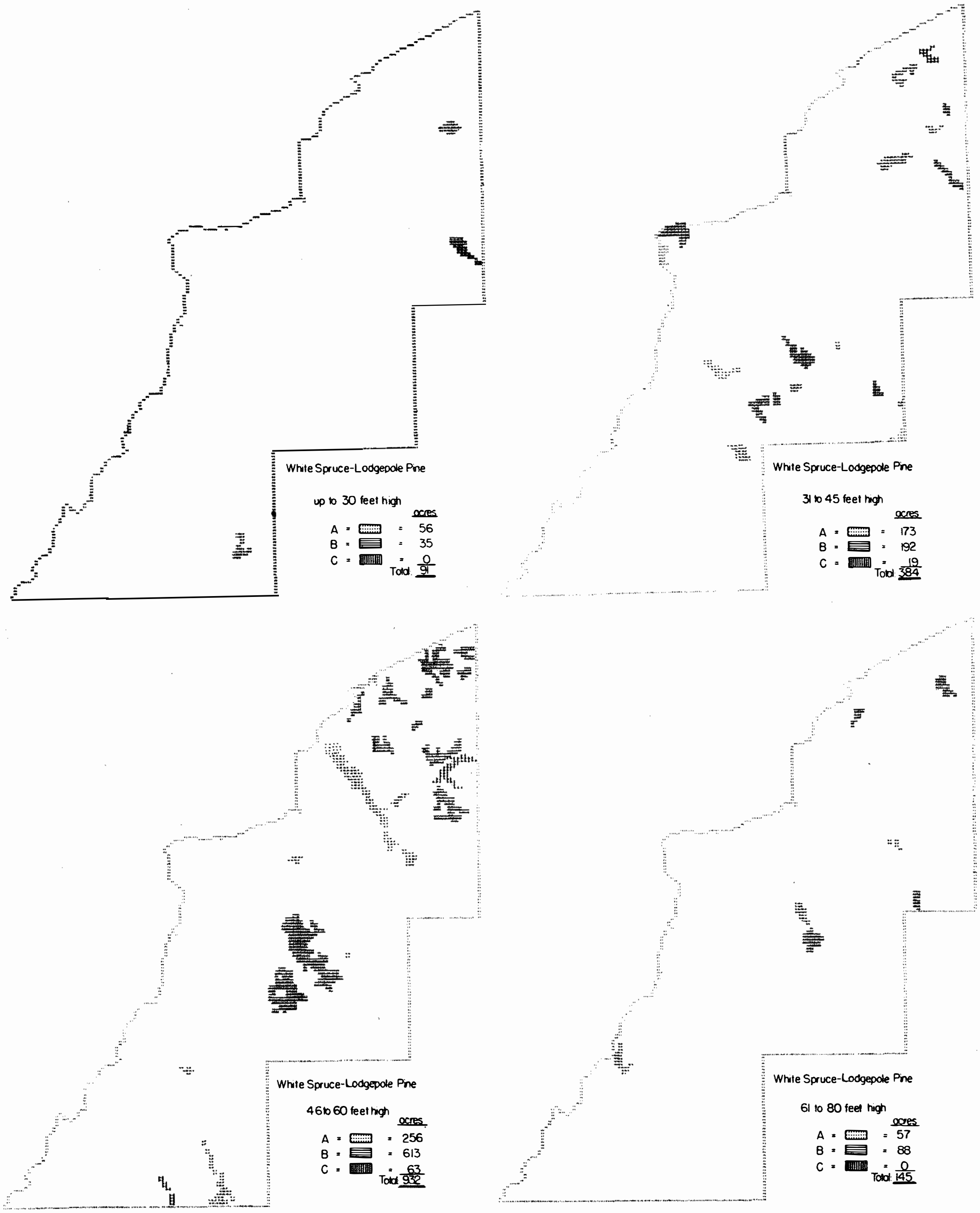


Figure 13. Spruce-lodgepole pine covertype.

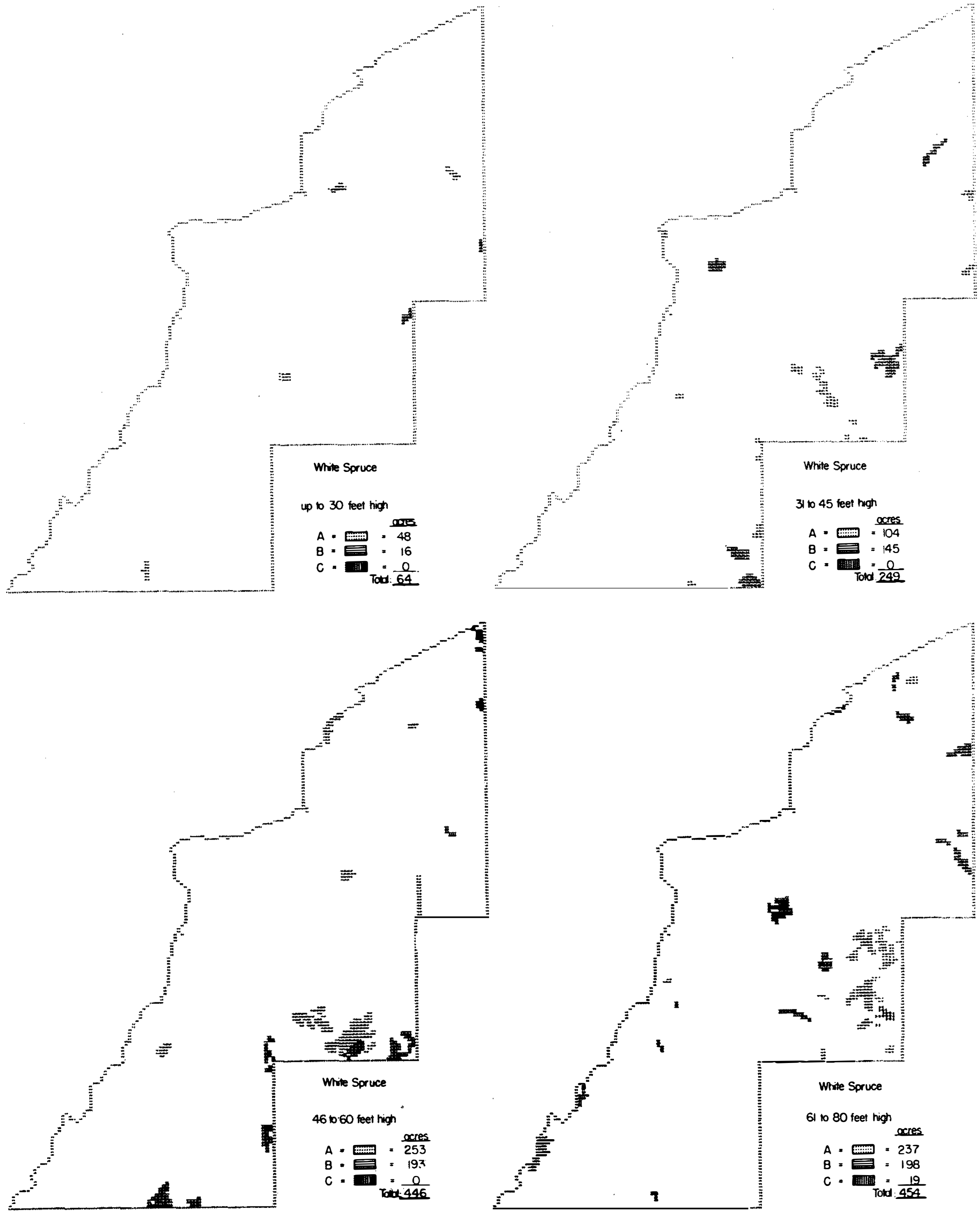


Figure 14. Spruce covertype

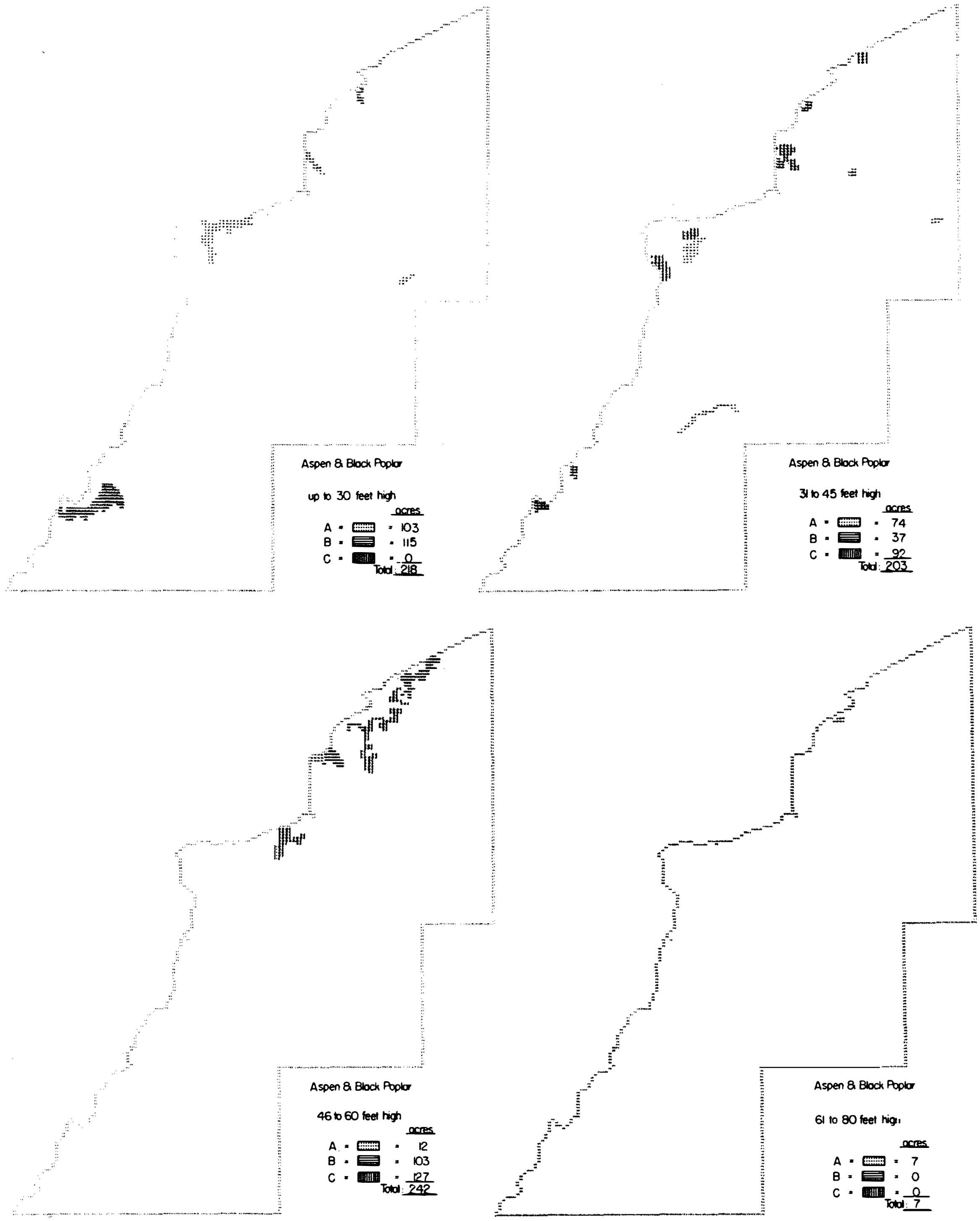


Figure 15. Aspen and black poplar covertype.

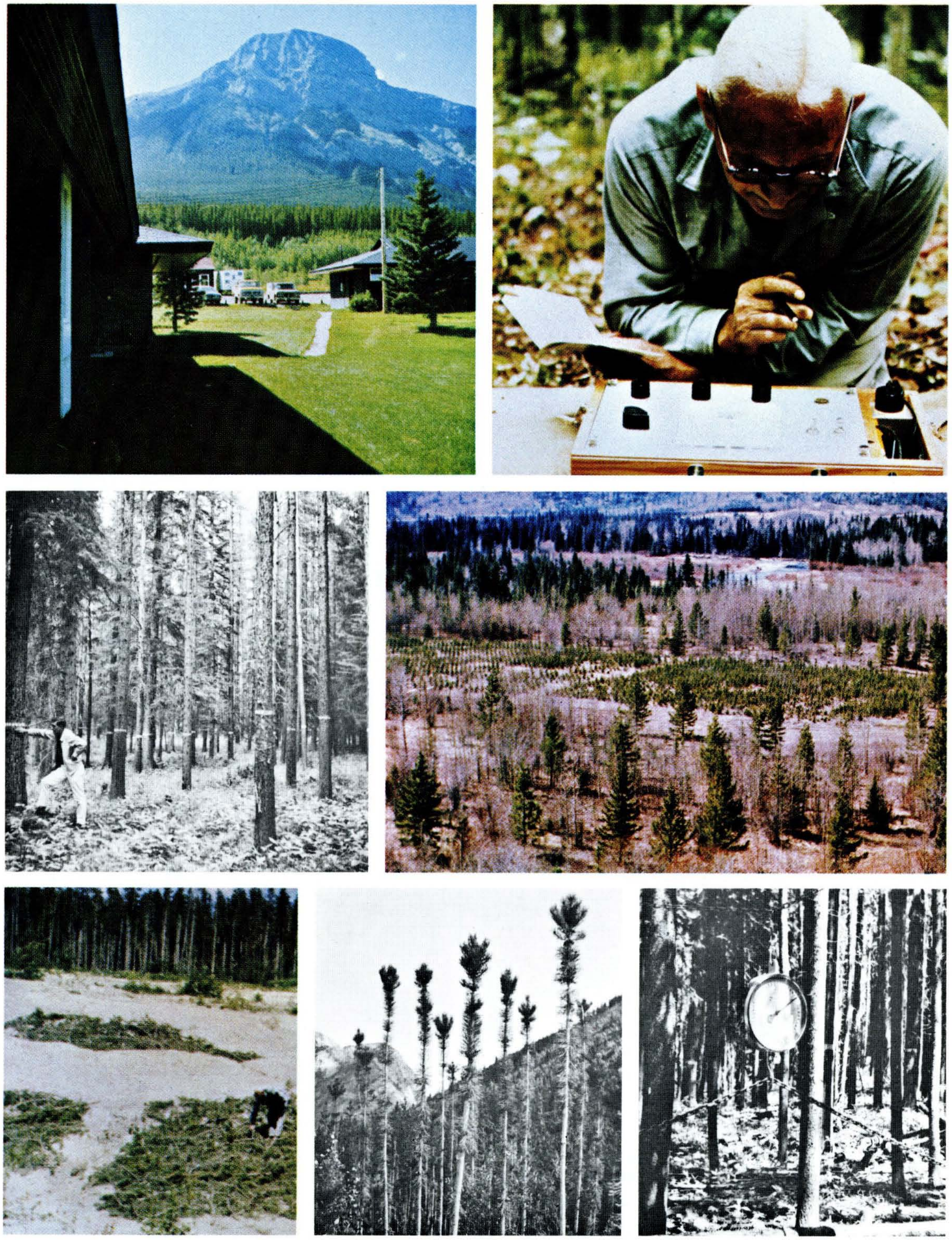


Fig. 16 — Research at the Kananaskis Forest Experiment Station.

a. The K.F.E.S. is located at the foot of Barrier Mountain. A modern research facility is now available.
b. Skilled technicians are engaged in a wide variety of environment related studies.
c. A 100-year-old lodgepole pine stand that was thinned at age 70. See Fig. 8, Plot 6-38.
d. Regeneration studies and provenance trials are carried out on permanent study plots.
e. The scars created by the hydro development are subject of erosion control studies.
f. Debranching and debudding of lodgepole pine in an effort to grow knot-free lumber.
g. All tree components are weighed in a forest productivity study.

TABLE 9. DISTRIBUTION OF FOREST COVER AND NON-PRODUCTIVE LAND ON WORKING PLAN FOREST ONLY OF K.F.E.S.

Cover Type	Height Class (feet)	Area in acres by density class			
		A	B	C	All
Lodgepole pine	1-30	7	8	125	140
	31-45	185	177	889	1,251
	46-60	51	459	1,381	1,891
	61-80	3	4	7	14
Total area: acres		246	648	2,402	3,296
per cent					48.36
Lodgepole Pine	1-30	4	0	0	4
	31-45	96	121	156	373
White Spruce	46-60	61	385	209	655
	61-80	7	91	79	177
Total area: acres		168	597	444	1,209
per cent					17.74
White Spruce	1-30	0	0	0	0
	31-45	0	44	40	84
Lodgepole Pine	46-60	184	196	32	412
	61-80	55	77	0	132
Total area: acres		239	317	72	628
per cent					9.21
White Spruce	1-30	19	13	0	32
	31-45	11	52	0	63
	46-60	81	17	0	98
	61-80	160	92	9	261
	81-100	0	4	0	4
Total area: acres		271	178	9	458
per cent					6.72
Aspen	1-30	69	128	0	197
	31-45	5	56	101	162
Black Poplar	46-60	24	96	133	253
	61-80	4	0	0	4
	81-100	0	0	0	0
Total area: acres		102	280	234	616
per cent					9.04
Clearings					137
Sand & Gravel Deposits					205
Rock Outcrops					29
Muskeg					12
Potential Productive Not Stocked					208
Eroded Cut Bank					1
Gravel Pit					3
Treed Meadow					13
		Total area: acres			608
		per cent			8.92
		Grand Total: acres			6,815
		per cent			100.00

TABLE 10. DISTRIBUTION OF WOOD VOLUME BY FOREST COVERTYPES ON WORKING PLAN FOREST ONLY OF K.F.E.S.

Cover Type	Height Class (feet)	Total cubic foot volume by density class			
		A	B	C	All
Lodgepole pine	1-30	760	9,152	143,381	153,293
	31-45	40,403	387,473	1,943,192	2,371,068
	46-60	15,352	1,393,886	4,197,868	5,607,106
	61-80	1,235	18,524	30,873	50,632
	Total volume: cu.ft.	57,750	1,809,035	6,315,314	8,182,099
	per cent				58.30
Lodgepole pine	1-30	516	0	0	516
	31-45	19,296	244,244	314,028	577,568
White Spruce	46-60	16,560	1,042,325	566,246	1,625,131
	61-80	2,947	401,109	348,021	752,077
	Total volume: cu.ft.	39,319	1,687,678	1,228,295	2,955,292
	per cent				21.06
White Spruce	1-30	0	0	0	0
	31-45	0	92,224	83,840	176,064
Lodgepole Pine	46-60	54,096	576,044	94,048	724,188
	61-80	27,771	392,853	0	420,624
	Total volume: cu.ft.	81,867	1,061,121	177,888	1,320,876
	per cent				9.41
White Spruce	1-30	635	4,533	0	5,168
	31-45	1,504	73,320	0	74,824
	46-60	17,975	38,255	0	56,230
	61-80	61,760	355,488	36,064	453,312
	81-100	0	19,188	0	19,188
	Total volume: cu.ft.	81,874	490,784	36,064	608,722
	per cent				4.34
Aspen	1-30	3,605	66,944	0	70,549
	31-45	928	97,608	176,624	275,160
Black Poplar	46-60	6,408	256,512	356,267	619,187
	61-80	1,560	0	0	1,560
	Total volume: cu.ft.	12,501	421,064	532,891	966,456
	per cent				6.89
		Grand total volume: cu.ft.			14,033,445
		per cent			100.00

REFERENCES

Beach, H. H. 1943. Moose Mountain and Morley Map-Areas, Alberta. Geological Survey of Canada Memoir 236.

Beal, H. W. 1940. Forecasting weather and forest fire hazard from local observations. Canada Dept. of Mines and Resources, Dominion Forest Service. Forest Research Note No. 10

Crossley, D. I. 1951. The soils on the Kananaskis Forest Experiment Station in the Sub-Alpine Forest Region in Alberta. Canada Dept. Resources and Development, Forestry Branch, Silvicultural Research Note 100. 32 pp.

Coves, E. ed. 1897. The Manuscript Journals of Alexander Henry and of David Thompson. Vol. 2. F. P. Harker, New York.

Dowling, D. B. 1905. Cascade Coal Basin. Geological Survey of Canada, Ottawa.

Duffy, P. J. B. and R. E. England. 1967. A forest land classification for the Kananaskis Research Forest, Alberta, Canada. Dept. of Forest and Rural Development, Forestry Branch. Internal report A-9.

Ferguson, H. L. and D. Storr. 1969. Some current studies of local preciptation variability over western Canada. pp. 80 - 100. IN Water Balance in North America. (Eds.) A. H. Laycock, M. Francisco and T. Fisher. Amer. Water Resources Assoc., Proc. of Symp. at Banff, Alta., June 335 p.

Henson, W. R. 1952. Chinook winds and red belt injury to lodgepole pine in the Rocky Mountain parks area of Canada. For. Chron. 28:62-64.

Kirby, C. L. and W. Chow. 1969. An adaptation of "MIADS" for an I.B.M. 360/30. Information report. Canadian Forestry Service.

Kirby, C. L. and R. T. Ogilvie. 1969. The forests of Marmot Creek watershed and research basin. Dept. of Fisheries and Forestry. Canadian Forestry Service Pub. No. 1259.

Longley, R. W. 1967a. The frequency of chinooks in Alberta. The Albertan Geographer No. 3:20-22.

Longley, R. W. 1967b. The frost-free period in Alberta. Can. J. Plant Sci. 47:239-249.

McHarg, I. L. 1969. Design with nature. Doubleday/Natural History Press. Garden City, New York. 197 pp.

MacHattie, L. B. 1963. Winter injury of lodgepole pine foliage. Weather 18:301-307

MacHattie, L. B. 1966. Relative humidity in Rocky Mountain forests in southern Alberta in summer. Can. Dep. For., For. Fire Res. Inst., Infor. Rept. FF-XX-1. 54 pp

MacHattie, L. B. 1968. Kananaskis valley winds in summer. J. Appl. Meteorol. 7:348-352.

MacHattie, L. B. 1970. Kananaskis valley temperatures in summer. J. Appl. Meteorol. 9:574-582.

MacInnes, C. M. 1930. In the Shadow of the Rockies. Rivingtons, London. 1930.

MacLeod, J. C. 1948. The effect of night weather on forest fire danger. Can. Dep. Mines & Resources, Dominion For. Serv., Forest Fire Res. Note. No. 14. 29 p.

Mulloy, G. A. 1947. Empirical stand density yield. Dept. Mines and Resources. Ottawa, Canada. Silvicultural Res. Note. No. 82.

Munn, R. E. and D. Storr. 1967. Meteorological studies in the Marmot Creek watershed, Alberta, Canada, in August 1965. Water Resources Res. 3:713-722.

National Soil Survey Committee of Canada. 1965. Report on the Sixth Meeting of the National Soil Survey Committee of Canada, Laval University, Quebec. Canada Dept. Agriculture Mimeograph, Ottawa. 132 pp

Reineke, L. H. 1933. Perfecting a stand density index for even-aged forests. Journal Agric. Res. 46:627-638.

Rowe, J. S. 1959. Forests regions of Canada. Canada Dept. Northern Affairs and National Resources, Forestry Branch Bulletin 123.

Sharp, P. F. 1955. Whoop-up Country. U. of Minnesota Press, Minneapolis.

Smithers, L. A. 1961. Lodgepole pine in Alberta. Canada, Dept. of Forestry, Bull. 127

Stalker, A. Mac S. 1963. Quaternary stratigraphy in southern Alberta. Geological Survey of Canada. Dept. of Mines and Technical Surveys, Paper 62-34.

Storr, D. 1967. Precipitation variations in a small forested watershed. Proc. 35th Western Snow Conf., Boise, Idaho. pp. 11-17.

Storr, D. 1969. Climate. p. 2. IN Kirby, C. L. and R. T. Ogilvie. The forests of Marmot Creek Watershed Research Basin. Can. Dep. Fisheries and Forest., Can. For. Serv. Pub. No. 1259.

Voorhis, E. 1930. Historic Forts and Trading Posts. Dept. of Interior, Ottawa.

Wallace, J. N. 1961. Early exploration along the Bow and Saskatchewan Rivers. Alberta Historical Review vol. 9 Part 2.

APPENDIX I

PLOT CODES

Punch Card Colums

1, 2	Growth year 36, 37, 38, 46, 61, 62
3	Season: 1 — May 16 to June 15 -
	2 — June 16 to July 15 -
as per standard code	3 — July 16 to Aug. 15 -
(11 D 24)	4 — Aug. 16 to May 15
4, 5, 6, 7, 8	Plot No. 00000 to 99999
	Status as per Standard Code (11 D 37)*
	0 — not classified
	1 — new plot
	2 — normal remeasurement
	3 — cutting since last measurement
	4 — insect damage
	5 — disease damage
	6 — wind damage
	7 — fire damage
	8 — other disturbances
	9 — plot abandoned
10, 11	as per Standard Code Plot Size (11 D 30)
code 10 — tenth-acre — ALL PLOTS	
12	Blank - No entry
13, 14, 15	Sub Compartment No. 001 to 150 approximately
16	Cover (11 D-14) System A by basal area
	1 — Softwood 81% + softwood
	3 — SH 51 - 80 softwood
	7 — HS 21 - 50 softwood
	9 — H 1 - 20 softwood
18-21	Sub type (11 D — 17-18)
22-23	Site — not used Blank — may be used for site type
24	Structure (11 D 39)
	0 = unclassified
	1 = even-aged
	2 = two-aged
	3 = uneven-aged
	4 = all-aged
25, 26, 27, 28, 29, 30	Plot Age (11 D 12)
	—coded to nearest year
31	(11 D 29) origin 2 = fire
32	(11 D 29) History
	3 = logging
	5 = thinning
33-35	Site Index - not used
36-37	Per cent crown density — not used
38-39	Height — based on average height of dominants and co-dominants of main stand
40	Height Class — Same as 38-39 but coded into classes: (same as Alta. Forest Service)
	1 = up to 30 feet
	2 = 31 to 45 feet
	3 = 46 to 60 feet
	4 = 61 to 80 feet
	5 = 81 to 100 feet

Column 41 & 42 — Simplified cover type classification based on basal area representation by species of trees 0.5 inches and greater.

Code	**Description**
1.	lP 80 per cent and greater.
2.	lP and wS mixed. lP dominant but wS usually greater than 20 per cent. Other constituents may include: D, alF, tA, bPo.

3.	wS and lP mixed. wS dominant. lP usually greater than 20 per cent. Other constituents as in (2).
4.	wS 80 per cent and greater.
5.	lP and hardwood mixtures. lP dominant.
6.	wS and hardwood mixtures. wS dominant
7.	wS and alF mixed. Either species dominant.
8.	D dominant.
9.	tA dominant.
10.	bPo dominant.

APPENDIX II
VOLUME TABLES
Standard Total Cubic Foot Volume Tables used in compilation of Kananaskis Working Plan Survey

Species	Source
white spruce (wS)	Silvical Leaflet No. 60 A. W. Blyth, 1952. Table 2
lodgepole pine (lP)	Technical Note. No. 9 A. W. Blyth, 1955. Table 1
aspen and black poplar (tA & bPo)	Technical Note. No. 18 McLeod and Blyth, 1955 Table 11
Douglas fir (interior) (D)	B. C. Forest Inventory Browne (1962) Table 3
alpine fir (interior) (alF)	B. C. Forest Inventory Browne (1962) Table 11
white birch (interior) (wB)	B. C. Forest Inventory Browne (1962) Table 23

APPENDIX III
CHECK LIST OF TREE SPECIES

Common names	Latin name
Alpine fir	*Abies lasiocarpa* (Hook.) Nutt.
Douglas fir	*Pseudotsuga menziessii* (Mirb.) Franco var. *glauca* Beissn. Franco
Lodgepole pine	*Pinus contorta* Dougl. var. *latifolia* Engelm.
Limber pine	*Pinus flexilis* (James)
White spruce	*Picea glauca* (Moench) Voss
Engelmann spruce	*Picea englemannii* Parry
White poplar, trembling aspen	*Populus tremuloides* (Michx.)
Balsam poplar, black poplar	*Populus balsamifera L.*
White birch	*Betula papyrifera* Marsh.

APPENDIX IV

TABLE 1. SUBCOMPARTMENT COVERTYPE AND AGE (1961-1962): WITH AREAS IN IN WORKING PLAN FOREST TREATED AND UNTREATED.

Subcompartment Number	Cover Type (1961) (1962)	Sub-Type 1961-1962 Species			Total Age (1962) Age			Structure*	Working Plan Forest (1946 area in acres)	
		1	2	3	1	2	3		Treated	Untreated
2	S	1P	D	wS	98	-	-	E	-	147.0
6	S	D	1P		98	68	-	T	-	36.0
8	S	1P	D	wS	98	68	-	T	-	65.5
9	H	tA	-	-	68	-	-	E	-	3.7
10	S	1P	-	-	98	68	-	T	-	29.7
11	S	D	-	-	98	68	-	T	-	13.5
13	S	wS	-	-	136	98	68	U	-	15.3
14	H	tA	-	-	68	-	-	E	57.1	41.9
16	S	D	-	-	136	98	68	U	-	2.9
17	S	wS	D	tA	136	98	68	U	5.0	1.3
18	S-H	wS	tA	1P	68	-	-	E	20.1	-
19	S	wS	bPo	-	98	68	-	T	7.7	-
20	H-S	tA	bPo	wS	68	-	-	E	31.6	73.8
21	S	1P	wS	tA	68	-	-	E	145.2	101.8
22	H-S	tA	wS	-	68	-	-	E	14.2	4.0
23	H	tA	-	-	26	-	-	E	-	7.1
24	S	wS	1P	-	98	68	-	T	17.7	-
25	S-H	wS	bPo	-	136	16-65	-	A	-	2.1
26	H-S	tA	1P	wS	68	-	-	E	19.5	8.2
28	H-S	tA	1P	-	68	-	-	E	10.6	22.7
29	S	wS	-	-	206	-	-	E	-	7.5
31	S-H	1P	tA	-	98	68	-	T	-	20.8
32	H	tA	bPo	-	68	-	-	E	-	20.2
33	S	1P	wS	-	98	-	-	E	-	2.7
34	S-H	1P	tA	wS	98	84	68	U	16.8	63.6
36	S	1P	wS	D	98	84	68	U	-	273.4
54	S	D	1P	wS	116	98	68	U	-	60.2
55	S	wS	1P	D	146	98	68	U	-	64.4
56	S	wS	1P	-	84	68	-	T	-	18.8
57	S	1P	wS	-	98	-	-	E	-	78.9
63	S	1P	-	-	98	-	-	E	-	62.9
64	S	1P	wS	-	98	68	-	T	-	244.7
69	S-H	D	1P	tA	116	68	-	T	-	2.5
70	S	1P	wS	-	116	84	-	T	-	35.8
71	S	1P	wS	-	98	84	68	U	84.3	79.1
73	S	1P	-	-	68	-	-	E	4.7	-
74	H-S	bPo	1P	tA	68	-	-	E	7.2	5.3
77	S-H	1P	tA	wS	68	-	-	E	9.2	57.9
81	S	1P	wS	-	68	-	-	E	-	7.5
82	H-S	tA	wS	1P	85	-	-	T	-	67.3
86	H-S	tA	bPo	wS	68	-	-	E	-	71.1
88	S	1P	wS	-	68	-	-	E	387.8	1580.7
89	S	1P	wS	-	68	-	-	E	2.8	62.0
90	S	wS	-	-	206	-	-	E	-	18.1
91	S	wS	1P	-	68	-	-	E	-	8.4
92	S	wS	-	-	28	-	-	E	-	7.6
93	S	wS	-	-	206	-	-	E	-	71.7
95	S	1P	wS	-	68	-	-	E	-	18.0
100	S	1P	-	-	68	-	-	E	-	249.4
103	S	1P	-	-	98	68	-	T	-	65.7
104	S	wS	-	-	166	12	-	T	23.0	-
106	S	wS	-	-	206	-	-	E	-	25.9
107	S	wS	1P	-	68	-	-	E	-	47.6
108	S	wS	1P	-	206	68	-	T	-	11.5
109	S	wS	1P	-	206	-	-	E	8.0	14.2
112	S	wS	1P	alF	206	-	-	E	-	175.6
116	S	1P	-	-	95	-	-	E	46.0	1153.3
124	S	wS	1P	-	216	68	-	T	-	11.0
125	S	1P	-	-	68	-	-	E	-	39.3
126	S	wS	alF	-	216	-	-	E	-	252.0
127	S	wS	alF	1P	68	-	-	E	-	158.8
128	S	wS	1P	alF	206	-	-	E	-	11.3
129	S	1P	-	-	68	-	-	E	-	56.3
134	S	1P	-	-	95	-	-	E	-	283.8
135	S	1P	-	-	48	-	-	E	-	69.0
137	S	1P	-	-	48	-	-	E	-	45.0
140	S	1P	wS	-	82	69	-	T	-	23.0
					Totals				918.5	6280.3

*E = even-aged
T = two-aged
U = uneven-aged

APPENDIX IV (CONTINUED)

TABLE 2. PLOT SUMMARY BY SUBCOMPARTMENT AND YEAR OF MEASUREMENT

(Per Acre Values)

Sub compart- ment	Year of meas.	No of samples	lodgepole pine				spruces				alpine fir				Douglas fir				aspen				black poplar				all species			
			B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV
2	36	3	85	607	5.1	1718	7	66	4.4	106					16	107	5.2	217	1	50	1.9	9					109	830	4.9	2050
	46	3	94	493	5.9	2051	8	63	4.8	139					24	113	6.2	340	T*	13	2.0	2					127	683	5.8	2533
	62	3	123	540	6.5	3006	12	93	5.6	222					33	153	6.3	516	T	3	2.1	T					167	790	6.2	3744
6	36	2	46	470	4.2	874	2	15	4.9	31					32	270	4.7	440	6	330	1.8	64					86	1085	3.8	1409
	46	2	53	435	4.7	1044	2	15	4.9	34					41	390	4.4	559	5	165	2.4	56					100	1005	4.3	1693
	61	2	62	335	5.8	1466	6	25	6.6	136					63	390	5.4	1072	5	110	2.9	72					137	850	5.4	2746
8	36	4	47	245	5.9	1009	19	435	2.8	233					37	535	3.5	456	7	123	3.2	96	T	15	2.4	6	110	1338	3.9	1794
	46	6	33	147	2.0	742	15	175	4.0	229					23	260	4.4	362	4	52	3.7	68	T	3	2.6	1	75	634	4.8	1402
	61	4	66	210	7.5	1907	35	345	4.3	639					66	473	5.1	1124	10	90	4.5	175					177	1118	5.4	3844
9	36	1																	39	500	3.8	600	18	320	3.2	224	56	820	3.5	824
	46	1																	53	440	4.7	923	6	160	2.6	65	58	600	4.2	988
	61	1													T	10	2.0	2	93	500	5.8	1983	14	210	3.5	219	107	720	5.2	2205
10	36	1	61	1190	3.1	996	T	30	1.0	1					6	40	5.3	78									67	1260	3.1	1075
	46	1	79	1230	3.4	1341	1	60	1.6	8					9	60	5.3	120					T	10	3.0	6	90	1360	3.5	1475
	61	1	94	820	4.6	1785	3	170	1.8	28					13	60	6.3	171					1	20	3.0	13	111	1070	4.3	1997
11	36	2	8	85	4.1	139	1	40	1.8	9					41	780	3.1	469	2	235	1.2	20	T	5	1.1	T	52	1145	2.8	636
	46	2	8	70	4.6	152	1	30	1.9	6					44	1120	2.7	493	1	100	1.4	9					53	1320	2.7	660
	61	2	12	55	6.3	241	2	40	3.0	23					86	1245	3.6	971	2	100	1.9	17					103	1440	3.6	1252
13	36	2					99	685	5.1	1689					8	110	3.6	95	2	70	2.3	24	T	15	1.4	2	109	890	4.7	1811
	46	2					111	610	5.8	2036					11	75	5.2	140	2	55	2.6	23					123	740	5.5	2199
	61	2					156	550	7.2	4195	T	5	2.0	1	11	75	5.2	193	3	25	4.7	59					171	655	6.9	4445
14	36	7	T	6	3.0	6	1	16	3.0	12					6	4	16.6	178	48	619	3.8	771	11	133	3.9	155	66	777	3.9	1121
	46	7	T	7	3.3	7	2	19	4.4	30					6	4	16.6	179	59	536	4.5	1058	14	177	3.8	205	81	743	4.5	1480
	61	7	2	6	7.8	43	6	23	6.9	131					9	3	23.5	152	85	503	5.6	1746	23	248	4.1	452	125	783	5.4	2524
16	36	1	T	10	1.0	1	T	10	1.0	T					60	230	6.9	869	T	40	1.0	2	T	10	1.0	T	60	300	6.1	872
	46	1					1	20	2.5	8					45	220	6.1	623	1	60	1.4	6	T	30	1.0	1	46	330	5.1	639
	61	1					4	230	1.8	50					63	410	5.3	1245	2	100	1.9	11	1	80	1.5	11	70	820	4.0	1318
17	36	2					62	65	13.2	2109					T	5	2.0	1	48	110	8.9	1357	T	20	1.0	1	110	200	10.1	3468
	46	2					67	75	12.8	2295					44	25	18.0	1084	42	170	6.7	1037	1	35	2.1	10	153	305	9.6	4427
	61	2					95	80	14.8	3000					57	25	20.4	1047	50	190	7.0	1355	T	20	1.7	3	202	315	10.8	5405

* T - Trace < 1

SUMMARY BY SUBCOMPARTMENT AND YEAR OF MEASUREMENT

(Per Acre Values)

Sub compart-ment	Year of meas.	No. of plots	lodgepole pine				spruces				alpine fir				Douglas fir				aspen				black poplar				all species			
			BA	N	$\bar{D}$	TCFV	BA	N	$\bar{D}$	TCFV	BA	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TCFV	B.A.	N	$\bar{D}$	TFCV
18	36	2	4	20	6.1	91	5	25	6.1	103					1	5	6.0	14	15	165	4.1	235	6	60	4.3	92	31	275	4.6	535
	46	2	7	15	9.2	185	15	35	8.9	364					2	5	8.6	37	26	445	3.3	539	5	215	2.1	55	55	715	3.8	1180
	61	2	11	20	10.0	289	27	50	10.0	684					5	5	13.6	89	23	990	2.5	600	13	365	2.5	167	87	1430	3.4	1830
19	36	2	3	5	11.0	106	23	550	2.7	279									3	40	3.7	50	12	100	4.7	177	41	695	3.3	613
	46	2					67	1180	3.2	879													12	175	3.5	158	79	1355	3.3	1037
	61	2					86	1160	3.7	1365													21	200	4.4	430	108	1360	3.8	1795
20	36	10	6	28	6.3	134	5	26	5.9	118									40	600	3.5	640	22	261	3.9	318	74	915	3.9	1210
	46	10	8	31	6.9	199	9	31	7.3	211									54	540	4.3	939	23	289	3.8	322	93	891	4.4	1670
	61	10	10	27	8.2	296	16	54	7.4	350					T	3	1.7	T	69	524	4.9	1367	24	126	5.9	465	120	734	5.5	2477
21	37	15	50	450	4.5	975	6	81	3.7	94					1	9	3.3	6	7	271	2.2	87	5	42	4.4	67	68	847	3.9	1225
	46	15	64	429	5.3	1341	6	70	3.8	83					1	6	5.2	8	14	277	2.6	196	7	41	5.2	113	91	822	4.6	1739
	61	15																									116	821	5.1	2554
22	36	2					7	65	4.4	82									34	645	3.1	471	2	65	2.4	27	42	775	3.2	580
	46	2					10	65	5.3	173									38	450	3.9	609	3	75	2.7	38	52	590	4.0	820
	61	2					23	95	7.0	527									30	355	3.9	552	6	125	3.0	57	58	575	4.3	1135
23	36																													
	46	1	1	10	1.0	1													11	1870	1.0	95					11	1880	1.0	95
	61	1	4	90	2.8	46	T	10	2.0	1									44	2090	2.0	451					48	2190	2.0	499
24	36	1	28	190	2.9	575	60	830	3.6	825									T	10	1.0	T	2	20	4.3	22	90	1050	3.9	1423
	46	2	25	140	5.7	525	110	915	4.7	3606									1	10	1.0	T	2	10	6.1	34	123	995	4.9	2083
	61	2	34	150	6.4	783	111	800	5.3	2066													T	15	1.0	T	129	890	5.4	2457
25	36	1					23	90	6.8	482									T	70	1.0	3	T	30	1.0	1	24	190	4.8	486
	46	1					29	90	7.7	658									1	110	1.3	14	5	130	2.6	58	36	330	4.4	731
	61	1					48	130	8.2	1237									3	50	3.3	31	13	80	5.4	129	63	260	6.6	1397
26	36	4	14	70	6.1	317	4	53	3.7	56									56	1245	2.8	759	6	148	2.7	77	80	1515	3.1	1209
	46	4	17	58	7.3	438	6	68	4.0	96									72	830	4.0	1196	7	95	3.7	96	102	1050	4.2	1827
	61	4	21	58	8.1	557	17	103	5.5	321									99	615	5.4	2058	8	93	4.0	154	146	868	5.5	3090
28	36 }	2	5	27	5.8	115	T	3	3.1	2									25	490	3.1	355	T	13	2.4	5	31	533	3.3	477
	37 }	1																												
	46	3	8	23	8.0	196	T	10	2.9	6									40	453	4.0	653	1	43	2.1	14	50	530	4.1	870
	61	3	10	23	8.9	229	2	10	6.1	35									63	470	5.0	1077	3	137	2.0	36	78	640	4.7	1376

SUMMARY BY SUBCOMPARTMENT AND YEAR OF MEASUREMENT

(Per Acre Values)

Sub compart-ment	Year of meas.	No. of plots	lodgepole pine				spruces				alpine fir				Douglas fir				aspen				black poplar				all species			
			BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV
29	36	1					119	340	8.0	2744																	119	340	8.0	2744
	46	1					140	300	9.3	3583									1	10	1.0	T	T	20	1.0	1	140	330	8.8	3584
	61	1					129	360	8.1	3321									T	10	2.0	2	1	100	1.6	15	131	470	7.1	3338
31	36	2	68	160	8.8	1861	1	30	2.5	11					2	10	6.1	39	42	815	3.1	579	5	65	3.7	69	118	1080	4.5	2561
	46	2	70	150	9.2	1982	2	30	3.5	29					3	10	7.4	50	56	615	4.1	898	5	30	5.5	72	136	835	5.5	3031
	61	2	87	150	10.3	2637	7	45	5.3	117					4	10	8.6	79	53	355	5.2	1007	5	20	6.8	97	156	580	7.0	3937
32	36	2	7	25	7.2	157													67	775	4.0	1084	18	280	3.4	244	92	1080	4.0	1485
	46	2	11	30	8.2	295													73	600	4.7	1285	29	255	4.5	436	113	885	4.8	2016
	61	2	9	20	9.1	244	T	15	1.0	1									90	420	6.3	1910	43	205	6.2	912	143	660	6.3	3067
33	36	1	170	1460	4.6	3261	3	80	2.6	30									1	20	3.0	20					174	1560	4.6	3312
	46	1	193	1120	7.9	4062	4	80	3.0	55					1	10	3.0	6									198	1210	5.5	4123
	62	1	177	700	9.6	4965	8	80	4.3	138					1	10	4.0	12									187	790	6.6	5115
34	36	9	21	180	4.6	446	1	28	2.5	22					1	17	3.3	13	29	693	2.7	415	4	111	2.6	54	58	1029	3.2	950
	46	9	29	153	5.9	668	2	41	3.0	31					3	20	5.3	37	33	492	3.5	531	2	56	2.5	24	69	762	4.1	1291
	61	9	39	141	7.1	974	7	63	4.5	117					6	19	7.6	97	42	419	4.3	794	3	66	2.9	38	97	708	5.0	2020
36	36	12	111	1018	4.5	2119	6	148	2.7	78					5	28	5.7	68	5	128	2.7	70	T	14	2.0	3	127	1336	4.2	2339
	46	12	132	883	5.2	2718	9	135	3.5	135					7	28	6.8	104	7	92	3.7	103	T	11	2.4	4	155	1148	5.0	3065
	61	12	142	652	7.3	3481	14	140	4.3	274					11	28	8.5	192	7	66	4.4	129	T	8	1.1	6	175	895	6.0	4082
54	36	3	38	293	4.9	767	24	200	4.7	391					44	370	4.7	568	4	183	2.0	48					110	1047	4.4	1774
	46	3	43	230	5.8	951	33	173	5.9	622					70	373	5.9	967	3	80	2.6	46					150	857	5.7	2585
	61	3	52	177	7.3	1519	42	237	5.7	941					83	357	6.5	1411	2	40	3.0	28					178	810	6.3	3899
55	36}	3	13	98	4.9	247	118	988	4.7	2252					15	60	6.8	216									146	1145	4.8	2716
	37}	1																												
	46	4	16	88	5.9	349	129	1020	4.8	2444					19	58	7.6	297									164	1166	5.1	3090
	61	4	15	45	7.8	374	166	1020	5.4	3864					19	63	3.7	337									200	1128	5.7	4575
56	36	1	17	60	7.2	403	103	2690	2.6	1223									2	80	2.2	20	T	20	1.6	3	122	2850	2.8	1648
	46	1	12	30	8.6	333	141	2910	3.0	1763									2	60	2.5	21	T	20	1.0	1	155	3020	3.1	2118
	61	1	19	30	10.8	511	166	2230	3.7	2702					T	10	1.0	T	3	50	3.3	48	T	10	2.0	2	188	2330	3.8	3262
57	36	5	125	1070	4.6	2495	11	418	2.2	118					5	82	3.3	62	T	10	1.9	2	T	24	1.7	4	142	1604	4.0	2681
	46	5	143	942	5.3	3036	16	398	2.7	198					6	74	3.9	79	T	2	1.9	T	T	8	2.1	2	166	1424	4.6	3316
	61}	2																												
	62}	3	140	626	6.4	3469	20	322	3.4	304					7	58	4.7	96					T	6	2.9	4	168	1012	5.5	3873

SUMMARY BY SUBCOMPARTMENT AND YEAR OF MEASUREMENT

(Per Acre Values)

Sub compart- ment	Year of meas.	No. of Plots	lodgepole pine				spruces				alpine fir				Douglas fir				aspen				black poplar				all species			
			BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV
63	37	6	150	1763	4.0	2922	1	55	1.7	9					T	3	1.1	T	T	22	1.0	1					151	1843	3.9	2932
	46	6	142	1137	4.8	2977	1	63	1.7	12	T	2	1.0	T					1	32	1.7	5					144	1233	4.6	2994
	61}	3																												
	62}	3	153	700	6.3	3980	4	92	2.8	69	T	5	2.0	1					2	20	4.3	27					159	817	6.0	4078
64	37	20	70	811	4.0	1303	8	163	3.0	100					6	42	5.1	73	2	87	2.0	24	1	38	1.9	8	86	1139	3.7	1509
	46	20	79	687	4.6	1572	10	170	3.3	146					5	42	4.7	73	2	72	2.2	28	1	14	2.5	6	98	984	4.1	1825
	61}	16																												
	62}	4	98	497	6.0	2434	18	229	3.8	318	T	1	1.4	T	9	42	6.3	146	3	53	3.2	51	T	12	3.3	11	129	833	5.3	2960
69	37	1	T	10	2.0	3	1	20	3.0	18					41	340	4.7	529	5	350	1.6	48					47	720	3.5	598
	46	1	24	100	6.6	558	3	20	5.3	59					47	170	7.1	688	23	520	2.8	295					97	810	4.7	1601
	61	1	33	80	8.7	855	8	40	6.1	157					68	170	8.6	1220	28	410	3.5	438					138	700	6.0	2670
70	36	2	103	1140	4.1	1878	9	170	3.1	126					1	15	2.6	6	4	190	2.0	51	T	5	1.1	T	117	1520	3.8	2062
	46	2	144	1045	5.0	2894	15	190	3.8	215					1	20	3.0	15	6	155	2.6	82	T	5	2.0	1	166	1415	4.7	3206
	61	2	149	730	6.1	3475	22	215	4.3	382					2	20	4.3	34	5	130	7.6	71					179	1095	5.5	3962
71	37	17	89	1138	3.8	1582	7	132	3.1	96					1	15	2.6	7	1	41	2.2	13	8	120	3.5	115	106	1446	3.7	1813
	46	17	86	576	5.2	1793	10	164	3.4	144					1	14	3.6	9	2	43	2.9	26	9	60	5.2	139	107	857	4.8	2121
	61	17	97	459	6.2	2293	17	198	4.0	285					1	16	3.4	18	2	66	2.4	24	8	36	6.4	175	125	775	5.5	2795
73	37	1	8	240	2.5	125																					8	240	2.5	125
	46	1	20	230	4.0	361	T	10	1.0	T									T	20	1.0	T					20	260	3.7	362
	61	1	36	270	4.9	766	T	10	2.0	2									1	100	1.0	4					36	380	4.2	771
74	37	2	10	60	5.5	198	T	35	1.4	3									T	45	1.2	4	7	210	2.5	79	17	350	3.0	285
	46	2	21	85	5.3	488	2	55	2.6	22									8	280	2.3	89	18	535	2.5	210	48	955	3.1	809
	61}																													
	62}	2	28	100	7.2	622	8	105	3.7	118									10	290	2.5	127	28	555	3.0	385	75	1050	3.6	1252
77	37	6	21	410	3.0	342	2	112	1.8	17					3	10	2.4	49	11	427	2.2	124	2	125	1.7	20	38	1083	2.5	552
	46	6	36	437	3.9	660	6	233	2.2	61	T	7	1.7	1	4	10	8.6	77	18	552	2.4	228	3	93	2.4	30	66	1332	3.0	1056
	62	6	54	367	5.2	1145	18	348	3.1	251					7	27	6.9	118	31	513	3.3	500	4	85	2.9	47	114	1340	4.0	2061
81	38	1	18	270	3.5	299	5	230	2.0	47									T	10	1.0	T					22	510	2.8	347
	46	1	61	620	4.2	1140	4	100	2.7	43									2	70	2.3	18					67	790	3.9	1201
	62	1	96	590	5.5	1820	12	110	4.5	163									3	60	3.0	34					111	760	5.2	2016
82	38	3	5	77	3.4	78	T	33	0.0	6									26	1127	2.1	296	T	17	1.2	1	31	1253	2.1	382
	46	3	10	160	3.4	166	3	60	3.0	35									36	1190	2.4	444	1	67	1.6	10	49	1477	2.5	655
	62	3	20	113	5.7	399	28	290	4.7	397									70	1120	3.4	1007	1	23	2.3	7	119	1547	3.7	1810

SUMMARY BY SUBCOMPARTMENT AND YEAR OF MEASUREMENT

(Per Acre Values)

Sub compart- ment	Years of meas.	No. of Plots	lodgepole pine				spruces				alpine fir				Douglas fir				aspen				black poplar				all species			
			BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV
86	37, 38	4, 1	T	2	1.0	T	6	46	4.9	110									14	512	2.2	138	17	860	1.9	198	37	2132	1.8	445
	46	5	T	24	1.7	5	7	44	5.4	123									37	1976	1.8	416	29	1054	2.2	350	73	3098	2.1	895
	62	6	1	22	2.9	12	10	48	6.2	186									61	1485	2.8	755	29	533	3.2	372	101	2088	3.0	1326
88	37, 38	94, 14	80	2026	2.7	1327	5	195	2.2	62	T	1	4.1	1	T	1	1.7	T	1	55	1.8	18	1	31	2.2	10	88	2309	2.6	1419
	46	124	103	2000	3.1	1829	9	260	2.5	111	T	4	2.9	3	T	1	2.1	T	2	41	3.0	22	1	32	2.4	15	115	2338	3.0	1979
	61, 62	32, 93	121	1150	4.4	2432	16	284	3.2	243	T	6	3.4	6	T	1	3.4	1	3	40	3.7	45	2	40	3.0	31	143	1521	4.2	2760
89	37	7	44	521	3.9	789	4	103	2.6	41	T	1	1.4	T					3	210	1.6	36	1	39	1.5	5	51	874	3.3	871
	46	7	56	483	4.6	1092	5	100	3.0	67	T	3	1.7	T					3	147	1.9	31	1	37	2.0	9	65	770	3.9	1199
	62	7	80	441	5.8	1766	14	114	4.7	223	T	1	2.4	T					4	64	3.4	52	1	30	2.5	15	100	651	5.3	2057
90	37	1	3	10	7.4	65	133	770	5.6	2384	1	20	3.0	17													137	800	5.6	2466
	46	1	3	10	7.4	65	155	760	6.1	2947	2	20	4.3	35													160	790	6.1	3047
	62	1					153	710	6.3	3045	3	20	5.3	54													156	730	6.3	3099
91	37	1	7	280	2.2	101	23	900	2.2	246					T	10	1.0	5	T	20	1.0	1					30	1210	2.1	348
	46	1	12	240	3.0	204	45	1020	2.8	557					1	10	3.0	6	T	20	1.6	3					59	1290	2.9	769
	62	1	29	220	4.9	519	86	1130	3.7	1121					1	10	1.4	3	T	10	2.0	2					116	1370	3.9	1656
92	46	1					T	30	1.0	1																	T	30	1.0	1
	62	1					6	290	1.9	43																	6	290	1.9	43
93	37	3	6	7	12.5	11	72	423	5.6	1366	5	63	3.8	62									6	57	4.4	79	83	550	5.3	1518
	46	3	1	7	5.1	18	82	373	6.4	1659	5	57	4.0	79									7	60	4.6	113	96	497	5.9	1869
	61, 62	2, 1	2	7	7.2	38	88	290	7.5	2120	7	40	5.7	141									10	50	6.1	215	106	387	7.1	2515
95	37	1	21	610	2.5	316	2	60	2.5	24									T	20	1.6	3	T	30	1.4	3	23	720	2.5	345
	46	1	48	1000	3.0	777	5	80	4.8	69									1	30	2.2	9	T	40	1.3	4	54	1150	2.9	858
	62	1	82	1000	3.9	1400	13	80	5.5	199					T	3	2.7	1					2	90	2.0	18	97	1170	3.9	1617
100	37	6	114	2060	2.2	2078	5	163	2.4	55					T	2		T					T	3	5.4	7	119	2228	3.1	2140
	46	6	118	1347	4.0	2289	7	160	4.6	89					T	3	1.7	T					T	5	4.1	6	125	1515	3.9	2384
	62	6	143	907	5.4	3427	14	253	3.2	226	T	2	1.0	T									T	2	2.7	1	157	1167	5.0	3655
103	37	1	118	3520	2.5	1793	3	50	3.3	45																	121	3570	2.5	1837
	46	1	115	1920	3.3	1924	4	80	3.0	57																	120	2000	3.3	1981
	62	1	142	960	5.2	2982	9	90	4.3	209																	151	1050	5.1	3190

SUMMARY BY SUBCOMPARTMENT AND YEAR OF MEASUREMENT

Per Acre Values

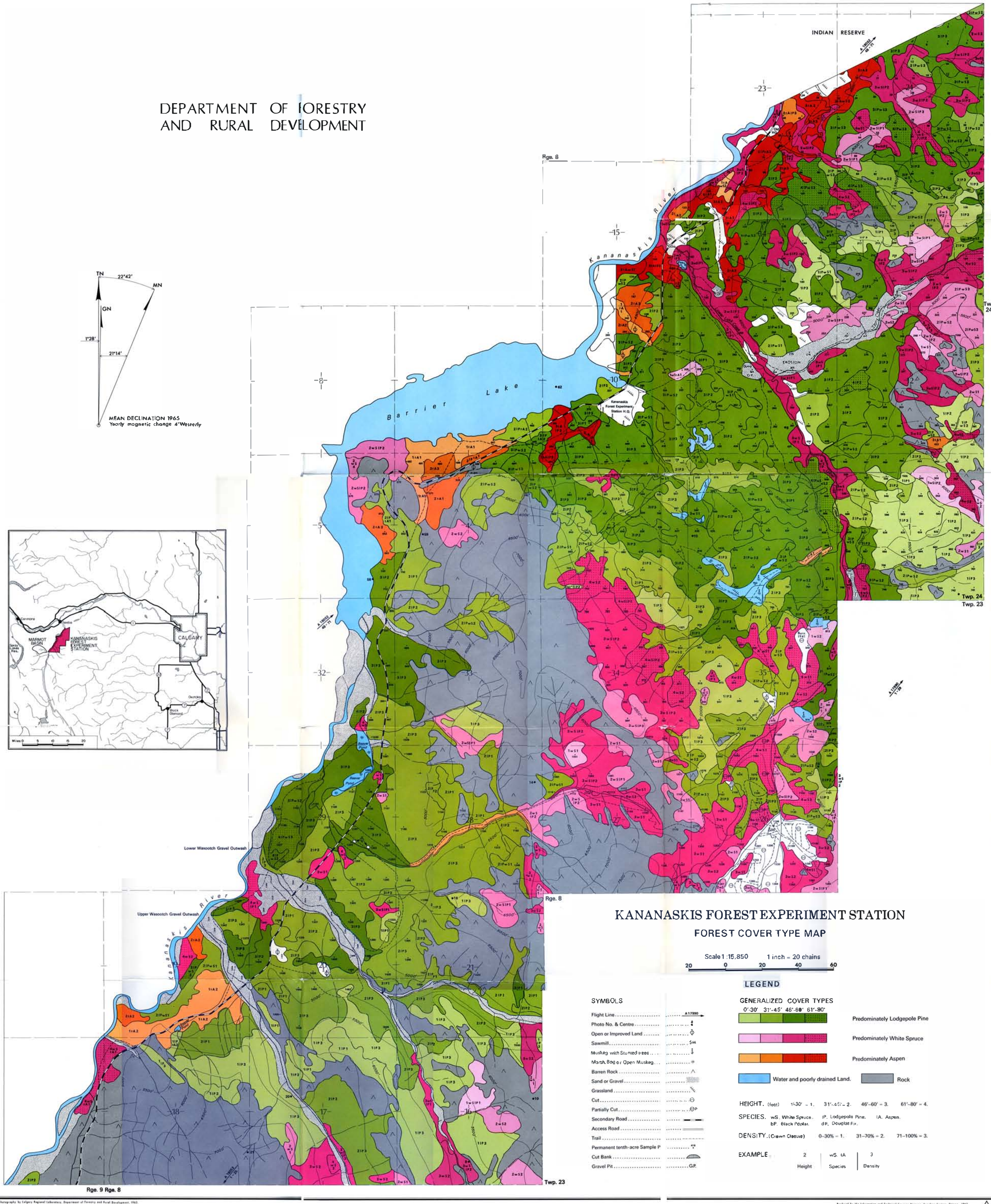
Sub compartment	Year of meas.	No. of plots	lodgepole pine				spruce				alpine fir				Douglas fir				aspen				black poplar				all species			
			BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV	BA	No	$\bar{D}$	TCFV
104	38	1					195	310	10.7	5613	18	120	5.3	309	9	20	9.1	143									221	450	9.5	6066
	46	2					8	90	4.0	123	1	35	2.3	12													9	125	3.7	135
	62	2	4	25	5.4	71	35	785	2.8	394	2	10	6.1	24					2	30	3.5	21	1	40	4.6	5	43	890	3.0	516
106	38	5	1	2	9.6	18	171	744	6.5	3502	1	8	4.1	11	T	2	1.9	T									173	756	6.5	3532
	46	5					158	726	6.3	3148	1	38	2.2	12									T	2	6.0	7	160	766	6.2	3167
	62	5					151	628	6.6	3356	2	26	3.7	24									1	4	5.7	7	154	658	6.6	3387
107	46	1	37	230	5.4	765	23	2310	1.3	210									6	480	1.5	66	T	30	0.9	1	67	3050	2.0	1043
	62	1	45	230	6.0	745	65	4630	1.6	471									6	240	2.2	66	1	60	1.5	7	117	5160	2.0	1289
108	38	2	7	220	2.4	108	38	335	4.6	644	T	5	2.0	1									T	15	1.9	3	45	575	3.8	756
	46	2	16	310	3.1	281	41	545	3.7	631	1	15	2.7	6													57	870	3.5	918
	62	2	33	385	4.0	510	78	695	4.5	1430	3	50	3.3	31													114	1130	4.3	1971
109	38	3	87	223	8.5	2338	110	283	8.4	2642					T	3	4.2	4									199	510	8.5	4984
	46	4	37	85	8.8	1000	80	223	8.1	1935	1	8	4.0	10													117	316	7.6	2945
	62	4	19	48	8.5	548	99	268	8.2	2466	1	8	4.8	21													119	323	8.2	3035
112	38	6	60	233	6.9	1452	93	192	9.4	2503	11	157	3.6	160	1	2	7.3	9									164	583	7.2	4125
	46	14	68	216	7.6	1742	77	327	6.6	1885	21	440	3.0	268	1	5	5.1	10									167	989	5.6	3905
	62	14	60	172	8.0	1582	86	351	6.7	1991	33	575	3.2	538	1	1	10.2	10									180	1099	5.5	4121
116	38	45}																												
	39	11}	130	3454	2.6	2088	6	109	1.0	89	T	1	1.9	T					T	1	4.8	2	3	13	6.5	57	139	3578	2.6	2236
	46	56	140	2719	3.1	2369	9	156	3.2	141	T	2	1.7	T	T	1	3.3	T	T	1	5.3	3	2	10	6.1	45	151	2888	3.1	2559
	62	56	132	1476	4.0	2468	15	143	4.4	280	T	2	2.2	1	T	1	2.2	T	T	1	6.5	5	2	15	5.0	31	149	1638	4.1	2784
124	38	1	2	70	2.3	25	13	330	2.7	146									1	30	2.2	9	4	160	2.2	48	19	590	2.5	228
	46	1	7	120	3.3	126	37	930	2.7	440									3	40	3.7	39	8	280	2.3	86	55	1370	2.7	691
	62	1	11	110	4.3	180	103	1290	3.8	1602									4	40	4.3	62	8	180	2.8	124	126	1620	3.7	1968
125	38	4	59	1143	3.0	1005	4	240	1.7	35	T	5	1.0	T													63	1388	2.9	1040
	46	5	80	1120	3.6	1415	5	278	1.8	56	T	10	0.6	1	T	2	1.0	T									85	1410	3.4	1472
	62	5	121	1122	4.4	2242	23	634	2.6	287	1	61	1.7	9													145	1820	3.8	2538
126	38	15	3	16	5.9	68	94	279	7.8	2394	16	264	3.3	210	1	3	5.5	7					T	5	4.1	6	114	567	6.1	2686
	46	19	6	18	7.8	161	97	288	7.8	2620	21	339	3.4	274									1	5	4.8	10	125	651	5.9	3065
	62	19	4	14	7.2	103	54	362	5.2	1127	23	301	3.7	368	T	1	7.9	3					1	7	5.1	24	82	684	4.7	1625

SUMMARY BY SUBCOMPARTMENT AND YEAR OF MEASUREMENT

Per Acre Values

Sub compartment	Year of meas.	No. of plots	lodgepole pine				spruce				alpine fir				Douglas fir				aspen				black poplar				all species			
			BA	No	D̄	TCFV	BA	No	D	TCFV	BA	No	D̄	TCFV	BA	No	D̄	TCFV	BA	No	D̄	TCFV	BA	No	D̄	TCFV	BA	No	D̄	TCFV
127	38	5	23	706	2.4	361	22	1086	1.9	225	T	26	1.4	2	T	2	3.0	1	1	18	3.2	15	1	14	2.6	7	46	1852	2.2	612
	46	13	22	398	3.2	365	34	1075	2.4	405	1	25	4.4	6	T	2	2.9	1	5	75	3.5	77	T	42	1.2	4	62	1619	2.6	858
	62	13	34	507	3.5	558	76	1392	3.2	1059	1	50	1.9	14	T	2	4.7	2	8	48	5.5	153	2	47	2.8	30	121	2045	3.3	1816
128	38	1	24	70	7.9	624	124	320	8.4	2977	27	270	4.3	409													176	660	7.0	4010
	46	2	76	130	10.3	2285	102	335	7.5	2312	15	150	4.3	225													193	615	7.6	4822
	62	2	54	80	11.1	1699	125	430	7.3	3043	23	305	3.7	415													202	815	6.7	5157
129	38	1	88	590	5.2	1796	T	30	4.4	3																	89	620	5.1	1799
	46	2	153	2160	3.6	2754	1	80	1.5	5																	153	2240	3.5	2759
	62	2	151	1190	4.8	2707	4	185	2.0	30	T	5	1.1	T													154	1380	4.5	2737
134	39	14	139	5246	2.2	2103	3	114	2.2	43	T	1	1.4	T									1	10	4.3	19	143	5371	2.2	2165
	46	14	157	4415	2.5	2489	5	134	2.6	68	T	2	1.9	T									2	9	6.4	27	164	4561	2.6	2584
	62	14	145	2003	3.6	2455	9	149	3.3	126	T	3	1.9	T									2	8	6.8	45	156	2163	3.6	2627
135	39	4	13	1160	1.4	172													T	33	1.4	4					13	1193	1.4	176
	46	4	39	1438	2.2	604													2	55	2.6	18					41	1493	2.2	622
	62	4	91	1385	3.5	1518	T	3	0.8	T									3	68	2.8	41	T	3	2.7	1	94	1458	3.5	1560
137	39	4	42	3458	1.5	564																					42	3458	1.5	564
	46	4	42	2478	1.7	593	T	13	1.2	1													T	3	0.8	T	42	2493	1.7	594
	62	4	94	2053	2.9	1396	1	28	2.5	11																	95	2080	2.9	1407
140	39	1	46	240	5.9	993	22	570	2.6	251									6	110	3.2	75	8	220	2.6	94	81	1140	3.6	1413
	46	1	52	290	5.7	1109	32	830	2.7	381					1	20	2.5	8	7	140	3.0	98	6	200	2.4	71	98	1480	3.4	1668
	62	1	69	250	7.1	1784	54	600	4.1	871	T	10	2.0	1	1	10	3.0	5	11	120	4.2	190	5	90	3.2	77	140	1080	4.9	2928

The back cover of this report is a stereo triplet of aerial photography taken in August 1972. The scale of these contact prints is close to 1:127,000 (½" = 1 mile). A camera with a 3½" focal length lens at 37,000 feet above mean ground level, with I. R. ektachrome film was used.



Aerial photography by Calgary Regional Laboratory, Department of Forestry and Rural Development, 1963.
Original cover type map by Alberta, Department of Lands and Forests, Forest Service. 1963.
Revised by the Calgary Regional Laboratory, Department of Forestry and Rural Development, 1965.

Produced by the Information and Technical Services Division, Graphics Section, Ottawa, 1967.


Marmot Basin