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# THE FRASER EXPERIMENTAL FOREST ..... Its work and aims


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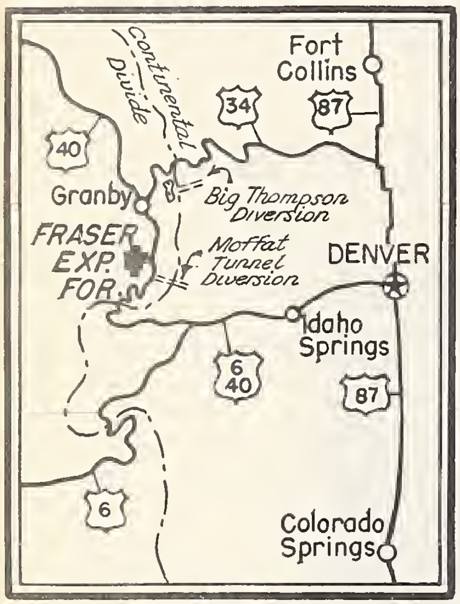
U. S. Department of Agriculture
Forest Service

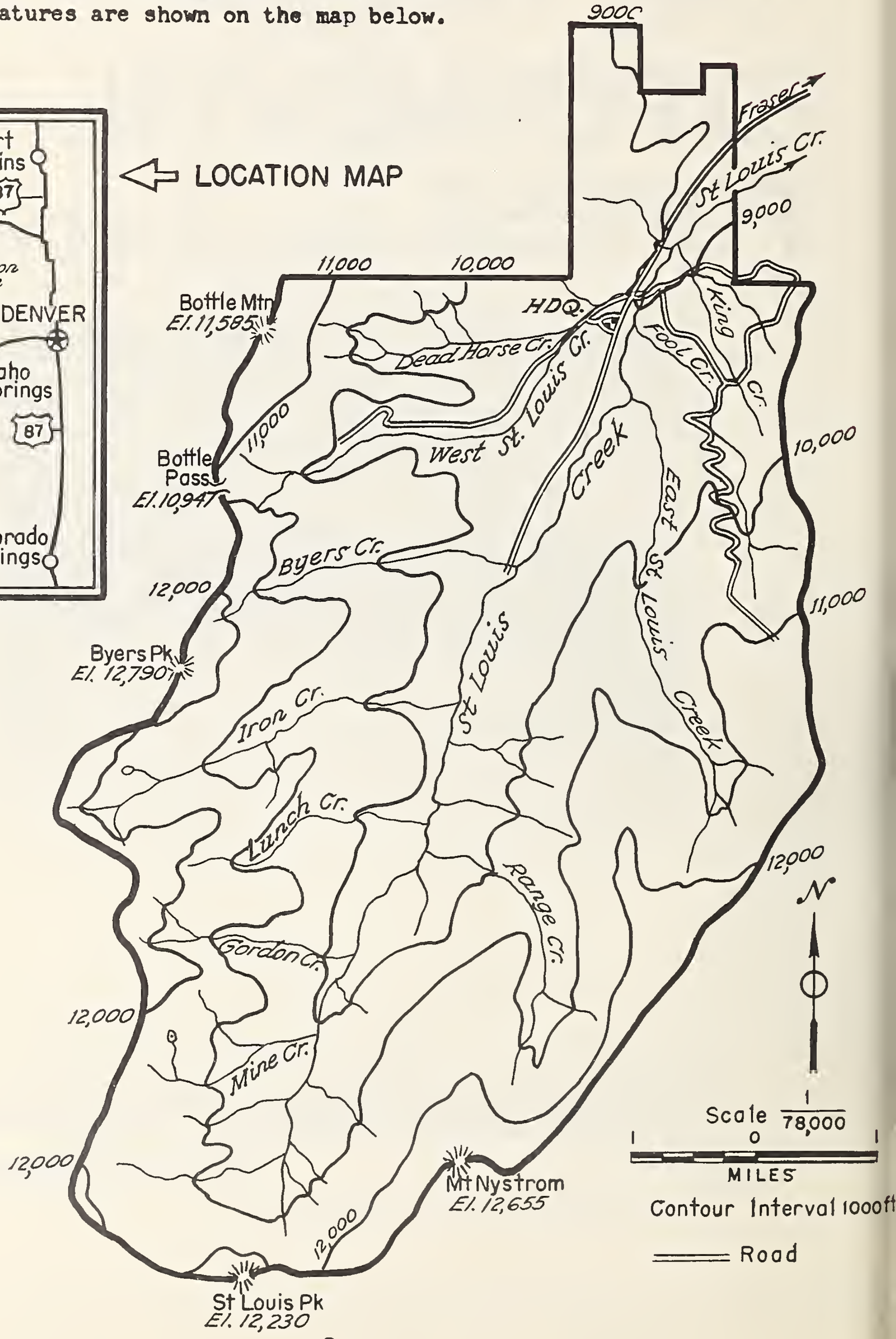
ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, FORT COLLINS, COLORADO
W. G. Mc GINNIES, DIRECTOR

# FRASER EXPERIMENTAL FOREST

## LOCATION

The Fraser Experimental Forest lies 65 miles west and north of Denver. The experimental area totals 36 square miles, and represents the land of the Continental Divide. Its general features are shown on the map below.



## PURPOSES

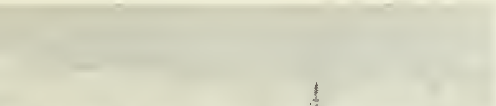
Fraser Experimental Forest was established in 1937 to study problems of non-cultivated lands. The principal value of these lands in the Continental Divide is for water supply, timber production, recreation, livestock grazing, and hay production. The objective of research work on the Forest is to develop better methods of managing some of the basic natural resources upon which these uses depend. Major studies consist of (1) Forest Management, and (2) Watershed Management.

## IMPORTANCE OF PROBLEMS STUDIED

Water supply is the most important subject of research at the Experimental Forest. Water yield from the forested watersheds amounts to 45 to 55 percent of the annual precipitation or from 1 to 1½ acre-feet per acre. About 70 percent of this yield comes from melting snow during April, May, and June each year.

Timber production is another important land use. Lodgepole pine and Engelmann spruce are the chief sources of wood products. A major problem is to perfect methods for growing these trees at a maximum sustained rate of production. This goal may be achieved by encouraging reproduction, reducing mortality, and stimulating growth.

Recreation, livestock grazing, and hay production are less important on the Forest. Elsewhere in the Continental Divide, however, these uses furnish a living for many local residents.

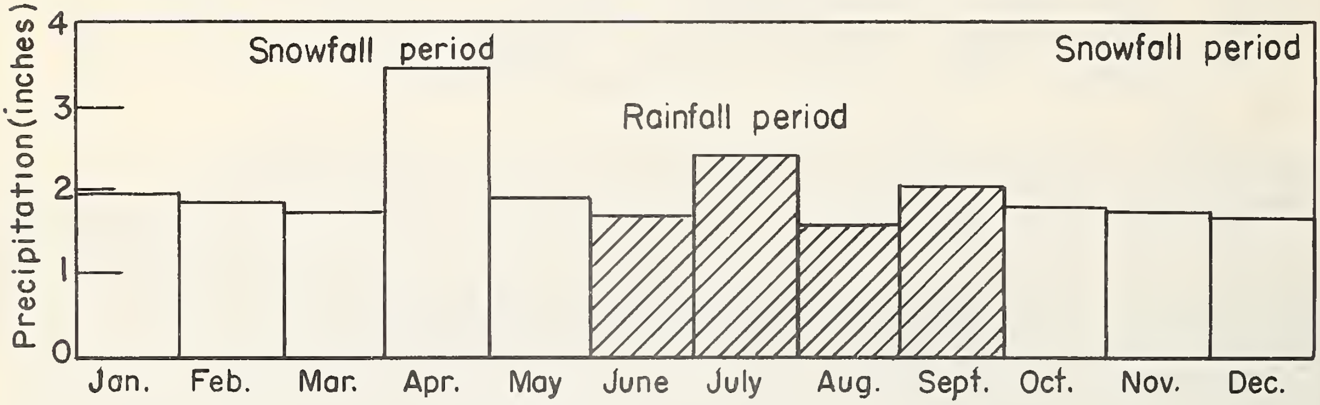



Water supply for farms, homes, and industries, and timber for lumber are important products of the Forest

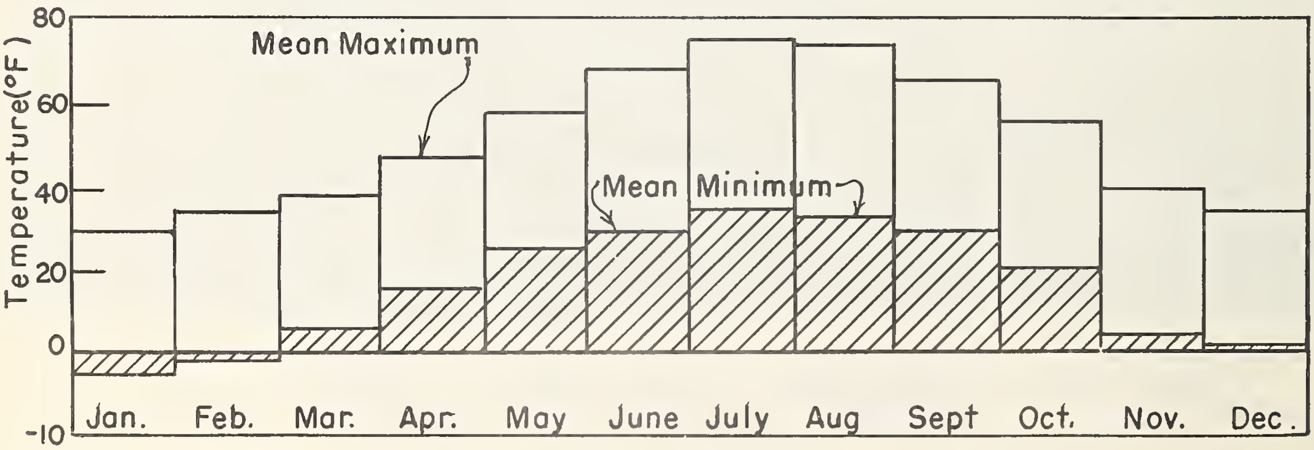
Because various kinds of land use are studied on the Experimental Forest, coordination of effort is important. Under the direction of the Rocky Mountain Forest and Range Experiment Station at Fort Collins, Colorado, resident technicians undertake research work in forest and watershed management. Several college students in forestry are selected each year as summer assistants. Nearby residents are cooperators in the research studies. Field days are held, with special opportunities for public discussion of the research program.

## CLIMATE

The climate is cool, with an average yearly temperature of about 35 degrees. The mean monthly temperature for January is 15 degrees; for July, 55 degrees. On the average, there are 75 days in the growing season, the frost-free period extending from mid-June to mid-September. Annual precipitation averages about 24 inches; of this, two-thirds occurs as snowfall. Yearly precipitation has varied from 15 inches to 30 inches.

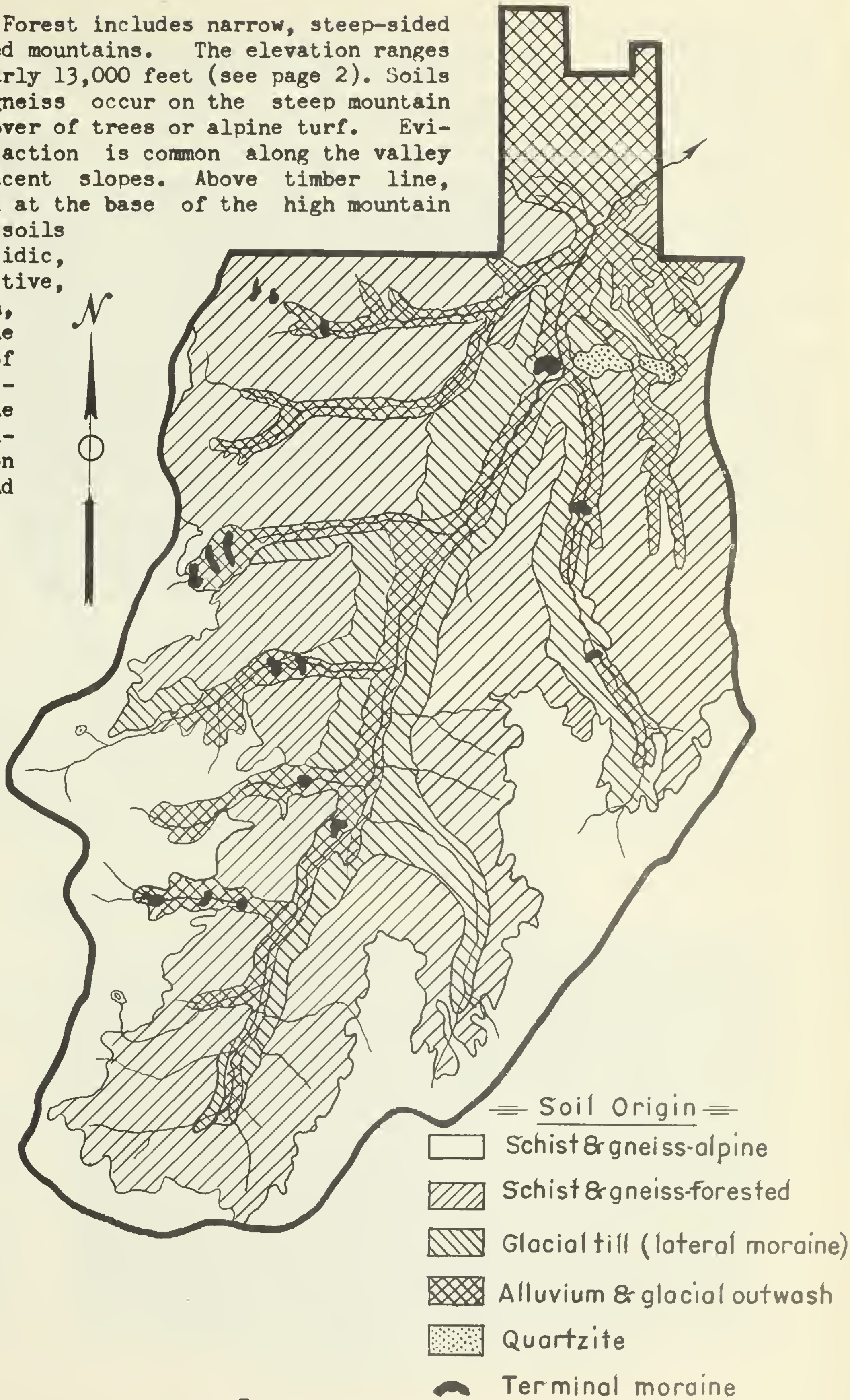



MONTHLY PRECIPITATION



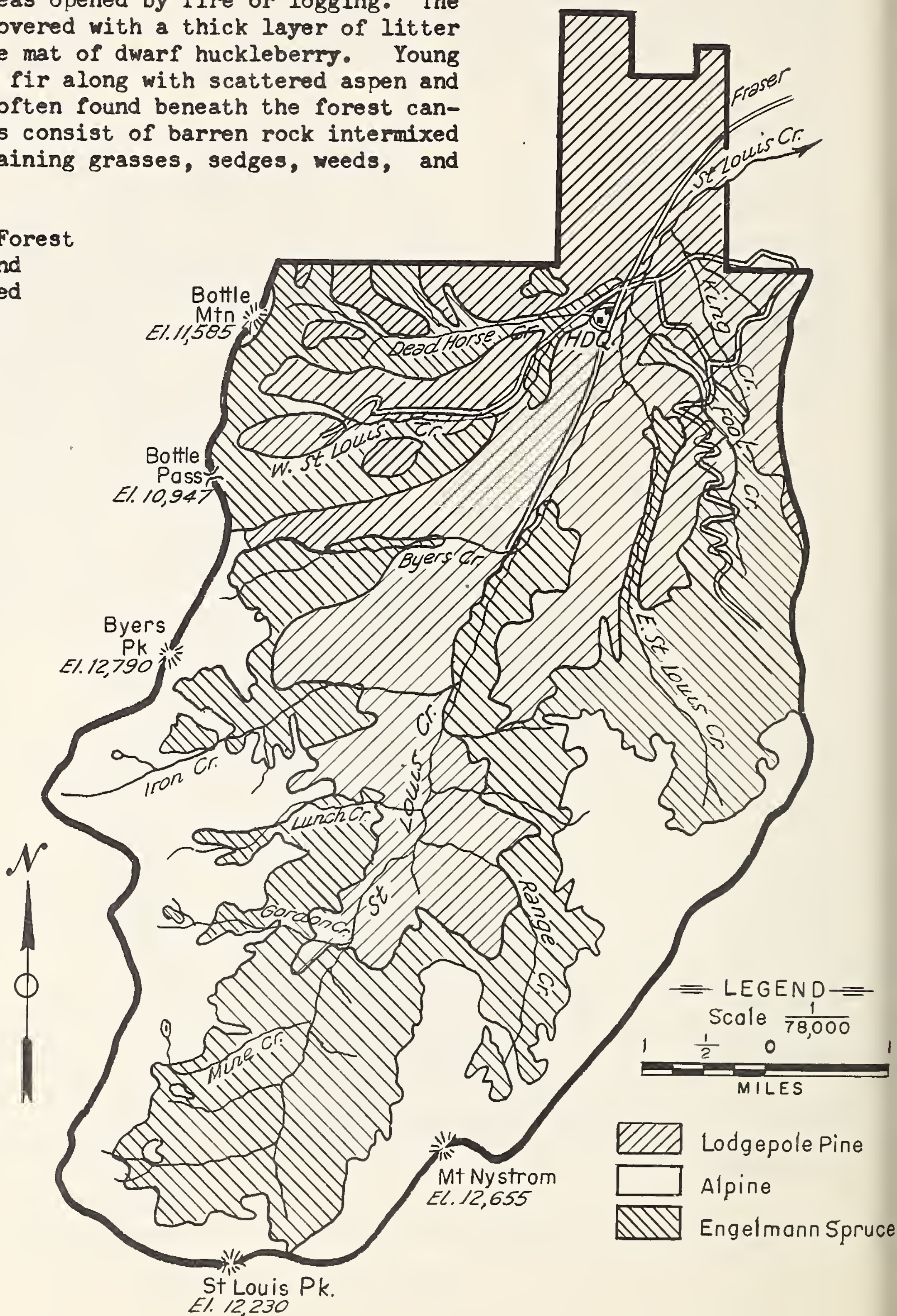

MONTHLY TEMPERATURE

The Experimental Forest includes narrow, steep-sided valleys and rugged mountains. The elevation ranges from 9,000 to nearly 13,000 feet (see page 2). Soils from schist and gneiss occur on the steep mountain slopes under a cover of trees or alpine turf. Evidence of glacial action is common along the valley floors and adjacent slopes. Above timber line, cirques are found at the base of the high mountain peaks. The rocky soils are generally acidic, moderately productive, of varying depth, and adapted to the rapid movement of water. Little erosion occurs. The map shows the general distribution of the soils and their origin.



Native vegetation is typical of the Continental Divide zone of the southern Rocky Mountains. Lodgepole pine, Engelmann spruce, and alpine fir are the important tree species. Virgin stands are commonly 200 to 400 years old. Scattered patches of quaking aspen occur in areas opened by fire or logging. The forest floor is covered with a thick layer of litter and often a dense mat of dwarf huckleberry. Young pine, spruce, and fir along with scattered aspen and buffaloberry are often found beneath the forest canopy. Alpine areas consist of barren rock intermixed with meadows containing grasses, sedges, weeds, and dwarf willows.

The Experimental Forest has been grazed and logged to a limited extent. The map shows the general distribution of the native vegetation.



## HARVEST-CUTTING STUDIES

An important job at the Experimental Forest is to develop methods for harvesting mature lodgepole pine and Engelmann spruce. These species comprise 26 billion board feet of saw timber in Colorado and Wyoming. They support the lumber industry in both states. Forest management research is concerned with problems of sustained yield of lumber and other wood products from the two forest types.

Logging by horse skidding

## MORTALITY STUDIES

Heavy inroads into virgin pine and spruce occur from natural causes; mainly insects, disease, blowdown, and fire. The spruce bark beetle is the chief offender, creating important salvage problems. Blowdown is serious, particularly when timber stands are thinned by logging. Disease and fire have not been serious sources of loss. All natural losses are modified by local cutting methods.

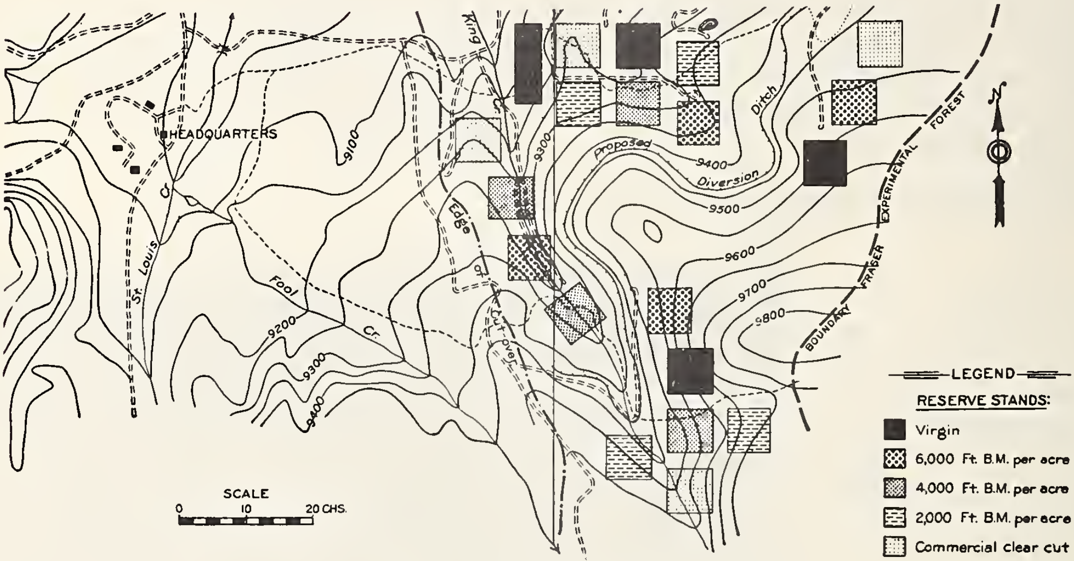
## REGENERATION STUDIES

The essence of sustained yield is reproduction. Forest management encourages natural seeding, but, if this fails, planting is necessary. Studies are concerned with the amount and kind of natural reproduction obtained by various methods of timber harvesting.

Dense lodgepole pine reproduction

On a variety of slopes and exposures, 20 harvest-cutting plots were established in 1938 for forest and watershed management research. Each plot is 5 acres in size and was covered by mature lodgepole pine. The plots were logged in 1940; all trees larger than 9.5 inches in diameter were cut on four plots; a 2,000-board-foot reserve was left on four; 4,000 on another four; and 6,000 on another. Four plots remain uncut.

Cut-over plot with a 4,000-board-foot reserve stand




Arrangement of the lodgepole pine harvest-cutting plots

In 1944 an experiment to determine the best method of harvesting spruce-fir was started. The study consists of four 8-acre plots, three of which were treated differently and the fourth left as an uncut control. The treatments used are alternate-strip clear cutting, group-selection cutting, and single-tree selection cutting. In each plot 60 percent of the volume of timber was removed.

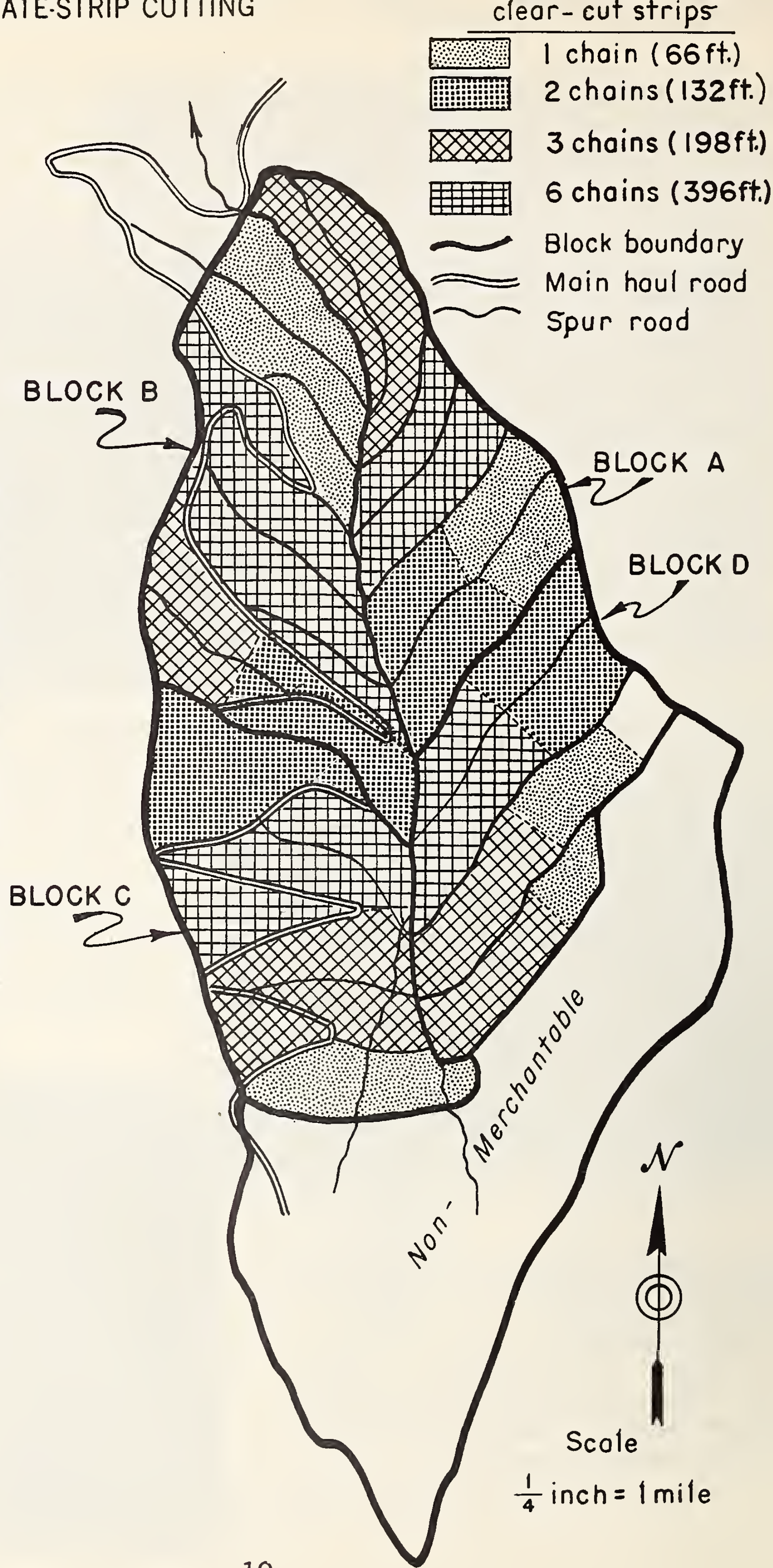
Alternate-strip clear cutting removed 50 percent of the volume by cutting all trees above 9.5 inches in diameter in alternate strips; an additional 10 percent was removed from the remaining area by cutting overmature trees. Annual loss from windfall averaged 12 board feet per acre. Damage to reproduction was moderate on the cut strips.

Group-selection cutting removed 50 percent of the volume by cutting all trees above 9.5 inches in diameter in small circular clear-cut groups; an additional 10 percent was removed from the remaining area by cutting overmature trees. Annual loss from windfall averages 6 board feet per acre. Damage to reproduction was light in the openings.

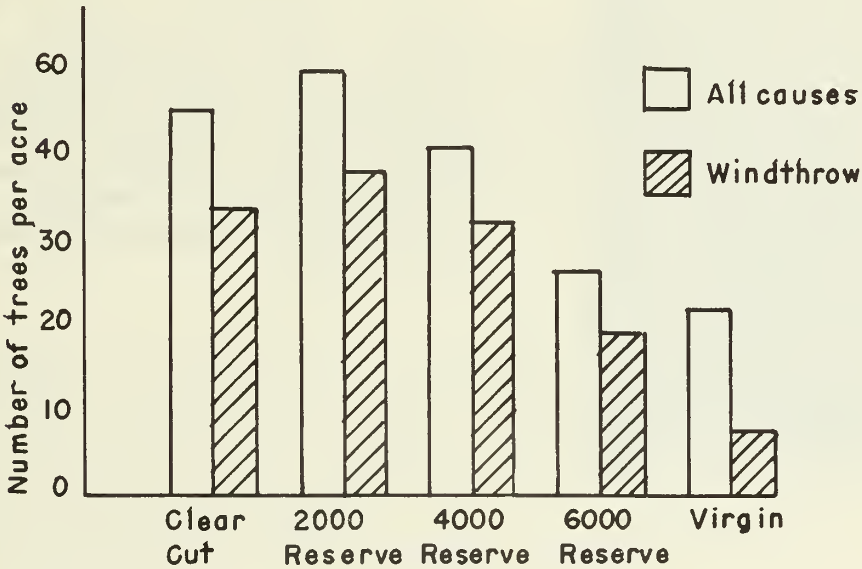
Single-tree selection cutting removed 60 percent of the volume by cutting uniformly over the plot. No trees smaller than 9.5 inches in diameter were removed. Annual loss from windfall averaged 18 board feet per acre. Damage to reproduction was heavy on the plot.

## APPLICATION OF ALTERNATE-STRIP CUTTING TO A WATERSHED

Merchantable timber in Fool Creek watershed will be harvested by means of the alternate-strip clear-cutting method. Strips are designed to test four variations in width; each series of variations, in turn, is repeated in four blocks. Strips average 400 to 500 feet in length, depending on distance separating spur roads. Logs will be skidded to the nearest spur road where they will be decked and then removed from the watershed by trucks.



Windfall is the greatest cause of mortality in the harvest-cutting plots. Partial cutting increases the chances for blowdown among the least windfirm trees in the reserve stand. In years following cutting, the lodgepole pine plots lost more volume from mortality than they gained in growth. In 12 years the plots had suffered a 17-percent loss: 12 percent was due to windfall alone.




MORTALITY IN LODGEPOLE PINE PLOTS SINCE CUTTING IN 1939-40

Windfalls in a lodgepole pine plot originally containing a reserve stand of 4,000 board feet

In the spruce-fir plots, windfall during 4 years following cutting caused the greatest loss in the single-tree selection and the least in the group selection.

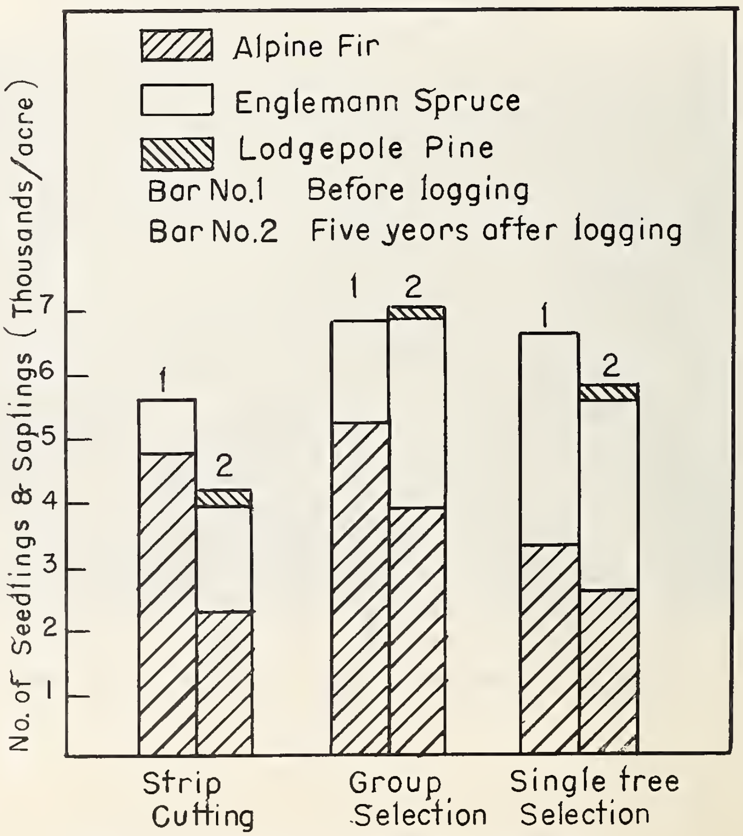
| Method | Number of windfalls per acre |
|---|---|
| Group selection | 5 |
| Alternate-strip | 12 |
| Single-tree selection | 15 |

Lodgepole pine: Adequate regeneration has generally followed cutting in lodgepole pine plots. Seven years after logging on west and northwest exposures, seedlings averaged 1,900 per acre-- an ample supply for complete stocking. Clear cutting results in the most abundant reproduction.

A lodgepole pine seedling

On south exposures, 4 years after logging, seedlings averaged 1,300 per acre, with relatively poor distribution. On these more difficult sites, partial cutting is more desirable because it leaves a reserve of mature timber to supply a continual source of seed and protection from the sun.

Spruce-fir: Prior to cutting, the spruce-fir plots contained 6,320 seedlings and saplings per acre. Logging destroyed 45 percent. Subsequent reproduction raised the count to 5,655 per acre 5 years after logging. The new seedlings are composed of a higher ratio of spruce and some lodgepole pine indicating that cutting favors these species over alpine fir.




 EFFECT OF CUTTING ON REGENERATION

Snow storage: Some 85 to 90 percent of the annual stream flow in high mountain streams comes from snow. From mid-October to mid-May snow accumulates, without melting, on the ground. Fresh snow contains about 10 percent water. As it settles, the snow becomes denser and when the "snowpack" contains about 35 percent water, it contributes to stream flow. The water in the stored snow can be measured before the snow melts. It is an important measurement in watershed studies.

Climatic factors: The climatic factors of temperature, humidity, and wind in various combinations influence the amount of snow stored, as well as the rate at which it melts. Continuous records of these factors are maintained from April to November. They are used in conjunction with records of stream flow, daily snow-melt, evaporation, and growth of vegetation.

Stream flow: Stream flow is influenced by soil, water, and climate on a watershed. It is the basic measurement in watershed studies. In streams of the high mountains there annually occurs a peak in stream flow from the melting of the stored snow followed by a gradual declining flow during summer and fall. The character of stream flow may be altered by logging, grazing, or road building.

The observation that more snow is stored in openings than under trees led to the present watershed studies under way on the Experimental Forest

Interception: Trees subtract a portion of the snow from every storm by holding it on their branches. Exposure to wind and sun returns this portion as vapor to the air. More of the winter snow is stored between trees than under trees.

Snow is deeper between trees than under them

Evaporation: Snow surfaces exposed to wind and sun lose water vapor to the air. Losses vary according to slope, exposure, pattern, and density of tree cover. Studies indicate winter-spring evaporation from 0.80 inch in a dense forest to 2.23 inches in the open parks.

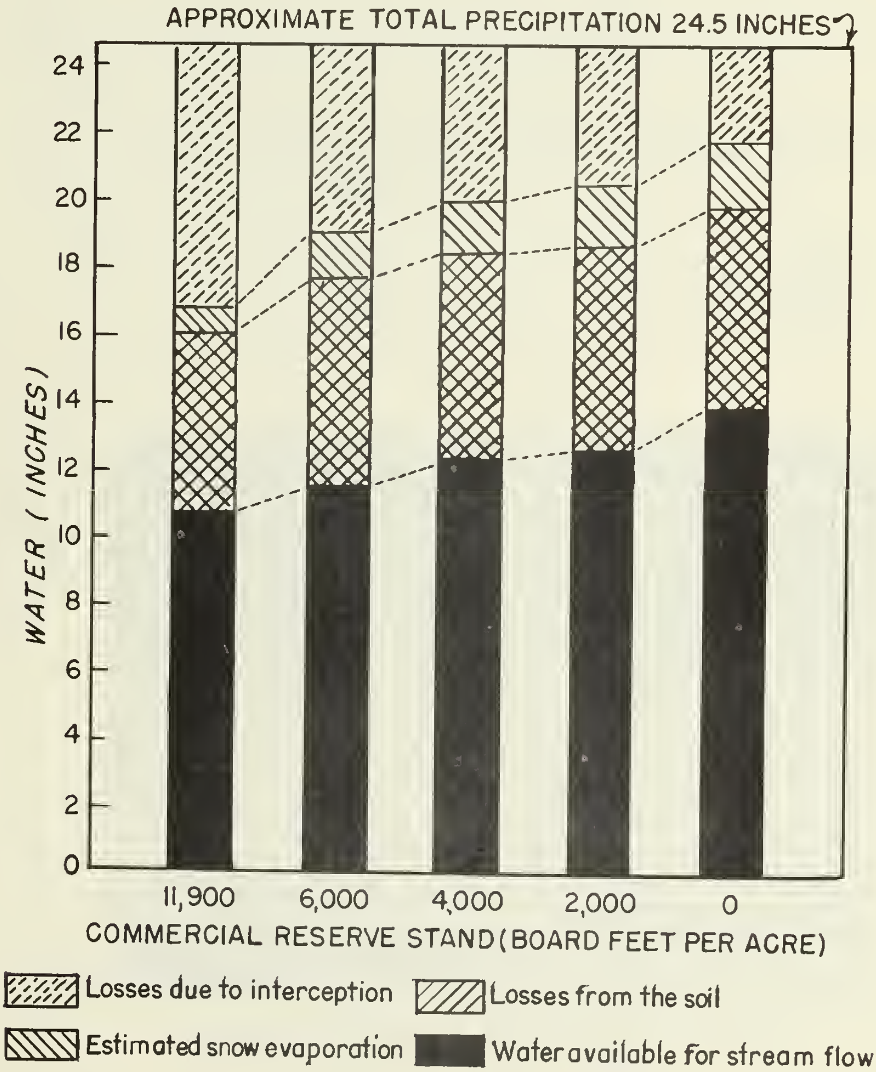
Snow evaporation measured from a 500-square-foot pan

Transpiration: Trees in their growth processes use water. Most of this water comes from the top 3 feet of soil. The greatest use is during the early summer months when growth is rapid. Water losses may amount to as much as 3 acre-inches annually.

Soil-moisture losses: The fall soil moisture varies with the density of the trees occupying an area. Under virgin conditions the amount may be 2.19 inches below field capacity in the top 18 inches of soil while not more than 1.63 inches below field capacity under a heavily cut stand. The greater the difference, the less will be the stream flow from a given snow pack during the spring.

After trees are removed in timber harvesting, more of the winter snow can reach the ground. Here less of its water content is lost to the air, and so more is available for stream flow. From the lodgepole pine plots (see page 8) an increase in water available for stream flow was observed as follows:

| Commercial reserve stand Board feet per acre | Water available for stream flow Inches | Percent increase |
|---|---|---|
| Uncut | 10.34 | None |
| 6,000 | 11.38 | 10 |
| 4,000 | 12.32 | 19 |
| 2,000 | 12.44 | 20 |
| 0 | 13.52 | 31 |




More water is released for stream flow by timber cutting in mature lodgepole pine.

Young stands of lodgepole pine are extremely dense. Two methods of thinning a 35-year-old stand were employed to observe the effect of snow storage. On six 3/4-acre plots, single-tree thinning left 485 of the better trees spaced 8.5 feet apart. On six other plots, crop-tree thinning consisted of cutting all trees in a 16-foot-diameter circle around each of 75 of the best developed trees. No thinning was done on six other plots. Snow storage was measured on all 18 plots. Below are the results.

| Thinning method | Snow storage (water) | |
|---|---|---|
| | Inches | Percent increase |
| None | 10.03 | None |
| Crop-tree | 11.72 | 17 |
| Single-tree | 12.34 | 23 |

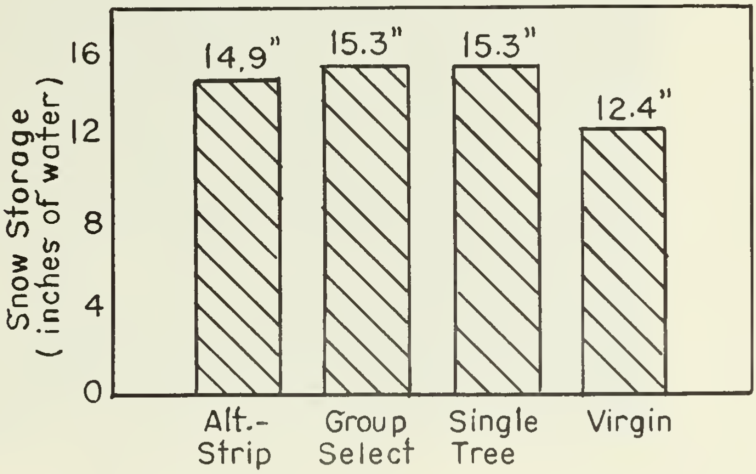
The rate of snow-melt was increased as results for 1949 show:

| Thinning method | Average rate per day (water) Inches |
|---|---|
| None | 0.26 |
| Crop-tree | 0.36 |
| Single-tree | 0.38 |

Winter snow storage on a plot thinned by the single-tree method

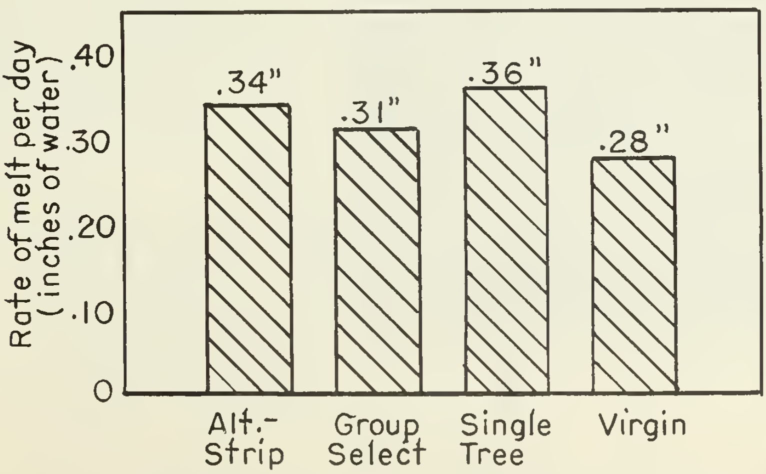
## SPRUCE-FIR PLOTS

Snow storage: Snowfall reaching the ground has been increased following harvest cuttings in the spruce-fir plots (see page 9). Measurements in four of the years since logging, show that the cut plots have stored an average of 22 percent more water than the uncut. No significant difference in snow accumulation results from variation in cutting. In all three methods, 60 percent of the volume was removed; only the pattern varied.




Effect of cutting on snow storage.

Snow-melt: Successive weekly measurements during the spring period indicate slight differences in the rates of melt. Snow disappears at the slowest rate in the virgin plot. Of the three cut plots, group selection is most effective in retarding melt and single-tree selection is least effective.



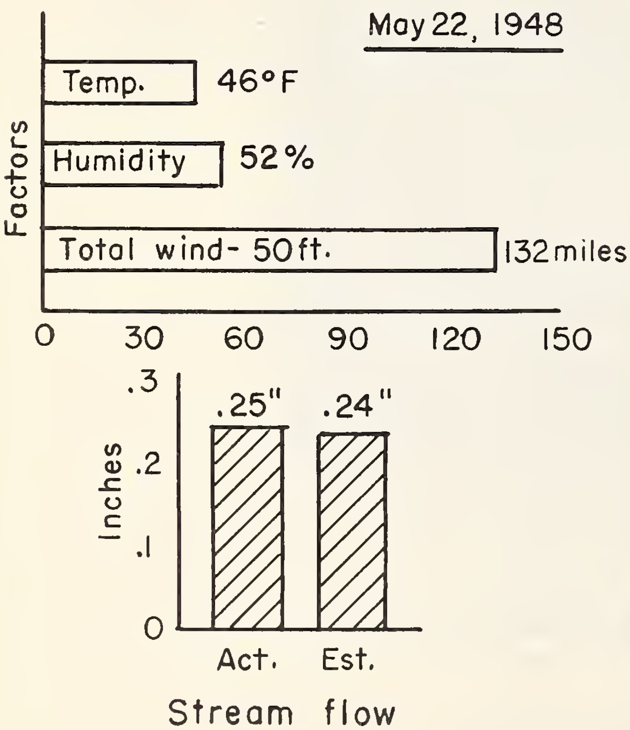

Effect of cutting on daily snow-melt

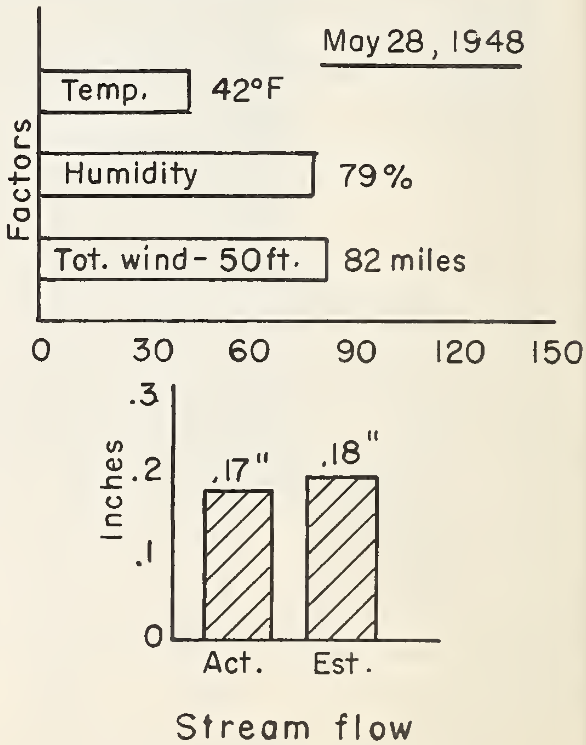
# CLIMATIC FACTORS AND STREAM FLOW

Temperature, humidity, and wind influence the daily rate of snow-melt which, in turn, governs spring stream flow. Continuous records of these climatic factors are useful in calculating rates of stream flow for the main St. Louis drainage. Cooperative studies with the Bureau of Reclamation have resulted in methods of forecasting daily stream flow. Forecasts are useful in reservoir operation and power generation. Examples are shown below.

Climatic station and wind tower at 10,500 feet, on the Fool Creek watershed

Comparison of actual stream flow of main St. Louis Creek with estimated flow, determined from the daily values of temperature, humidity, and wind:



## STREAM FLOW

Stream flow is the quantity of surface water flowing past a given point in a stream channel and is measured by means of flumes, weirs, or stabilized channels. It is related to the cross-sectional area of the flume, weir, or channel, and to the velocity of the flowing water. Stream flow is expressed as a rate in cubic feet per second, or as an amount in acre-feet, or inches depth over a known area.

Stream flow originates from melting snow banks and from seeps and springs.

Fool Creek gaging station is a combination of a flume and two broadcrested weirs. Stream flow shown here is from snow-melt; water is flowing at the rate of 13 cubic feet per second.

Cutting timber on small experimental plots (pages 15, 16, 17) has resulted in the accumulation of greater amounts of water, mostly from added volumes of snow. Presumably this water will cause increased stream flow. The assumption is still problematical, however, until similar cutting is done in a forested watershed from which stream flow can be measured. A watershed study has been started to provide the answer.

## FOOL CREEK WATERSHED

Fool Creek watershed, a 710-acre drainage, has been selected for this study. Stream flow, rainfall, and snow storage have been measured since 1940. Average annual yield of water in stream flow would cover the watershed to a depth of 13 inches. Elevations range from 9,500 to 11,500 feet. About half the 6 million board feet of timber is lodgepole pine and the rest is a mixture of Engelmann spruce and alpine fir. Part of this is soon to be logged.

## EAST ST. LOUIS CREEK WATERSHED

East St. Louis Creek is the companion watershed to Fool Creek. It will not be logged. Since 1943 stream flow and snow storage have been measured on this 2,430 - acre drainage. Elevations range from 9,500 to 12,000 feet; the vegetation consists of lodgepole pine, Engelmann spruce, alpine fir, and alpine turf above timber line. Annual water yield is equivalent to 18 inches depth over the area. The flow from the two experimental watersheds is well correlated and procedures are available to estimate, within about 7 percent, the flow of Fool Creek from that of East St. Louis Creek.

Measuring water content of snow with Utah snow tube

# FOOL CREEK STUDIES

Forest and watershed management research is a multiple-use program. The long-time treatment scheme for the Fool Creek watershed is:

1. Construct all logging roads prior to timber harvesting and measure their effect on stream flow.

2. Remove some 3 million board feet of timber from the watershed by alternate-strip cutting and measure its effect on stream flow.

3. About 1960 remove the remaining timber from the watershed and measure its effect on stream flow.

All timber down to 9.5 inches in diameter will be removed in the cut strips, while the uncut strips will remain in their original condition. The alternate-strip cutting will provide information concerning logging methods, loss of trees by windthrow, and reestablishment of the stand from seed.

Along with silvicultural and streamflow studies, measurements will be made of such physical factors as wind, temperature, humidity, precipitation, snow depth, snow-melt, and evaporation. Relation of soil moisture to spring stream flow is of major importance. The mass of soil material as it rests on solid rock varies in thickness, composition, and source. The geological origin of the soil has much to do with stream flow as there is little surface movement of water in forested mountain watersheds.


Sketch Map
FOOL CREEK & LODGEPOLE PINE PLOTS
Fraser Experimental Forest

# SNOW STORAGE

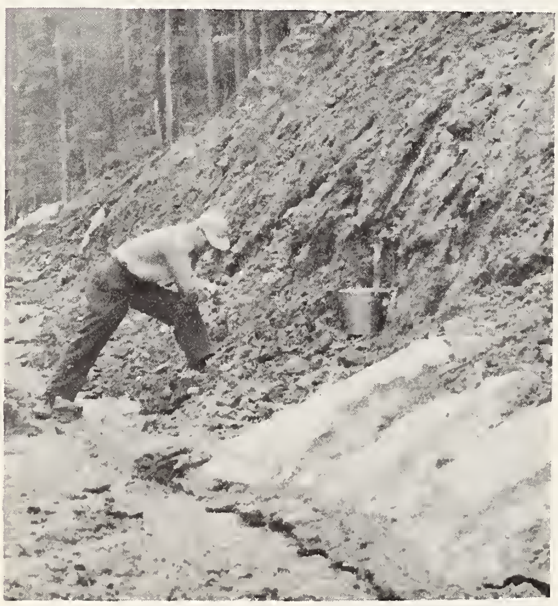
Snow-storage measurements have been made annually since 1943 on Fool Creek watershed. Amount of snow at each of the 100 stations on a snow course is measured each spring. Half of the stations are in dense timber and half cleared of timber in 100-foot circles. The difference in the water content of the snow between the uncleared and cleared stations reflects the amount of water intercepted by the trees.

A summary of these differences follows:

| | Water content of snow | | |
|---|---|---|---|
| | In clearings | Under trees | Difference |
| Seven-year average | 15.32 inches | 11.57 inches | 3.75 inches |

# SOIL-MOISTURE STUDIES

The rocky, porous soils of the Fool Creek watershed become charged with snow-melt water about 2 weeks before the spring peak in stream flow. Water flowing through the soil comes to the surface at many seeps and springs. At eight different locations the seasonal variation of soil moisture is studied. The effect of logging on soil moisture will be observed in the lodgepole and spruce-fir soils.



Flow of water along a deep clay layer in the soil exposed by a road cut

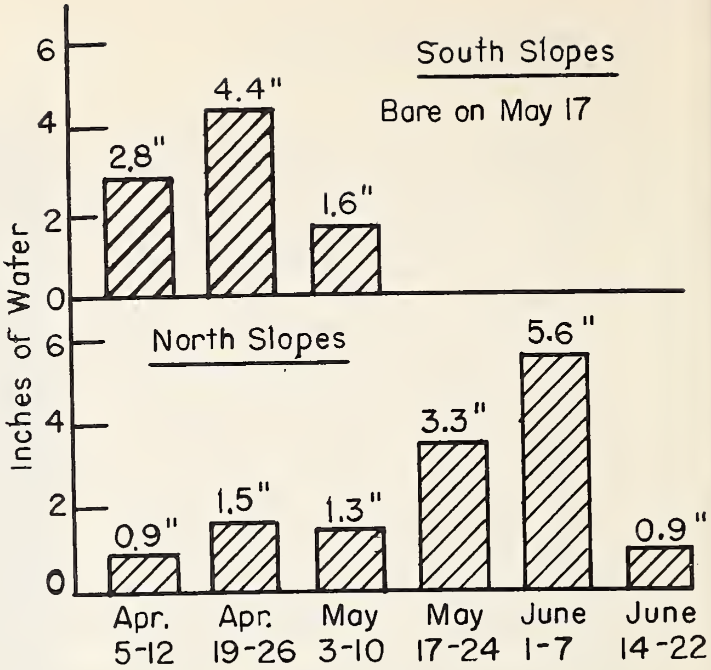
Difficulties of constructing logging roads have limited the harvesting of timber from the high-elevation forests. On the Fool Creek watershed, 5 miles of access road at an average 7-percent grade have been completed. In addition, there are 8 miles of spur roads, branching out from the main road. Some 8 percent of the forest area has been cut to make way for the roads. Presently, the effect of road construction on erosion and stream flow are being studied. Total erosion will be measured by depositions in a sediment pond below the lower stream gage.

Constructing a logging road with a bulldozer

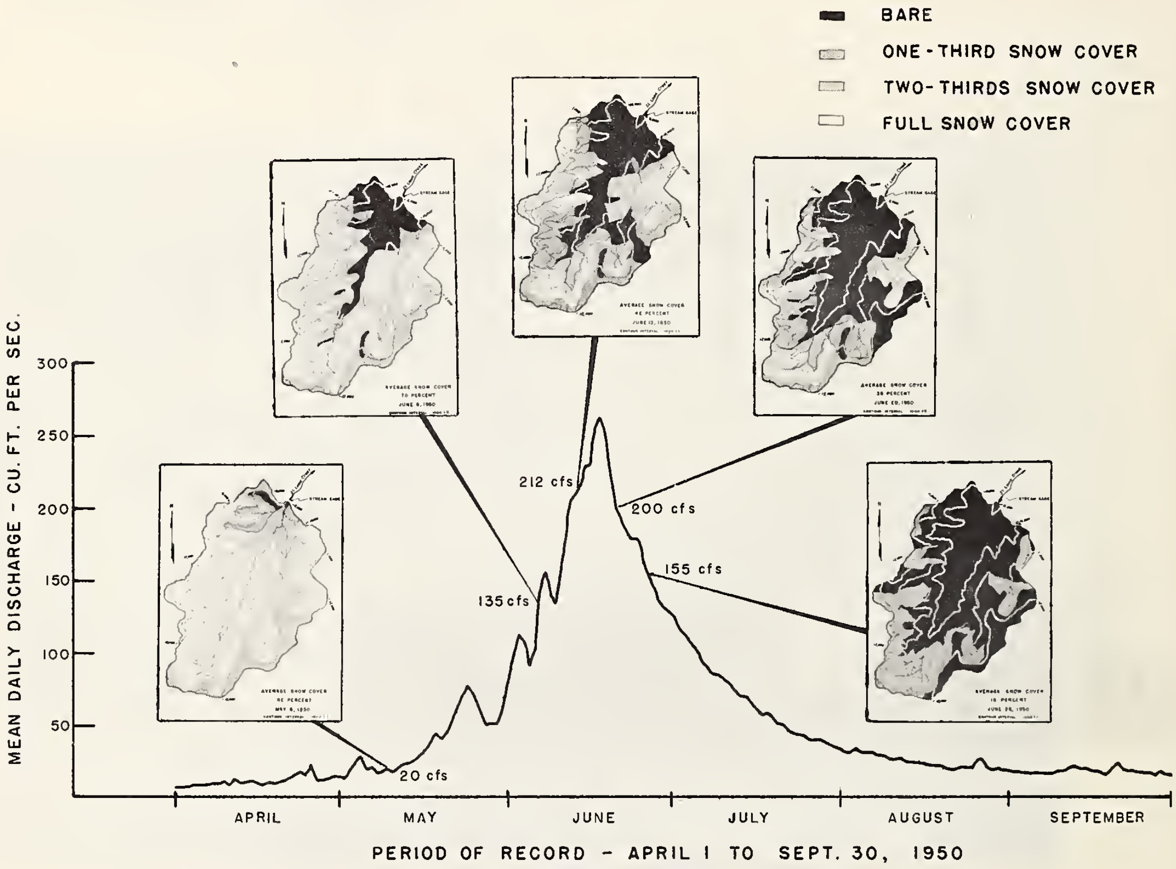
Pond of $\frac{1}{4}$ acre-foot capacity in which to trap sediment

## SNOW-COVER DISAPPEARANCE

At the end of winter the entire Forest is covered with snow. Snow melts and disappears from south slopes about a month before it does from north slopes. As spring advances, the snow disappears progressively from the lower elevations to the higher. When one-half of the snow has disappeared, the spring peak in stream flow is approached; when 80 percent of the snow is gone the stream is declining in flow.




**Snow disappears first from south slopes**




Relation of snow-cover disappearance to stream flow of St. Louis Creek

Each year, 200 to 300 people visit the Fraser Experimental Forest. Many of these visitors see field research work for the first time. They often learn about measures which apply directly to their home conditions.

Many campers and fishermen spend from a day to several days at the picnic and camp grounds along the main St. Louis Creek. The State Game and Fish Department stocks the stream annually with legal-size trout.

During the fall months, the Forest is used for deer and elk hunting. The absence of numerous roads and trails challenge the hunters in stalking the game.

The western part of the Forest is bounded by Byers Peak and other peaks of the William's River mountains. They provide a scenic hiking trip. The many lookout points give a panoramic view of the surrounding mountains and the valley of Middle Park.

Camping and hiking are Forest uses.
St. Louis Lake in center

## NOTES REGARDING THE EXPERIMENTAL FOREST

1. Visitors are always welcome. To obtain more detailed published information about the experimental work, ask the resident technicians, or a letter may be addressed to the Director, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

2. Research at the Fraser Experimental Forest is coordinated to provide knowledge about the many interrelated uses of forest lands. This is necessary in order to serve the greatest number of people in the long run. Research deals with the effect of use on renewable resources and requires a long time. Because of the possibility of fire, public use of the research areas is discouraged. The public has a large investment in research installations and records which are difficult to replace, once destroyed by fire.

3. The economy of the area surrounding the Forest is one of mountain agriculture. Through the occupancy, development, and use of the land by people, various problems of land management, water rights, land ownership, and tenure leases arise. No problem is static where full use of the resources is yet to be realized. Studies of the conditions affecting water supply will be continued while those of bug-killed timber and uses of forest products will receive more emphasis.

4. Opportunities are unlimited for graduate students to undertake fundamental research in the conservation and use of natural resources. Arrangements may be made through colleges, universities, foundations, or other interested groups and the U. S. Forest Service on a cooperative basis.

5. The facilities of the Fraser Experimental Forest are used from time to time for training schools,for undergraduate field work, for field meetings of forestry and conservation societies, and for the Point IV program in forestry. Excellent examples, nearby and on the Forest, serve as on-the-ground illustrations of both beneficial and harmful practices in mountain agriculture.

FARMS AND CITIES OF SIX WESTERN STATES DEPEND

ON

CONTINENTAL DIVIDE WATERSHEDS

From the high forested watersheds comes the water for homes, cities, industries, and farms. Water is a first necessity of western life and livelihood. To be fully useful, its flow should be adequate and controlled naturally

# WATER SUPPLY THROUGH MANAGEMENT

The Fraser Experimental Forest is a research unit of the Rocky Mountain Forest and Range Experiment Station, which is maintained in cooperation with the Colorado A & M College at Fort Collins, Colorado

Prepared by L. D. Love and E. G. Dunford, Foresters